SC-CAMLR-42

SCIENTIFIC COMMITTEE FOR THE CONSERVATION OF ANTARCTIC MARINE LIVING RESOURCES

REPORT OF THE FORTY-SECOND MEETING OF THE SCIENTIFIC COMMITTEE

HOBART, AUSTRALIA
16 – 20 OCTOBER 2023

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Chair of the Scientific Committee
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Abstract

This document presents the adopted report of the Forty-second Meeting of the Scientific Committee for the Conservation of Antarctic Marine Living Resources held in Hobart, Australia, from 16 to 20 October 2023.

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Contents

The Glossary of Acronyms and Abbreviations is available from the CCAMLR website.

Report of the Forty-second
Meeting of the Scientific Committee
(Hobart, Australia, 16 to 20 October 2023)

Opening of the meeting

1.1 The Forty-second meeting of the Scientific Committee was held from 16 to 20 October 2023 at the CCAMLR Headquarters in Hobart, Tasmania, Australia. The meeting was chaired by Dr D. Welsford (Australia). The plenary sessions of the meeting were streamed to a listening audience.

1.2 Dr Welsford welcomed all participants, whether in-person or as an online audience (Annex 1). He acknowledged the First Nations people of Australia as the first conservationists and scientists of the lands on which the Scientific Committee meets and noted that the CCAMLR Headquarters is located on the traditional lands of the Muwinina people. He noted that the conservation of marine ecosystems around Antarctica is critical for future generations and encouraged delegates to work together in a respectful and constructive way to show the positive outputs of peaceful collaboration.

1.3 Dr Welsford noted that the Scientific Committee has significant work to do to manage the significant challenges facing the marine ecosystems around Antarctica, and that the Committee will need to work together, using the best available science to provide advice to the Commission. As scientists, he urged Committee Members to frame any disagreements as testable hypotheses, and also to be respectful of each other.

1.4 The List of Documents considered during the meeting is given in Annex 2, while some of the documents tabled by the Russian Federation (Russia) were noted but not presented due to their absence. A glossary of acronyms and abbreviations used in CCAMLR reports is available online at https://www.ccamlr.org/node/78120.

1.5 While all parts of this report provide important information for the Commission, paragraphs of the report summarising the Scientific Committee's advice to the Commission have been highlighted. Contributed statements are indicated in italics.

1.6 The report of the Scientific Committee was prepared in accordance with Rule 3 of the SC-CAMLR Rules of Procedure by S. Alfaro-Rodríguez (European Union (EU), M. Belchier (United Kingdom (UK)), C. Cárdenas (Chile), R. Cavanagh and M. Collins (UK), A. Dunn (New Zealand), T. Earl (UK), M. Eléaume (France), S. Fielding and S. Hill (UK), S. Kawaguchi and N. Kelly (Australia), P. Koubbi (France), L. Krüger (Chile), A. Makhado (South Africa), B. Meyer (Germany), T. Okuda (Japan), S. Parker (Secretariat), M. Santos (Argentina), F. Schaafsma (Kingdom of the Netherlands (Netherlands)), S. Thanassekos (Secretariat), N. Walker (New Zealand), X. Wang (People's Republic of China (China)) and G. Watters (United States of America (USA)).

Adoption of the agenda

1.7 The Scientific Committee adopted the Provisional Agenda which had been circulated as SC CIRC 23/74 prior to the meeting consistent with Rule 7 of the Scientific Committee's Rules of Procedure. The Agenda was adopted without change (Annex 3).

Chair's report

1.8 The Chair of the Scientific Committee noted the large amount of work undertaken this past year, which included the meetings of five working groups, as well as five workshops which were conducted both online and in-person, all of which have reports submitted to this meeting and have generated significant and important advice for the Scientific Committee to consider. In addition, the Scientific Committee submitted papers to the Committee for Environmental Protection (CEP) and the International Whaling Commission (IWC) to report on and progress specific issues. The following meetings were held:

(i) Working Group on Acoustic Survey and Analysis Methods (WG-ASAM), 22 to 26 May, Tokyo, Japan (Annex 4)

(ii) Working Group on Statistics, Assessments and Modelling (WG-SAM), 26 to 30 June, Kochi, India (Annex 5)

(iii) Working Group on Ecosystem Monitoring and Management (WG-EMM), 3 to 14 July, Kochi, India (Annex 6)

(iv) Working Group on Incidental Mortality Associated with Fishing (WG-IMAF), 5 to 10 October, CCAMLR Headquarters, Hobart, Australia (Annex 7)

(v) Working Group on Fish Stock Assessment (WG-FSA), 2 to 13 October, CCAMLR Headquarters, Hobart, Australia (Annex 8)

(vi) Workshop on Tagging of toothfish and skates (WS-TAG-2023), 14 to 17 March, CCAMLR Headquarters, Hobart, Australia (Annex 9)

(vii) Workshop on Age Determination Methods (WS-ADM-2023), 10 and 11 May, online

(viii) Independent Review to Toothfish Stock Assessments, 3, 15, 16 and 17 August, online with Chair summary report (SC-CAMLR-42/02)

(ix) Krill Fishery Observer Workshop (WS-KFO-2023), 19 to 21 July, Shanghai, China (Annex 10)

(x) Workshop on Climate Change (WS-CC-2023), 4 to 8 September, hybrid format, Cambridge, UK and Wellington, NZ (Annex 11).

Harvested species

2.1 The Scientific Committee noted SC-CAMLR-42/BG/01 which summarised catches of target species from directed fishing on toothfish, icefish and krill in the Convention Area in 2021/22 and 2022/23 (until 31 July) and from research fishing under Conservation Measure (CM) 24-01. Catches from 2021/22 were derived from aggregated haul by haul (C1, C2 and C5 data), whilst 2022/23 data were derived from in-season catch and effort data.

2.2 The Scientific Committee noted CCAMLR-42/BG/08 Rev. 1, which summarised fishery notifications for the 2023/24 season. The Scientific Committee noted that the bottom impact assessment for the Namibian-flagged vessel *Helen Ndume* (notified for Subareas 88.1 and 88.2) was submitted late, but as there was insufficient time to review these in the Scientific Committee, the late notification was considered a matter for the Commission.

2.3 The Scientific Committee noted the recent record lows in sea-ice extent in the Antarctic and the importance that sea-ice plays as a critical habitat for Antarctic krill. The Scientific Committee also noted the recent switch from La Niña to El Niño conditions, which will also influence environmental conditions in the Convention Area. The Scientific Committee further noted that whilst the recent low in sea-ice levels may not represent a new normal, it cannot be assumed that past or current environmental and ecological conditions will endure in the future. Consequently, the Scientific Committee needs to take changes in sea-ice levels into account when considering management advice and consider the types of data needed to monitor the potential effects of reduced sea-ice on krill and marine living resources in general.

2.4 The Scientific Committee noted the unprecedented threat that Antarctic wildlife faces from high pathogenicity avian influenza (HPAI), the need to act to reduce the risk of HPAI reaching the region and the need to be prepared to take appropriate management action if avian flu impacts wildlife in the Antarctic region (paragraphs 5.17 and 8.13).

Krill resources

Status, trends and general issues

2.5 CCAMLR-42/17 presented a review of catch statistics of Antarctic krill by conventional and continuous fishing systems in Area 48, noting that the latter fishing method has contributed to most of the observed increase in overall catches in recent years. The authors proposed limiting catches for vessels operating with the continuous fishing system to 70% of the total allowable catch in Area 48, on the basis of outcompeting economic efficiency, displacing traditional fishers, and humanitarian access to food sources by Ukraine. The authors also highlighted that the proposed measures should be considered as a temporary requirement, which could be revised as new data on the impact of different krill fishery technologies emerge.

2.6 The Scientific Committee recalled its discussion on this matter at previous meetings and noted that while the proposal is an issue of the Commission, the carbon emission of different fishing systems could also be considered in the future, noting that new technologies and approaches within the fishery may increase the catch efficiency, thus reducing carbon emissions per unit catch.

2.7 SC-CAMLR-42/BG/10 presented the activities conducted by the Association of Responsible Krill harvesting companies (ARK) vessels in support of the revised krill fishery management approach, exemplified by their support of krill surveys in Subareas 48.1 and 48.2, which also included the Gerlache Strait in the 2022/2023 fishing season. ARK also expressed their concern on the approaching of CCAMLR vessels by the Sea Shepherd vessel *Allankay* during March 2023, which caused some disruption in normal fishing operations. ARK expressed their concern that the *Allankay* took on a role as private patrol vessel, independent of the CCAMLR System of Inspection and Scheme of International Scientific Observation (SISO), implying that the krill fishery is not adequately regulated or controlled.

2.8 The Scientific Committee noted that the safety issues caused by the activities of the Sea Shepherd vessel *Allankay* may not relate solely to fishing vessels, but also to other vessels, and considered that this should be brought to the attention of the Commission to consider taking future actions to address such safety issues.

2.9 The Scientific Committee welcomed the survey activities made by ARK vessels in support of the implementation of the revised krill fishery management approach, and ARK's commitment to the implementation of voluntary restricted zones (VRZs) in Subarea 48.1.

2.10 The Scientific Committee also noted the VRZs in Subarea 48.1 may have encouraged the krill fishing vessels to operate in Subarea 48.2 during the summer seasons, and the increased fishing activity in Subarea 48.2 occurs close to shore in relatively close proximity to breeding colonies of krill-dependent predators.

2.11 SC-CAMLR-42/BG/22 considered that implementing the revised krill fishery management approach in Subarea 48.1 in a staged manner is a viable option to move forward and creates incentives for expanding krill survey efforts. In its paper, ARK provided the following recommendations for the consideration of the Scientific Committee: (i) designating specific transects for conducting krill survey on each stratum identified by the Scientific Committee in 2022; (ii) using existing commercial trawls for estimating krill length frequency distributions for target identification in conjunction with the new sampling protocol agreed this year, and (iii) continuing exploring seafloor backscattering as an alternative mechanism for acoustic calibration. ARK also suggested that the Scientific Committee consider adopting a daily catch and effort reporting system when the quota assigned or left is smaller than 30 000 tonnes to improve forecasts of fishery closure notifications.

2.12 The Scientific Committee noted that the issue of using the seafloor backscattering for acoustic calibration methods was discussed at WG-ASAM-2023 and recommended that WG-ASAM-2024 develop guidelines for collection of relevant data to further assess this method. It also noted that the analysis of acoustic data collected by fishing vessels is already identified as a high priority work item for WG-ASAM.

2.13 SC-CAMLR-42/BG/21 considered that the Antarctic ecosystem is confronting complex challenges driven by climate change and growing concentration of the krill fishery and emphasised the urgent need for CCAMLR and the Scientific Committee to take immediate actions. The actions include designating the proposed Domain 1 marine protected area (D1MPA), bridging scientific gaps in the agreed krill work plan to achieve a preferred management strategy, and strengthening scientific and compliance monitoring. Until the timed work plan is completed, the Antarctic and Southern Ocean Coalition (ASOC) recommended to renew CM 51-07, and also to expand krill and predator monitoring and develop decision making criteria which can be used for dynamic management to detect and prevent negative impacts of fishing on the ecosystem.

2.14 The Scientific Committee noted that the revised krill fishery management approach has implicitly incorporated several considerations on the effect of climate variability, such as the average of a set of krill biomass estimates and the assessment of krill recruitment using time-series data, into the process of determining the precautionary catch limits.

2.15 SC-CAMLR-42/BG/31 provided an update on the Antarctic Wildlife Research Fund (AWR) and summarised the achievements by AWR since the fund was established in 2015. It also noted that AWR have funded several science projects that have produced results presented in CCAMLR scientific working groups and in peer reviewed journals.

2.16 The Scientific Committee thanked the AWR for providing funds in support of CCAMLR work and the research projects targeting priority work of the Scientific Committee.

2.17 The Scientific Committee noted the discussion relevant to krill resources during the WG-FSA meeting (WG-FSA-2023, paragraphs 3.1 to 3.9), including the variability in sea-ice extent within Subareas 48.1 and 48.2 and how it may affect the operation of krill fishery.

2.18 The Scientific Committee noted an analysis on the intrinsic productivity of krill in Subarea 48.1 conducted by the current CCAMLR Scholarship recipient, Mr M. Mardones (Chile) and discussed at WG-FSA-2023 (paragraphs 3.8 to 3.9).

Statistical Area 48

Conservation Measure 51-07

2.19 CCAMLR-42/42 Rev.1 presented a proposed amendment to CM 51-07 to include a requirement to collect acoustic data from vessels participating in the krill fishery in Area 48, at the temporal and spatial scale endorsed by the Scientific Committee for managing the fishery, as this would be essential for science-based and precautionary approaches in krill fishery management. The proposed improvement includes an additional operative paragraph that specifies starting year and how often data collection should be done, and an annex that specifies minimum requirements for the data collection.

2.20 The Scientific Committee welcomed the proposal noting it is relevant to a specific request from WG-EMM (WG-EMM-2023, paragraph 5.64(i)), but that there may need to be consideration of specifying catch limits in the conservation measure. The Scientific Committee further suggested inclusion of the details of the procedure and the timeline for acoustic data processing.

2.21 The Scientific Committee noted that due to limited ship time available on research vessels, using fishing vessels to conduct monitoring is becoming an integral part of stock assessment. At the same time the broader need for at-sea monitoring has been identified by other working groups such as WG-EMM (WG-EMM-2023, paragraphs 5.64(i) and (ii)).

2.22 The Scientific Committee noted a view was expressed that adding the data collection requirements in the conservation measure should be accompanied with advice for a commensurate increase in catch limits.

2.23 The Scientific Committee noted that it is not in a position to provide any immediate advice for updating catch limits in Area 48 as there are various initiatives currently in progress, such as the Harmonisation Symposium, D1MPA, VRZs, and will need some time to bring together and coordinate all these initiatives. However, the Scientific Committee further noted the importance of monitoring through coordinated data collection with the implementation of the revised krill fishery management approach.

2.24 The Scientific Committee considered whether three years is an appropriate period for collecting data to provide management advice and recalled the Scientific Committee discussion regarding importance of capturing the full periodicity of krill dynamics, for example 5 to 7 years as discussed during the development of the revised krill fishery management approach, and that there is a need for further deliberation at WG-EMM and WG-FSA on this matter.

2.25 The Scientific Committee recommended a rollover of current CM 51-07 for one year.

2.26 Dr X. Zhao (China) recalled that the Scientific Committee has agreed that the catch limits presented in Table 2 of SC-CAMLR-41, are based on the use of the best available science. He further noted that next year, it is important for the Scientific Committee and its relevant working groups to discuss how the historic and new data be utilised for management, and to find a strategy to maximise the use of information collected over many years that has been used for the development of the precautionary catch limits derived at SC-CAMLR-41.

2.27 The Scientific Committee noted the importance of providing a definitive advice using contemporary data and analysis such as spatial overlap analysis.

2.28 The Scientific Committee noted the Annex 12 and Annex 13 developed by a subgroup during the meeting, based on CCAMLR-42/42 Rev.1 are useful documents, as they provide important guidance for conducting surveys. The Scientific Committee agreed that it is a priority that these documents be finalised in WG-ASAM and WG-EMM in the expectation that CM 51-07 is revised very soon. Once these annexes are finalised, it will be appropriate that they are subject to regular review by WG-ASAM and WG-EMM and, based on their advice, be updated as required.

Standard method for map projection

2.29 The Scientific Committee noted discussion regarding: an updated method for defining and calculating spatial polygons that could be dynamically updated as coastlines were updated; proposed thresholds for line densification; and a standardised projection using the European Petroleum Survey Group (EPSG) code 6932 (WG-ASAM-2023, paragraphs 3.6 and 3.7).

2.30 The Scientific Committee endorsed the WG-ASAM and WG-FSA recommendations (WG-ASAM-2023, paragraph 3.9 and WG-FSA-2023, paragraph 3.18), requesting Members apply the following geospatial rules:

(i) geographical information system (GIS) objects use the EPSG 6932 projection

(ii) lines of more than 0.1 degree of longitude be densified

(iii) polygon vertices be given clockwise in decimal degrees with at least five decimal places

(iv) vertices be added where polygons meet (see WG-FSA-2023, Figure 1)

(v) inland vertices be used for polygons that are bound by any coastline (continent and islands)

(vi) polygons be clipped to all coastlines (continent and islands) based on the most recent available coastline data.

(vii) the coastline be based on the latest available coastline data, as obtained from the SCAR Antarctic Digital Database (ADD) and other sources where needed (e.g. www.naturalearthdata.com)

(viii) analyses cite CCAMLR geospatial data (i.e., shapefiles) as CCAMLR. [Year]. Geographical data layer: [Layer name]. Version [Version], URL: [URL]

(ix) all maps cite data sources and projection used.

2.31 In order to enable this the Scientific Committee further requested:

(i) the Secretariat develop a data form for Members to submit coordinates of polygon vertices when proposing new spatial polygons

(ii) the Secretariat work with Members to develop standard tests and diagnostics to verify the validity of spatial polygons (WG-FSA-2023, paragraph 3.19).

2.32 The Scientific Committee requested that both the spatial objects and the R code used to generate them (including the version of the coastline data) be made available via the CCAMLR GitHub repository, and to be updated as necessary by the Secretariat in consultation with appropriate working groups. The Scientific Committee further noted the importance of ensuring this protocol be visible to the scientists contributing to working groups and the Scientific Committee, on the website and during paper submission and also for clarifying the types of work this standardised method will be applied to, for example, for planning surveys and the spatial overlap analysis.

2.33 The Scientific Committee noted the discussion on a number of spatial inconsistencies between spatial units developed at various stages of the work to progress the revised krill fishery management approach for Subarea 48.1 (WG-FSA-2023, paragraphs 3.10 to 3.14). These include the strata used to estimate krill biomass (WG-ASAM-23/01) and those applied to two parallel implementations of the spatial overlap analysis (WG-FSA-2022/39; WG-EMM-2022/17).

2.34 The Scientific Committee identified a need for common understanding of the calculations performed in developing the revised krill fishery management approach, and of the spatial footprint of the area for which it is possible to develop advice. This requires clear and accessible documentation of all stages of the revised krill fishery management approach with sufficient detail to allow consistent implementation. The Scientific Committee requested that the relevant working groups (WG-ASAM, WG-EMM) resolve the spatial inconsistencies.

Progress towards acoustic biomass estimates

2.35 The Scientific Committee noted the discussion on the recent developments on the CCAMLR Acoustic Data Repository (WG-ASAM-2023, paragraphs 3.14 to 3.18) and suggested that the Secretariat investigate a cloud-based solution for exchanging acoustic data and the development of the acoustic data explorer tool, and that it be made available to Members though the Members-only section of the CCAMLR website.

2.36 The Scientific Committee noted the discussion on the deployment and results from moored 120 kHz EK80 echosounder data in Subarea 48.3 between 2018 and 2022, and that the increasing value of autonomous systems for krill study and the potential to use autonomous vehicles and systems to elucidate not only temporal variation but also spatial variation (WG-ASAM-2023, paragraphs 6.1 to 6.3).

2.37 The Scientific Committee noted the use of seafloor as an alternative way for calibration and agreed that near-concurrent completion of seafloor transects by a sphere-calibrated vessel and an uncalibrated vessel would improve the results of the seafloor-based calibration. The Scientific Committee also suggested that seabed substrate data could be used to help identify new suitable sites (WG-ASAM-2023, paragraph 4.6).

2.38 The Scientific Committee noted the WG-ASAM discussion on survey design and data collection plan for fishing vessels (WG-ASAM-2023, paragraphs 4.7 to 4.11) and suggested that the Secretariat work with Dr S. Menze (Norway) to test the open-source software 'Krillscan' package using the krill fishing vessel acoustic data collected along nominated transects.

2.39 The Scientific Committee also noted the discussion on the recent development and additional sampling capacities of broadband echosounders, and the updates on the 'Instruction manual for the collection of fishing vessel-based acoustic data' by WG-ASAM during the meeting (WG-ASAM-2023, paragraphs 4.12 to 4.15).

2.40 The Scientific Committee endorsed the recommendations by WG-ASAM that:

(i) WG-ASAM develop test datasets, as recommended in WG-ASAM-2022, paragraph 2.13, to benchmark processing software and methods. (WG-ASAM 2023, paragraph 4.12)

(ii) the updated instruction manual, Appendix D in WG-ASAM-2023, be made available to fishing vessels and be available on the CCAMLR website (WG-ASAM-2023, paragraph 4.15).

2.41 The Scientific Committee noted that some of the nominated transects in Subareas 48.1 and 48.2 in Appendix D of WG-ASAM-2023 are already surveyed as part of annual surveys conducted by China and Norway. At the same time the Scientific Committee noted further requirements for guidelines and monitoring the strata of the Gerlache Strait, Drake Passage, and Powell Basin, where data is currently limited, to progress the implementation of the revised krill fishery management approach.

2.42 The Scientific Committee noted discussion in WG-EMM-2023 (WG-EMM 2023, paragraphs 4.9 and 4.10) regarding a summary document of the current and ongoing development of the revised krill fishery management approach and agreed that this should be updated regularly by WG-EMM to supplement the revised krill fishery management approach document available on the CCAMLR website (WG-EMM-2023, paragraph 4.11).

2.43 The Scientific Committee noted the discussion regarding the krill biomass estimates in Subarea 48.1 at WG-ASAM-2023 (WG-ASAM-2023, paragraphs 5.1 and 5.7), and noted that a workflow was created which could be used to calculate krill biomass estimates for the management strata in Subarea 48.1 as they are defined by WG-ASAM-2023/01.

Progress towards a stock assessment

2.44 The Scientific Committee noted WG-FSA discussions of the selectivity function described by Krag et al. (2014) and used in the Grym.

2.45 The Scientific Committee recalled reports from WG-FSA-2023, paragraphs 3.6 and 3.7, WG-SAM-2023, paragraphs 3.1 to 3.3 and WG-EMM-2023, paragraph 4.23, which discussed issues in the use of the selectivity function in Krag et al. (2014) in applications for the Grym for krill but recognised that there are currently no alternative methods and Krag et al. (2014) remains the best available science.

2.46 The Scientific Committee noted WG-FSA-2023, paragraph 3.7, that recommended further work investigating whether results from the Grym would be sensitive to changes in the parameterisation of fishery selectivity. WG-FSA-2023 noted that this question could be investigated using sensitivity tests (e.g. by comparing gamma values produced with different parameter values in the selectivity function) and by comparing length-frequency data collected by SISO to expectations from the model developed by Krag et al. (2014).

2.47 The Scientific Committee noted that implications of including data from multiple vessels and seasons to evaluate selectivity should be taken into account in sensitivity analyses.

2.48 The Scientific Committee noted that the paper by Herrmann et al. (2018) provides an update of the Krag et al. (2014) analysis by examining selectivity in both the codend and trawl net to refine fishing selectivity parameters.

2.49 The Scientific Committee noted discussions on an evaluation of the sensitivity of the Grym stock assessment model for Antarctic krill to seasonal trends in natural and fishing mortality (WG-EMM-2023/35).

2.50 The Scientific Committee endorsed the recommendations in WG-EMM-2023, paragraph 4.27, for good practices when modelling krill populations:

(i) sensitivity analyses to assess the robustness of models, their assumptions, and any resulting advice

(ii) medium-term projections (e.g. 20–35 years) to describe plausible futures rather than short-term, specific predictions

(iii) 'bookending' simulations, where parameter values are set close to, or at their extremes to test model boundaries and develop precautionary advice.

2.51 The Scientific Committee thanked the SCAR Krill Expert Group (SKEG) for the work undertaken so far towards the development of a krill stock hypothesis in Area 48 and noted that this is a CCAMLR priority. It noted the krill stock hypothesis information collection plan (WG-EMM-2023, Table 1) that was agreed as a workplan to progress in the krill stock hypothesis.

2.52 The Scientific Committee recalled that the krill stock hypothesis was developed following a request from the Scientific Committee and provided an exemplar of collaborative work between experts in SCAR and SC-CAMLR.

2.53 The Scientific Committee recommended that WG-ASAM, WG-EMM and WG-FSA take the krill stock hypothesis into account in developing their advice in the future.

2.54 The Scientific Committee encouraged SKEG to continue to work on the krill stock hypothesis and provide an update to WG-EMM and the Scientific Committee in 2024.

Progress towards a spatial overlap assessment

2.55 The Scientific Committee noted SC-CAMLR-42/07 which provided comments on the revised krill fishery management approach in Area 48 on the issue of ecosystem effects of fishery based on results of the RV *Atlantida* survey in 2020. The document suggests that spatial overlap is not sufficient to conclude that there was functional overlap.

2.56 The Scientific Committee recalled that this document was discussed at WG-EMM-2023 (WG-EMM-2023, paragraphs 4.40 to 4.42).

2.57 The Scientific Committee noted that whilst spatial overlap does not necessarily imply evidence of impact of fishing on predators, it is precautionary to use spatial overlap as an indicator of potential functional overlap. The spatial overlap analysis is therefore an appropriate method given lack of specific information on functional overlap.

2.58 The Scientific Committee noted that paired surveys such as the ones presented in SC-CAMLR-42/07 can be used to study krill flux, with due consideration of natural mortality and individual growth, noting that the predation-induced mortality rate is higher than average during predators' breeding season when krill demand from predators increases with time.

2.59 The Scientific Committee supported the idea of using temporal analysis to distinguish between flux and natural mortality as drivers of krill availability and recalled that the US-AMLR program has several years of paired acoustic survey data that could be analysed in conjunction with the RV *Atlantida* survey.

Ecosystem effects in the krill fishery

2.60 SC-CAMLR-42/BG/19 presented by ASOC highlighted the ongoing recovery of many baleen whale populations, one of the biggest conservation success stories of recent decades. The authors urged the Scientific Committee to take additional steps to help conserve these important krill predators in the context of accelerating climate change and increasing fishing pressure on krill. These steps are:

(i) to enhance cooperation between SC-CAMLR and the Scientific Committee of the IWC

(ii) to formalise a Memorandum of Understanding (MoU) between the Secretariats of the IWC and CCAMLR

(iii) to consider a move-on rule for krill fishing and continued work on eliminating whale by-catch through WG-IMAF

(iv) to continue the work of the Scientific Committee to distribute the krill catch on a precautionary basis to prevent localised depletion

(v) to implement International Maritime Organization guidance for non-SOLAS vessels on voyage planning and cetaceans; and to designate an MPA in Domain 1.

2.61 The Scientific Committee agreed that supporting ongoing recovery of whale populations is important and recalled that its strategic plan includes better coordination with IWC. It recalled that Dr N. Kelly (Australia) is the liaison between the Scientific Committees of CCAMLR and IWC (paragraph 8.22) and thanked them for their work during the intersessional period. The Scientific Committee noted that it has received advice from IWC on various issues including cetacean by-catch and noted recommendations to enhance this engagement (paragraph 8.4).

2.62 The Scientific Committee noted that toothfish have been by-caught in the krill fishery in the past. The Scientific Committee noted that retaining otoliths from toothfish may be valuable if they are encountered again, and that a mechanism for returning those samples for ageing needs to be developed.

2.63 The Scientific Committee noted that fish by-catch in the krill fishery provides an excellent opportunity to study the early life stages of fish in the Convention Area and suggested that identifying priority species for data collection would be useful.

2.64 The Scientific Committee requested that Members develop proposals for fish by-catch data collection and identify priority species.

2.65 The Scientific Committee requested that the Secretariat include fish by-catch data and observer-derived estimates of by-catch weights, as presented in WG-FSA-2023/73, in future krill fishery reports.

2.66 The Scientific Committee endorsed the recommendation of WG-FSA (WG-FSA-2023, paragraph 3.49) that all working groups should continue to review requests and priorities for krill fishery observer data, and provide details of data requirements, including estimates of the effective sample size for a given number of samples, and the spatial and temporal scales required to address these questions.

2.67 The Scientific Committee noted the increasing amount of information being generated through winter krill monitoring by the UK in Subarea 48.3 and the long-term krill biomass survey by Norway in Subarea 48.2 since 2011, representing significant progress in the development of data to underpin the spatial overlap analysis in Subareas 48.2 and 48.3 (WG-EMM-2023, paragraph 6.4).

2.68 The Scientific Committee agreed that the krill work plan has helped facilitate data accumulation vital for progressing the development of the revised krill fishery management approach in Area 48 and looked forward to further analyses of these datasets.

2.69 The Scientific Committee agreed that regular reporting based on analyses of CCAMLR Ecosystem Monitoring Program (CEMP) data, in conjunction with other related environmental data, is important to inform the Commission, Members, and other stakeholders on the status of the ecosystem and Antarctic marine living resources in the Convention Area. A mechanism is required for communicating such reports.

2.70 The Scientific Committee noted that WG-EMM-2023 (WG-EMM-2023, paragraph 5.62) identified three broad objectives for ongoing discussion of CEMP:

(i) supporting the implementation of the revised krill fishery management approach for Subarea 48.1

(ii) enhancing circumpolar ecosystem monitoring in the context of climate change and fishing

(iii) supporting MPA design and monitoring.

2.71 Noting the discussion at WG-EMM-2023 (WG-EMM-2023, paragraphs 5.19 to 5.66) the Scientific Committee recommended that:

(i) implementation of a revised krill fishery management approach in Subarea 48.1 should be accompanied by enhanced ecosystem monitoring at appropriate scales in those management strata that are fished

(ii) such monitoring could include data collected on vessels and at breeding sites, using remote observations and automated monitoring systems for biological and physical variables

(iii) partnership with other programmes that collect predator data in these areas might be an appropriate way of expanding CCAMLR's access to monitoring data

(iv) sustainable funding mechanisms (potentially including incentives for submitting monitoring data) should be identified, as enhanced data collection and analysis require additional effort and resources

(v) consideration should be given to the acquisition of environmental data at appropriate spatial and temporal scales to identify potential drivers of monitored parameters

(vi) analysis should be conducted on existing CEMP data to advise the Scientific Committee on status and trends of the ecosystem and to progress implementation of the revised krill fishery management approach.

2.72 The Scientific Committee agreed to add a third aim to the objectives of CEMP, and that all relevant ecosystem data and information on the status and trends of all krill predators, dependant and related species should be considered as contributing to CEMP. It also noted the benefits of communicating to a broad audience in non-technical summaries how CEMP information is used to inform management decisions in CCAMLR such as krill catch limits and their spatial distribution (WG-EMM-2023, paragraph 5.53).

2.73 The Scientific Committee requested members develop methods to enable ecosystem 'health check' including CEMP data, in line with one of the original objectives of CEMP to distinguish between changes due to harvesting of commercial species and changes due to environmental variability, should be integrated into the revised krill fishery management approach.

2.74 The Scientific Committee endorsed the proposal (WG-EMM-2023, paragraph 5.65) to establish four temporary teams (with leads noted) to progress these recommendations through intersessional work and a dedicated session at WG-EMM-2024:

(i) analysis of existing monitoring data (Dr Hill with support from the Secretariat)

(ii) monitoring of current and potential sentinel species (Drs L. Emmerson (Australia), C. Waluda and M. Collins (UK))

(iii) krill fishery and at sea monitoring (SKEG)

(iv) environmental/non-biological parameters of relevance to wider ecosystem monitoring (Dr T. Knutsen (Norway)).

2.75 The Scientific Committee thanked the Members who have provided experts to lead the temporary teams, encouraged all members to engage in the work of these groups intersessionally, and requested that sufficient time is devoted to these topics at WG-EMM-2024.

2.76 The Scientific Committee requested the four teams to ensure that their analyses and proposals consider the effects of climate change.

2.77 The Scientific Committee noted that, while the current priority for CEMP analyses is to support the implementation of the revised krill fishery management approach for Subarea 48.1, CEMP also aims to monitor the wider ecosystem in the Convention Area and could be discussed under a dedicated agenda item, 'Ecosystem monitoring and management to support CCAMLR's objective' in future meetings.

2.78 The Scientific Committee further noted that while to-date CEMP has provided critical information on the structure, function and status of the ecosystems in CCAMLR, as it is currently configured, it cannot provide comprehensive information on the whole ecosystem. As CEMP evolves to meet its broader remit discussed above, it is expected that it will be important for monitoring climate change impacts and help to disentangle these impacts from the effects of fishing. It noted that developing a list of data standards for ecosystem data used in developing Scientific Committee advice is an important task for the Scientific Committee in the near term to facilitate this.

2.79 The Scientific Committee discussed incentives for submitting ecosystem monitoring data, particularly in relation to engaging the fishing industry in ecosystem monitoring.

2.80 One Member (China represented by Dr Zhao) recalled the recommendation by WG-EMM-2023 (paragraph 2.71(iv)) regarding sustainable funding mechanisms and noted the direct and indirect costs (loss of fishing days) incurred by vessels involved in krill monitoring and suggested that the Commission consider developing appropriate incentives.

2.81 Some other Members questioned the need for further incentives given the significant contributions of the CCAMR scientific community (including fishing and non-fishing Members) to ensuring the sustainability of krill fisheries. In particular, the CEMP monitoring provided by Members supports the fishery and it is important that the fishing industry should also contribute data and other resources to support the Scientific Committee.

2.82 Oceanites indicated its willingness to facilitate interpretation of its 30-year penguin monitoring data and to provide details so that they can be integrated with CEMP analyses. Oceanites also offered its expertise to assist CCAMLR with analyses of Oceanites penguin monitoring data. Belgium manages the SCAR Biodiversity Data Portal and indicated its willingness to deliver data in formats that support CEMP analyses. France reported that it has initiated a programme monitoring crabeater seals as a sentinel species and indicated willingness to contribute these data to CEMP analyses. The Scientific Committee thanked Oceanites, Belgium and France for these offers.

2.83 The Scientific Committee discussed the participation of external experts in proposed CEMP analyses (WG-EMM-2023, paragraph 5.66) and noted that such participation should be consistent with CCAMLR procedure, particularly on the use of e-groups. The Scientific Committee advised the leaders of the teams (paragraph 2.74) to identify appropriate platforms for conducting their work, including those that do not require access to the CCAMLR website.

2.84 The Scientific Committee requested that the Secretariat identify online tools that can support collaborative working and facilitate access to relevant CCAMLR information without providing access to restricted documents not directly relevant to the work.

Harmonisation of spatial management in Subarea 48.1

2.85 The Scientific Committee supported the proposal to hold a symposium on harmonising various conservation and krill fishery management initiatives being applied and developed for Subarea 48.1 (including the D1MPA proposal, the revised krill fishery management approach and the ARK VRZs) during the intersessional period. The Scientific Committee recognised the strong interactions between adjacent subareas in terms of ecology and fishing activities and recommended that, while the symposium should focus on Subarea 48.1, it should also consider the implications for adjacent Subareas (48.2, 48.5 and 88.3).

2.86 The Scientific Committee recommended that the Harmonisation Symposium should be held after WG-EMM-2024, so that the Working Group can conduct relevant analyses to be carried into the symposium. The Scientific Committee requested that the symposium produce an adopted report to be submitted to Scientific Committee and Commission in 2024.

2.87 The Scientific Committee thanked ASOC and ARK for offers to fund the symposium.

2.88 The Scientific Committee suggested that the symposium should be co-convened by a member of the Commission and a member of the Scientific Committee. Furthermore, the symposium steering committee should include members of the Scientific Committee and Commission.

2.89 The Scientific Committee requested that the Secretariat work with the symposium steering committee to support the symposium.

2.90 The Scientific Committee endorsed the Terms of Reference for the Harmonisation Symposium (Annex 14) and requested the Commission support this symposium.

Statistical Area 58

2.91 WG-FSA-2023, paragraphs 3.20 to 3.28, reports discussion of proposed revisions to the precautionary catch limits in Divisions 58.4.1 and 58.4.2-East based on recent biomass estimates from a 2019 survey conducted by Japan in Division 58.4.1 and a 2021 survey conducted by Australia in Division 58.4.2-East and stock assessments using the Grym. These biomass estimates have been endorsed by WG-ASAM and published in peer-reviewed literature. The proposed precautionary catch limits are:

(i) in Division 58.4.1, the total catch limit be set at 366 243 tonnes, with a subdivision of 132 725 tonnes west of 103°E, 54 462 tonnes between 103°E and 123°E, and 179 056 tonnes east of 123°E

(ii) in Division 58.4.2, the total catch limit be set at 2 005 280 tonnes, with a subdivision of 1.448 million tonnes west of 55°E and 557 280 tonnes east of 55°E.

2.92 The Scientific Committee welcomed the work of Australia and Japan to develop these proposals and noted that there was no current proposal to update the trigger levels stated in CM 51-03.

2.93 The Scientific Committee noted that sea ice coverage had prevented the surveys in Division 58.4.2 east from surveying shelf-break areas where high krill densities had been recorded in the earlier survey (BROKE-WEST survey 2006, Jarvis, 2010), and recognised that variable sea ice coverage is an important challenge for acoustic biomass surveys in polar regions.

2.94 The Scientific Committee also noted the discussion on the corrections to the mean weighted areal krill biomass density and the degree of coverage values from the 2019 survey conducted by Japan in Division 58.4.1 and the 2021 survey conducted by Australia in the eastern sector of Division 58.4.2 (WG-ASAM-2023, paragraphs 5.8 to 5.16).

2.95 Recalling its discussion on the 2021 survey conducted by Australia in the eastern sector of Division 58.4.2 (SC-CAMLR-40, paragraphs 2.5 and 2.6), and its recommendation on the data collection and data reporting procedures for acoustic krill biomass surveys (SC-CAMLR-41, paragraphs 2.27 to 2.29), the Scientific Committee requested Australia and Japan to submit standardised metadata, as described in Tables 2 to 8 of WG-ASAM-2022, to the Secretariat for WG-ASAM to review.

2.96 The Scientific Committee discussed methods for combining the results of regional-scale surveys with those of smaller-scale surveys to derive biomass estimates. It noted that the development of an integrated stock assessment might eventually provide a means of using data from both types of surveys in estimates of interannual biomass variability.

Advice to the Commission

2.97 The Scientific Committee requested that the Commission identify members to join the steering Committee of the proposed Symposium on Harmonisation of conservation and krill fishery management initiatives in the Antarctic Peninsula Region, and identify a co-convener.

2.98 The Scientific Committee endorsed the assessment for Divisions 58.4.1 and 58.4.2-East (paragraph 2.91) and recommended the proposed catch limits for *Euphausia superba* in Tables 1 and 2 are used to update CMs 51-02 and 51-03 respectively, which will be reviewed and revision suggested as appropriate in 3 years.

2.99 The Scientific Committee further recommended the current trigger levels in CM 51-03 remain in force for both subdivisions of Division 58.4.2 until such time that an updated spatial overlap analysis can inform on a spatial allocation of catches within this division.

2.100 The Scientific Committee recommended a one-year rollover of CM 51-07 and urged the working groups to make progress on finalising the revised krill fishery management approach for Subarea 48.1 based on the substantial work done over the last decade and the results of the proposed harmonisation symposium.

2.101 Proposed changes to krill catch limits are shown in Table 3.

Fish resources

Independent stock assessment review

2.102 The Chair of the Scientific Committee presented a summary and a list of recommendations from the 2023 independent review of CCAMLR toothfish assessments (SC-CAMLR-42/02 Rev. 2). As recommended by the Scientific Committee in 2022 (SC-CAMLR-41, paragraph 4.39), and in accordance with Rule 2 of the SC-CAMLR Rules of Procedure, the independent review of CCAMLR toothfish stock assessments was conducted in August 2023 by a panel of three independent reviewers provided by the Centre for Independent Experts (CIE). The review considered the assessments of *Dissostichus eleginoides* in Subareas 48.3 and 48.4, and Division 58.5.2, and *D. mawsoni* in the Ross Sea region. Based on the papers provided and the discussions conducted online with CCAMLR scientists, the independent review panel concluded that the assessments reviewed were consistent with global best practice and constituted the best available science for CCAMLR to make decisions regarding the status and catch limits for these stocks (see WG-FSA-2023, paragraphs 4.47 to 4.51).

2.103 The Scientific Committee thanked the Chair, the CIE independent reviewers, the stock assessments teams, the Secretariat and funding organisations for supporting what was a very valuable process, noting that it required significant time and effort for those involved. The Scientific Committee further noted the panel's recommendations, including on the transition to the use of Casal2 software, the estimation of biological parameters, the generation of fishery-independent data, analyses of parameter trends in space and time, incorporation of environmental and ecosystem parameters, evaluation of biases introduced by interannual spatial patterns in fishing effort and tagging data, undertaking retrospective analyses, exploration of alternative methods for determining recruitment used in projections, investigations of alternative decision rules, and use of Management Strategy Evaluations (MSE).

2.104 The Scientific Committee further noted that the review panel concluded no evidence of statistical trends in biological parameters of toothfish such as size at maturity or size at age were evident in Subarea 48.3. The Scientific Committee also noted that there was no evidence that size or maturity of catches were misrepresented in the assessment models, and the fact that all toothfish fisheries catch a proportion of juvenile fish was accounted for in the estimate of stock status and catch limits and was consistent with CCAMLR decision rules.

2.105 The Scientific Committee recommended that the Commission note the conclusion of the independent review panel that the reviewed 2021 assessments for *D. eleginoides* in Subareas 48.3 and 48.4, and Division 58.5.2, and *D. mawsoni* in the Ross Sea region were consistent with global best practice and constituted the best available science for CCAMLR to estimate status and catch limits in these fisheries.

2.106 The Scientific Committee noted that significant progress has been made to address the recommendations of the 2018 independent review (SC-CAMLR-XXXVII/02 Rev. 1), and that this had been recognised by the 2023 independent review panel. The Scientific Committee also noted that the transition from CASAL to Casal2 was recommended by the 2023 independent review panel, and this work had been completed with this year's assessments (WG-FSA-2023/13, WG-FSA-2023/15 Rev. 1., WG-FSA-2023/17, WG-FSA-2023/18, WG-FSA-2023/26 Rev. 1).

2.107 The Scientific Committee noted the value of continuing to undertake periodic reviews of the assessment methods it uses to generate management advice, as has been undertaken in 2018 (SC-CAMLR-XXXVII/02 Rev. 1) and 2023 (SC-CAMLR-42/02 Rev. 2) for toothfish integrated assessments.

Casal2 stock assessments

2.108 The Scientific Committee endorsed the recommendation that future Casal2 stock assessment reports include a table collating the values to be verified (WG-SAM-2023, Table 9), with Maximum of the Posterior Distribution (MPD) values rounded to the nearest integer and risks rounded to two significant digits, for the purpose of the Secretariat verifications.

2.109 The Scientific Committee noted the need for development of a standard set of diagnostic tools and formats for presentation of model diagnostics in Casal2. It recalled its advice from

WG-SAM-15, paragraphs 2.33 to 2.43, that described a standard set of outputs and diagnostics for CASAL models and agreed that these should be applied and updated for Casal2. The Scientific Committee also noted that Casal2 had advantages over CASAL in that summary plots and diagnostics are more easily generated, which allows the development of more informative summaries.

2.110 The Scientific Committee endorsed the recommendation that integrated stock assessments, irrespective of the assessment model or species, (including those using CASAL and Casal2) include (where relevant) the following:

(i) table of annual cycle with time steps used in the assessment model (WG-SAM-2023, Table 2)

(ii) table of tagging release and recaptures by year

(iii) table of process error weighting

(iv) plot of observations by year and their relative weights (e.g. WG-SAM-2023/10, Figure 1)

(v) table of the MPD likelihood components

(vi) plots of fits to age and length-frequency and abundance data and mean age

(vii) likelihood profiles

(viii) Markov Chain Monte Carlo (MCMC) model convergence diagnostics

(ix) model-derived estimates with MCMC credible intervals for example for selectivity functions, spawning, stock status, year-class strength (YCS), stock biomass projections and risk profiles.

2.111 The Scientific Committee encouraged the development and use of other plots and diagnostics, including:

(i) graphical representation of the MPD likelihood components

(ii) time-at-liberty likelihood profile

(iii) r-hat statistics for MCMC convergence

(iv) projections with constant *F* that give a long-term expected stock biomass of 50% B_0 with a 90% probability of being above 20% B_0

(v) Kobe plot with the 20% and 50% reference points and a target *F* reference point (from (iv) above)

(vi) stacked bar charts of the catch

(vii) retrospective analyses.

2.112 The Scientific Committee noted that the Secretariat has created a private GitHub repository (Casal2_resources) for Casal2 training materials and example R code to aid Members to develop their stock assessment models. The Scientific Committee encouraged Members using Casal2 to use and contribute to this resource, including sharing of code and resources related to paragraphs 2.128 and 2.132.

2.113 The Scientific Committee noted that Members need to ensure that the CCAMLR Data Access Rules are followed when sharing information or undertaking analyses via a GitHub repository and further noted that access to CCAMLR GitHub repository require the approval of the participant's Scientific Committee representative.

2023 integrated toothfish stock assessments

2.114 The Scientific Committee thanked Mr Walker and Mr Dunn for organising four Casal2 workshops held online during the intersessional period and noted the usefulness of these workshops which assisted Members to develop Casal2 assessment models for WG-FSA-2023.

2.115 The Scientific Committee noted that 2023 versions of the integrated stock assessments for toothfish were discussed by WG-FSA specifically in this report in the following sections, *D. eleginoides* in Subareas 48.3 and 48.4 (paragraphs 2.156 to 2.162), and Division 58.5.2 (paragraphs 2.177 to 2.184), and *D. mawsoni* in the Ross Sea region (paragraphs 2.199 to 2.200).

2.116 The Scientific Committee noted the summary provided by WG-FSA on its responses to the recommendations from the independent reviewers in SC-CAMLR-42/02 Rev. 2 and the high priority workplan that WG-FSA has developed (paragraphs 2.117 to 2.127). The Scientific Committee noted that the assessment teams have already started to address these recommendations and welcomed the transitioning of many assessments from CASAL to Casal2 and the production of retrospective analyses in the assessment models presented to WG-FSA (WG-FSA-2023, Table 6).

Work program for addressing issues in the integrated toothfish stock assessments

2.117 The Scientific Committee discussed the effects of spatial distribution of fishing effort and tag-recapture data on abundance and recruitment estimates from stock assessments (WG-FSA-2023, paragraphs 4.53 to 4.59). The Scientific Committee also noted that several of the integrated assessments showed strong trends in the recruitment estimates over time.

2.118 The Scientific Committee noted that during WG-FSA-2023, a 'tagging retrospective analysis' was conducted to evaluate the impact of tagging data on biomass and recruitment estimates in the stock assessment over time. In this analysis, tagging data were incrementally removed year-by-year from the 2023 stock assessments in Subarea 48.3, Division 58.5.1, Division 58.5.2 and the Ross Sea. The results of these analyses are presented for each stock in Figures 1 to 6.

2.119 The Scientific Committee noted that the tagging retrospective analyses suggested changes of biomass and patterns of relative recent recruitment that may reflect the effect of a spatial bias due to changes in the spatial distribution of the fishing effort.

2.120 The Scientific Committee noted that assumptions of future recruitment strongly influence the management advice resulting from the integrated stock assessments.

2.121 The Scientific Committee recommended that further work be undertaken to evaluate biases introduced by interannual spatial patterns (specifically those identified from the tagging retrospective analyses), explore alternative methods for determining recruitment used in projections, and investigate CCAMLR decision rules with MSE (WG-FSA-2023, paragraph 4.58). The Scientific Committee agreed that these were high priority items and should be progressed with urgency over the short term.

2.122 The Scientific Committee noted that although the catch limits are consistent with the CCAMLR decision rules for toothfish, catches in Subarea 48.3 and Division 58.5.2 at the level of the recommended catch limits would be expected to reduce the status of both stocks further below the 50% target in the short term and there is greater uncertainty if the stock would reach the 50% B_0 target at the end of the projection period. However, potential spatial bias in the tagging data and patterns in recent recruitment make the current estimated levels of depletion uncertain. Based on model exploration during the meeting of WG-FSA-2023, the Scientific Committee noted that stock status in 2023 for Subarea 48.3 and Division 58.5.2 may not be as pessimistic, and the recruitment may not have declined as strongly, as estimated by the current stock assessment models, used to calculate catch limits for these stocks.

2.123 The Scientific Committee noted that the effects of spatial bias in tagging data and trends in recruitment, including projected recruitment, within the integrated stock assessments and application of the CCAMLR decision rules for toothfish would potentially have large impacts on the catch advice for future years. As a result, the Scientific Committee recommended that the catch limits in Subarea 48.3, Division 58.5.2 and the Ross Sea region be set on the basis of the current stock assessments for one year while work to address these effects is undertaken.

2.124 The Scientific Committee recommended the following work be conducted, with methods to be presented to WG-SAM-2024 and then conclusions of the research to WG-FSA-2024:

(i) analyses of current and alternative decision rules, including building on the work of WG-FSA-2019/08, WG-SAM-2021/08, SC-CAMLR-38/15 and WG-FSA-2023/28 to investigate alternative rules and assumptions about future recruitment, and addressing the recommendations 6.1 and 6.2 of the report of the independent review (SC-CAMLR-42/02 Rev. 2)

(ii) work towards estimating and correcting for the effect of changing spatial distribution of fishing effort in assessments, including:

(a) an analysis of the spatial and temporal patterns of fishing effort, and tag release and recapture data

(b) localised and stock-based estimates of abundance using Chapman estimators to be included as abundance time series as an alternative to the inclusion of individual tag release and recapture data

(c) sensitivity tests when including alternative time series of tag-recapture information in the Casal2 stock assessments.

2.125 The Scientific Committee noted the commitment of Members undertaking integrated assessments for toothfish to collaboratively address the issues of effects of spatial bias in tagging data and trends in recruitment in the short-term and present results to WG-SAM-2024 and revised stock assessments to WG-FSA-2024.

2.126 The Scientific Committee recommended that the Commission note:

(i) the catch limits in Subarea 48.3, Division 58.5.2 and the Ross Sea should only be applied for the 2023/24 fishing season

(ii) the integrated toothfish stock assessments will be revised to address these issues

(iii) that the application of the current and any proposed revisions to CCAMLR decision rules for toothfish will be evaluated in 2024.

2.127 The Scientific Committee noted that the work program to address this work was ambitious (paragraph 2.124) but recognised the collegial and collaborative nature of the discussions during WG-FSA and noted that the assessment scientists present had already had discussions and initiated work in the margins of the Scientific Committee.

2.128 ASOC noted that this situation with the toothfish assessments is one that requires a stronger precautionary approach. ASOC noted that the Scientific Committee has acknowledged that management advice will be influenced by assumptions about future recruitment (see paragraph 2.120). ASOC considers that if these assumptions are not correct, these could have significant negative impacts on toothfish stocks. ASOC strongly urged SC-CAMLR and its working groups to develop a more concrete understanding of this situation so that appropriate precautionary advice can be developed in accordance with the requirements of the Convention. In ASOC's view, catch limit recommendations should be set at lower levels until there is greater certainty as to the best assumptions to use for future recruitment. The impact of climate change on model assumptions should also be included.

Age determination workshop

2.129 The Scientific Committee noted the report of the Age Determination Workshop (WG-FSA-2023/43 Rev. 1) co-convened by Dr P. Hollyman (UK) and Dr J. Devine (New Zealand) and thanked the Co-conveners for their leadership in preparing for and convening the workshop.

2.130 The Scientific Committee noted that while progress was made against the workshop's terms of reference, a further in-person workshop was required to:

(i) further develop age determination and quality control procedures

(ii) to assess consistency in otolith age interpretation within and between laboratories

(iii) to develop agreed reference sets for the different processing methods across Members.

2.131 The Scientific Committee agreed that a second ageing workshop should be conducted to bring together ageing experts to develop best practice guidelines and reference sets and encouraged all Members undertaking toothfish ageing to participate in the in-person ageing workshop.

2.132 The Scientific Committee noted that when ageing otoliths for the next workshop, laboratories using different preparation methods should coordinate to prepare the sister otoliths from the same individual fish, and estimate ages without knowledge of fish length, area, or other biological characteristics, complete an evaluation of reader comparison for WG-SAM-2024 and conduct statistical analyses such as estimating CVs.

2.133 The Scientific Committee endorsed the following recommendations from the Age Determination Workshop:

(i) All papers that use ageing data include the distribution of the readability scores, add readability scores to inter-reader comparison plots to indicate where potential biases may arise, and standardise reporting methods, such as by creating common scripts to be added to the CCAMLR GitHub or to the e-Group for the Workshop on Age Determination (WG-FSA-2023, Appendix D, paragraph 2.12.5),

(ii) the Scientific Committee re-establish the CCAMLR Otolith Network for Members to exchange knowledge and work together for ageing purposes (WG-FSA-2023, Appendix D, paragraph 2.17.1),

(iii) Members continue to work on age validation methods, particularly for non-toothfish species (WG-FSA-2023, paragraph 4.18(iii)),

(iv) Members create sets of up to 60 high-quality images, including notations (where currently available), for each species they age, beginning with toothfish, which will then be used to build the reference otolith set (WG-FSA-2023, Appendix D, paragraph 7.1.1),

(v) Members submit otolith images for Antarctic and Patagonian toothfish to the Secretariat by 1 March 2024 (WG-FSA-2023, Appendix D, paragraph 7.1.2).

2.134 The Scientific Committee tasked WG-SAM to consider paragraphs 2.12.3 and 2.16.2 in WG-FSA-2023/43 Rev. 1 for inclusion in their workplan in 2024 and give this work a high priority (WG-FSA-2023, Appendix D, Table 3).

2.135 The Scientific Committee supported the second Workshop on Age Determination Methods (WS-ADM2) and endorsed the WS-ADM2 arrangements, objectives and terms of reference (as detailed in WG-FSA-2023, Appendix E). It noted that A$15 000 would be set aside to support travel to the Workshop, with up to A$5 000 available to individual attendees requiring travel support. The Workshop is to be conducted in-person and provide a conveners' report that details the ages agreed by the Workshop for otolith reference sets.

Tagging workshop

2.136 The Scientific Committee noted the report of the Tagging Workshop (SC-CAMLR-42/03), convened by Dr C. Jones (USA) and Mr R. Arangio (Coalition of Legal Toothfish Operators (COLTO)) and thanked the Co-conveners for their leadership in preparing for and convening the workshop.

2.137 The Scientific Committee recommended to set a target tag overlap statistic of 80% while maintaining the current 60% minimum threshold for compliance. Members of vessels achieving between 60 and 80% will be notified by the Secretariat, and those Members shall report to WG-FSA for its review to better understand the issues causing a low tag overlap statistic.

2.138 The Scientific Committee recommended that CM 41-01, Annex C, paragraph 2(i), link to the 'best practice tagging protocol', (WG-FSA-2023, Appendix G), and that CM 41-01, Annex C, paragraph 2(v) remove reference to the 'Year of the Skate' and instead link to the 'best practice tagging protocol' (WG-FSA-2023, Appendix G). The Scientific Committee noted that changes are needed to the observer manual that reference these changes.

2.139 The Scientific Committee recommended the Working Group workplans in 2024 include:

(i) evaluating the method used by vessels in selecting fish to be tagged be recorded in the observer's cruise report (SC-CAMLR-42/03, paragraph 2.6)

(ii) exploring options to improve quality and linking of historical tagging release and recapture data, potentially through a scholarship

(iii) developing fishery- and vessel-specific tag shedding rates to identify vessel crew and observers which can benefit from additional training.

2.140 The Scientific Committee noted that the Secretariat will work with French scientists to progress work on conversion factors that could clarify recommendations to other Members who need to improve data collection methods for their vessel operations. The Secretariat will further develop a paper for WG-FSA-2024 on an implementation strategy based on the recommendations made by Members.

2.141 The Scientific Committee endorsed the recommendation that, consistent with advice (SC-CAMLR-41, paragraph 3.121) the Secretariat undertake to:

(i) use the calculation which scales the length distribution of the retained fish based on the number of fish caught for the calculation of tag-overlap statistics (WG-SAM-2023/18),

(ii) utilise tag-overlap statistics calculated using this method for Fishery Reports and the CCEP,

(iii) develop a publicly available R package for working with CCAMLR data extracts, including the calculation of the tag-overlap statistic,

(iv) propose modifications to CM 41-01, Annex C, footnote 3, to further clarify the tag overlap statistic calculation method,

(v) add a column in ‘Biologicals’ in order to specify if individual fish were part of a random sampled or not.

Data collection forms and instructions

2.142 The Scientific Committee recommended the replacement of CE reporting in the longline fishery with submission of the C2 form if the reporting period was every 5 days or greater, given that there is some duplication between the CE and C1 or C2 forms and requested the Secretariat identify the linked CM changes and any substantive issues in doing so intersessionally to enable implementation.

2.143 The Scientific Committee noted it would be useful to convene a trawl fisheries data workshop to discuss the revisions to the C1 form including the potential replacement of CE reporting in the krill fishery with submission of the C1 form. It encouraged Members and ARK to work together in the intersessional period to develop a proposal for such a workshop for consideration by the Scientific Committee in 2024.

2.144 The Scientific Committee recommended the B2 form be removed because all fisheries now have 100% observer coverage (making this form redundant) and noted the proposal to retire CM 23-05, which governs the submission of this form (CCAMLR-42/12).

Finfish research proposals

2.145 CCAMLR-42/21 presented a proposal to add a new Annex to CM 21-02 for finfish research proposals for exploratory fisheries. To reflect the potential substantial differences between research plans for exploratory toothfish fisheries under CM 21-02 and scientific research exemptions under CM 24-01, each measure should use its own Annex. Accordingly, a new Annex is proposed for CM 21-02, specifying the requirements for research plans under CM 21-02, paragraph 6(iii).

2.146 The Scientific Committee recommended that the Commission adopt the following:

(i) a new Annex to CM 21-02, specifying the requirements for finfish research plans under CM 21-02, paragraph 6(iii) (Attachment A)

(ii) amend the title of CM 24-01, Annex 24-01/A, Format 2 to remove the reference to CM 21-02 (Attachment B).

Status, trends and general issues

Provisional trend analysis for research blocks in data-limited toothfish fisheries

2.147 The Scientific Committee noted the value of the updated CPUE-by seabed area biomass estimation to reflect the update to the general bathymetric chart of the Oceans (GEBCO) dataset (WG-SAM-2023/16).

2.148 The Scientific Committee noted a new modelling approach using an agent-based modelling framework to support MSEs for the CCAMLR trend analysis and potential alternative data-limited approaches for managing toothfish fisheries under research plans. It welcomed further development of such approaches, to assist with addressing the high priority issues noted above for integrated assessments, and evaluating the likelihood that SC-CAMLR advice is consistent with Article II of the Convention.

Effects of climate change on stock assessment advice

2.149 The Scientific Committee highlighted the example provided in WG-FSA-2023, Table 5, based on the available information for the Antarctic toothfish stock assessment for the Ross Sea region for a summary of evidence for changes in stock assessment parameters or processes that could be due to the effects of environmental variability or climate change. The Scientific Committee recommended the development of this type of summary for all fisheries.

Statistical Area 48

2.150 SC-CAMLR-42/15 Rev. 1 and SC-CAMLR-42/BG/23 presented a preliminary description of the results obtained during a research campaign carried out aboard the vessel *Víctor Angelescu* (Argentina) in Statistical Subarea 48.3 during March 2023. The main objectives of the campaign were to estimate the relative abundances and spatial distributions of *Champsocephalus gunnari* and juvenile of *D. eleginoides* as well as to analyse the maturation condition of *C. gunnari* and estimate its fecundity. The reports document that, among the bony fishes, *Notothenia rossii* and *C. gunnari* were the species with the highest weight caught, while *Notothenia gibberifrons* was found in all hauls. The low catch of Patagonian toothfish was attributed to poor weather and complex bathymetry. Additional data on various environmental and oceanographic variables were collected, including hydroacoustics, oceanographic sampling to study different biogeochemical parameters, zooplankton, microplastics, ichthyoplankton and benthos. Final results from the research survey will be presented to the relevant working groups next year and Argentina aims to carry out a new scientific cruise in the future.

2.151 The Scientific Committee thanked Argentina for the reports from their research survey and noted discussions from WG-FSA (WG-FSA-2023, paragraphs 4.74 to 4.79). The Scientific Committee encouraged Argentina to present the final results to the relevant working groups.

Mackerel icefish (*C. gunnari*) in Subarea 48.2

2.152 The Scientific Committee noted that WG-ASAM (WG-ASAM-2023, paragraphs 7.1 to 7.4), WG-SAM (WG-SAM-2023, paragraphs 9.1 to 9.5) and WG-FSA (WG-FSA-2023, paragraphs 4.80 to 4.83) discussed a proposal from Ukraine to conduct an acoustic trawl survey of *C. gunnari* in Subarea 48.2. It was further noted the research would not be undertaken in the 2023/24 season and that the research plan will be resubmitted next year.

Mackerel icefish (*C. gunnari*) in Subarea 48.3

2.153 The fishery for mackerel icefish (*C. gunnari*) in Subarea 48.3 operated in accordance with CM 42-01 and associated measures. In 2022/23, the catch limit for *C. gunnari* was 1 708 tonnes (WG-FSA-2023, paragraph 4.66). Details of this fishery and the stock assessment of *C. gunnari* are contained in the Fishery Report (https://fisheryreports.ccamlr.org/).

2.154 The Scientific Committee noted the results of a bottom trawl survey in Subarea 48.3 conducted by the UK in February 2023, with a mean biomass of *C. gunnari* estimated at 61 567 tonnes (WG-FSA-2023, paragraph 4.68).

2.155 The Scientific Committee noted the updated stock assessment for *C. gunnari* in Subarea 48.3 used the biomass estimate from the UK survey (WG-FSA-2023, paragraph 4.70) and endorsed the recommendation of WG-FSA that the catch limits should be set at 5 138 tonnes for the 2023/24 season and 3 579 tonnes for the 2024/25 season.

Toothfish

Toothfish (*Dissostichus* spp.) in Subarea 48.2

2.156 The Scientific Committee noted discussion on a Chilean proposal to undertake research on *Dissostichus* spp. under CM 24-01 in Subarea 48.2 during the 2023/24 and 2025/26 seasons (WG-FSA-2023, paragraphs 4.114 to 4.124) and endorsed the recommendation that a revised research plan be presented at WG-SAM-2024 (WG-FSA-2023, paragraph 4.125).

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

2.157 The catch of *D. eleginoides* in Subarea 48.3 in 2022/23 was 1 615 tonnes. Details of the fishery for *D. eleginoides* in Subarea 48.3 and the stock assessment are contained in the Fishery Report (https://fisheryreports.ccamlr.org/).

2.158 The Scientific Committee noted the discussions at WG-FSA-2023 on the updated stock assessment for *D. eleginoides* in Subarea 48.3 (WG-FSA-2023, paragraphs 4.85 to 4.97). Model sensitivity runs during WG-FSA-2023 suggested that the observed trends in estimated spawning biomass and recruitment from the tagging retrospective analysis (paragraphs 2.108 to 2.113, Figures 1 and 2) may be explained by an increasing spatial concentration of tagging data which would result in smaller biomass estimates in recent times compared to relatively large biomass estimates from earlier years. Based on these analyses, the Scientific Committee noted that the stock status in 2023 may not be as pessimistic and the estimated recruitment may not have declined as strongly as that predicted by the stock assessment model presented in WG-FSA-2023/15 Rev. 1 (WG-FSA-2023, Figure 3).

2.159 The Scientific Committee agreed that the workplan (WG-FSA-2023, paragraphs 4.53 to 4.58) to evaluate biases introduced by interannual spatial patterns (specifically those identified from the tagging retrospective analyses), exploration of alternative methods for determining recruitment used in projections, investigations of CCAMLR decision rules with MSE were high priority items and should be progressed with urgency over the short term for *D. eleginoides* in Subarea 48.3

2.160 The Scientific Committee noted that the updated stock assessment for *D. eleginoides* in Subarea 48.3 presented in WG-FSA-2023/15 Rev. 1 proposed a catch limit set at 2 000 tonnes for 2023/24 and 2024/25.

2.161 The Scientific Committee recalled that the effects of spatial bias in tagging data and trends in recruitment, including projected recruitment, within the integrated stock assessments and application of the CCAMLR decision rules for toothfish would potentially have large impacts on the catch advice for future years. As a result, the Scientific Committee recommended that the catch limits be set on the basis of the current stock assessments for one year while work to address these effects is undertaken (paragraphs 2.117 to 2.128).

Patagonian toothfish (*D. eleginoides*) in Subarea 48.4

2.162 The fishery for *D. eleginoides* in Subarea 48.4 operated in accordance with CM 41-03 and associated measures. The catch limit for *D. eleginoides* in Subarea 48.4 in 2022/23 was 23 tonnes. Details of the fishery for *D. eleginoides* in Subarea 48.4 and the stock assessment are contained in the Fishery Report (https://fisheryreports.ccamlr.org/).

2.163 The Scientific Committee noted WG-FSA-2023, paragraphs 4.99 to 4.105, describing the updated stock assessment for *D. eleginoides* in Subarea 48.4, and that a catch limit for *D. eleginoides* in Subarea 48.4 set at 19 tonnes for the 2023/24 and 2024/25 seasons was based on the outcome of this assessment.

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

2.164 The fishery for *D. mawsoni* in Subarea 48.4 operated in accordance with CM 41-03 and associated measures. The catch limit for *D. mawsoni* in Subarea 48.4 in 2022/23 was 42 tonnes. Details of the fishery for *D. mawsoni* in Subarea 48.4 and the stock assessment are contained in the Fishery Report (https://fisheryreports.ccamlr.org/).

2.165 The Scientific Committee noted the recommendation from WG-FSA-2023, paragraphs 4.108 to 4.110 that the catch limit for *D. mawsoni* in Subarea 48.4 be set at 43 tonnes for the 2023/24 season based on the precautionary harvest rate and an updated estimate of local biomass.

Antarctic toothfish (*D. mawsoni*) in Subarea 48.6

2.166 The Scientific Committee noted an update to efforts involved in the research plan pertaining to Subarea 48.6 in 2021/22–2023/24 under CM 21-02, paragraph 6(iii), with revised catch allocations between vessels undertaking the plan to ensure that the same amount of research would be achieved (WG-SAM-2023/01 Rev. 1).

2.167 The Scientific Committee endorsed the recommendations of WG-FSA to continue the research fishing in Subarea 48.6 according to the research proposal in WG-SAM-2023/01 Rev. 1 (WG-FSA-2023, paragraph 4.128) and set catch limits for the research blocks in Subarea 48.6 for the 2023/24 season based on the updated trend analysis (Table 4, WG-FSA-2023, paragraph 4.129).

Advice to the Commission

Mackerel icefish (*C. gunnari*) in Subarea 48.3

2.168 The Scientific Committee recommended that the catch limit for *C. gunnari* in Subarea 48.3 should be set at 5 138 tonnes for the 2023/24 season and 3 579 tonnes for the 2024/25 season based on an updated stock assessment (WG-FSA-2023, paragraph 4.70).

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

2.169 The Scientific Committee recommended that the catch limit for *D. eleginoides* in Subarea 48.3 be set at 2 000 tonnes for the 2023/24 season based on an updated stock assessment (WG-FSA-2023, paragraphs 4.85 to 4.95).

2.170 The Scientific Committee recommended that a revised stock assessment for Subarea 48.3 addressing the issues identified in the workplan (WG-FSA-2023, paragraphs 4.53 to 4.59) be provided to WG-FSA in 2024.

Patagonian toothfish (*D. eleginoides*) in Subarea 48.4

2.171 The Scientific Committee recommended that the catch limit for *D. eleginoides* in Subarea 48.4 be set at 19 tonnes for the 2023/24 and 2024/25 seasons based on an updated stock assessment (WG-FSA-2023, paragraphs 4.99 to 4.105).

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

2.172 The Scientific Committee recommended that the catch limit for *D. mawsoni* in Subarea 48.4 be set at 43 tonnes for the 2023/24 season based on an updated estimate of local biomass and precautionary harvest rate (WG-FSA-2023, paragraphs 4.108 to 4.110).

Antarctic toothfish (*D. mawsoni*) in Subarea 48.6

2.173 The Scientific Committee recommended continuing the research fishing in Subarea 48.6 according to the research proposal in WG-SAM-2023/01 Rev. 1.

2.174 The Scientific Committee recommended that the catch limits for the research blocks Subarea 48.6 for the 2023/24 season be based on the updated trend analysis (Table 4) and set at 148 tonnes in research block 486_2, 42 tonnes in research block 486_3, 126 tonnes in research block 486_4, and 202 tonnes in research block 486_5.

Statistical Area 58

Mackerel icefish (*C. gunnari*) in Division 58.5.2

2.175 The fishery for *C. gunnari* in Division 58.5.2 operated in accordance with CM 42-02 and associated measures. In 2022/23, the catch limit for *C. gunnari* was 2 616 tonnes. Details of this fishery and the stock assessment of *C. gunnari* are contained in the Fishery Report (https://fisheryreports.ccamlr.org).

2.176 The Scientific Committee noted that WG-FSA reviewed a preliminary assessment of *C. gunnari* in Division 58.5.2 (WG-FSA-2023/10) that was based on the results of the trawl survey described in WG-FSA-2023/49. Bootstrapped biomass estimates had a mean of 16 127 tonnes, with a one sided lower 95% confidence bound of 10 092 tonnes, mainly comprised fish of age 3+. Projecting forward, the proportion of the one-sided lower 95th confidence bound of fish aged 1+ to 3+ (4 631 tonnes) gave yields of 714 tonnes for 2023/24 and 599 tonnes for 2024/25 that allow for 75% escapement and therefore satisfy the CCAMLR decision rules.

Advice to the Commission

2.177 The Scientific Committee recommended that the catch limit for *C. gunnari* in Division 58.5.2 should be set at 714 tonnes for 2023/24 and 599 tonnes for 2024/25 seasons.

Patagonian toothfish (*D. eleginoides*) in Division 58.5.2

2.178 The fishery for *D. eleginoides* in Division 58.5.2 operated in accordance with CM 41-08 and associated measures. Details of the fishery and the stock assessment are contained in the Fishery Report (https://fisheryreports.ccamlr.org/).

2.179 The Scientific Committee noted the discussions at WG-FSA-2023 on the updated stock assessment for *D. eleginoides* in Division 58.5.2 (WG-FSA-2023, paragraphs 4.149 to 4.158). The Scientific Committee also noted model sensitivity runs which were conducted during WG-FSA-2023 and suggested that the observed trends in estimated spawning biomass and recruitment by the tagging retrospective analysis may be explained by an increasing spatial concentration of tagging data which would result in much smaller biomass estimates in recent times compared to relatively large biomass estimates from earlier years. Based on these analyses, the Scientific Committee noted that the stock status in 2023 may not be as pessimistic, and the estimated recruitment may not have declined as strongly as that predicted by the stock assessment model presented in WG-FSA-2023/26 Rev. 1 (Figures 4 and 5).

2.180 The Scientific Committee agreed that the workplan in WG-FSA-2023, paragraphs 4.53 to 4.59 to evaluate biases introduced by interannual spatial patterns (specifically those identified from the tagging retrospective analyses), exploration of alternative methods for determining recruitment used in projections, and investigations of CCAMLR decision rules with MSE were high priority items and should be progressed with urgency over the short term for *D. eleginoides* in Division 58.5.2.

2.181 The Scientific Committee noted that the updated stock assessment presented in WG-FSA-2023/26 Rev. 1 estimated that a catch limit for *D. eleginoides* in Division 58.5.2, of 2 660 tonnes for 2023/24 and 2024/25.

Advice to the Commission

2.182 The Scientific Committee recalled that the effects of spatial bias in tagging data and trends in recruitment, including projected recruitment, within the integrated stock assessments and application of the CCAMLR decision rules for toothfish would potentially have large impacts on the catch advice for future years. As a result, the Scientific Committee recommended that the catch limits be set on the basis of the current stock assessments for one year while work to address these effects is undertaken (see paragraphs 2.122 to 2.126).

2.183 The Scientific Committee recommended that the catch limit for *D. eleginoides* in Division 58.5.2 be set at 2 660 tonnes for the 2023/24 season.

2.184 The Scientific Committee recommended that a revised stock assessment addressing the issues identified in the workplan (WG-FSA-2023, paragraphs 4.53 to 4.59) be provided in 2024.

2.185 No new information was available on the state of fish stocks in Division 58.5.2 outside areas of national jurisdiction. Therefore, the Scientific Committee recommended that the prohibition of directed fishing for *D. eleginoides*, described in CM 32-02, remain in force in 2023/24.

Patagonian toothfish (*D. eleginoides*) in Division 58.5.1

2.186 The fishery for *D. eleginoides* in Division 58.5.1 is conducted in the French Exclusive Economic Zone (EEZ) of the Kerguelen Islands. Details of the fishery and the stock assessment are contained in the Fishery Report (https://fisheryreports.ccamlr.org).

2.187 The Scientific Committee welcomed the ongoing development of the stock assessment of *D. eleginoides* in Division 58.5.1. It noted that the catch limit of 5 020 tonnes for 2023/24 that accounts for depredation was consistent with the CCAMLR decision rules (WG-FSA-2023, paragraph 4.142).

Advice to the Commission

2.188 No new information was available on the state of fish stocks in Division 58.5.1 outside areas of national jurisdiction. The Scientific Committee, therefore, recommended that the prohibition of directed fishing for *D. eleginoides*, described in CM 32-02, remain in force in 2023/24.

Patagonian toothfish (*D. eleginoides*) in Subarea 58.6

2.189 The fishery for *D. eleginoides* at Crozet Islands is conducted within the French EEZ and includes parts of Subarea 58.6 and Area 51 outside the Convention Area. Details of this fishery and the stock assessment are contained in the Fishery Report (https://fisheryreports.ccamlr.org/).

2.190 The Scientific Committee agreed that a catch limit of 930 tonnes (which represents a total removal of 1 352 tonnes, including depredation and catches on Del Cano Rise in the Southern Indian Ocean Fisheries Agreement (SIOFA) Area) for *D. eleginoides* in Subarea 58.6 for 2023/24 was consistent with CCAMLR's decision rules.

Advice to the Commission

2.191 No new information was available on the state of fish stocks in Subarea 58.6 outside areas of national jurisdiction. Therefore, the Scientific Committee recommended that the prohibition of directed fishing for *D. eleginoides,* described in CM 32-02, remain in force in 2023/24.

Antarctic toothfish (*D. mawsoni*) in Divisions 58.4.1 and 58.4.2

2.192 The Scientific Committee noted the research plan by Australia, France, Japan, the Republic of Korea, and Spain to continue research in the exploratory fishery for *D. mawsoni* in Divisions 58.4.1 and 58.4.2 (WG-SAM-2023/03).

2.193 The Scientific Committee noted that this research plan for Division 58.4.1 was evaluated by WG-FSA-2023, while the research plan for Division 58.4.2 had been agreed in 2022 and therefore did not need to be evaluated by WG-FSA-2023.

Advice to the Commission

2.194 The Scientific Committee recommended the research proposal as detailed in WG-SAM-2023/03 for Division 58.4.1 proceed.

2.195 The Scientific Committee 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 4.

Statistical Area 88

Antarctic toothfish (*D. mawsoni*)

2.196 CCAMLR-42/34 presented a proposal to clarify CM 41-01 by revising paragraph 2 of Annex B to accommodate research plans under CM 24-01 and CM 24-05 that propose to use gear configurations other than those on which paragraph 5 of CM 41-01 (2022) Annex B was initially based. The authors noted that the immediate issue had been clarified by the Secretariat and that the clarification may also apply to exploratory fisheries regulated under other conservation measures.

2.197 The Scientific Committee noted that there may be beneficial scientific reasons for the use of alternative configurations of gear, based on the objectives of the research and the research plan and recommended this proposal for modification of CM 41-01 to the Commission.

Subarea 88.1

2.198 The Scientific Committee noted that WG-FSA-2023/09 had presented the results from the 2023 Ross Sea shelf survey (RSSS). While the estimated relative biomass index of toothfish in 2023 was one of the lowest of the series, the length distribution was similar to previous years. The Scientific Committee noted that the low abundance estimated by the survey was not likely to represent lower recruitment and may be the effect of late timing of the survey. Biological data and samples were collected from 1 662 toothfish; samples and measurements were also collected on by-catch species, and the environment. A total of 155 toothfish were tagged and released with a 92% tag overlap statistic; no tagged fish were recaptured. The catch limit of 99 tonnes was not exceeded, as catches in all strata were lower than the previous years.

2.199 The Scientific Committee recommended the continuation of the research proposal for Ross Sea shelf survey (WG-SAM-2023/02) and noted that the survey was an important monitoring tool in the Ross Sea region MPA and provided standardised information on abundance and age structure for use in the stock assessment, as well as for improving understanding of the ecosystem in the area. The Scientific Committee noted that the Ross Sea shelf survey has a catch limit as agreed in SC-CAMLR-41 (SC-CAMLR 41, paragraph 3.138):

(i) 2023/24: 69 tonnes (including the core strata and the McMurdo Sound stratum)

(ii) 2024/25: 99 tonnes (including the core strata and the Terra Nova Bay stratum).

2.200 The Scientific Committee welcomed the updated stock assessment presented in WG-FSA-2023/13 for the Ross Sea in Subarea 88.1 and small-scale research units (SSRUs) 882A–B and noted the model sensitivity runs during WG-FSA-2023 using the tag data retrospectives. The Scientific Committee noted that MPDs of the retrospective runs with tagging data excluded year-by-year back to 2013 showed that there was only a small amount of change attributable to spatial bias from the tag data, with patterns of SSB, percent SSB, recruits, and year class strength showing very similar values between the retrospectives from 2013 to 2023 (Figure 6).

2.201 The Scientific Committee noted that although the effects of spatial bias were not so apparent in the Ross Sea fishery, there may still be the potential for spatial bias in the tag data and assumptions about future recruitment in the assessment to impact management advice.

Subarea 88.2

2.202 The Scientific Committee noted that WG-FSA-2023/62 presented a characterisation of the fishing and tagging programme in the Amundsen Sea Region. It highlighted that there was an increase in the number of recaptures of tagged toothfish within the four research blocks. However, data on recaptured fish were limited due to an uneven distribution of fishing effort on the seamounts in SSRU 882H.

2.203 The Scientific Committee noted that although fishing in SSRU 882H had extended to an additional seamount in the last year, effort was still concentrated on only two seamounts. The Scientific Committee recommended that further information was needed across this SSRU and recommended that the requirement in CM 41-10, paragraph 12, to spatially spread effort continue for at least two more seasons, pending updated assessment being presented to WG-FSA, and advice from the Scientific Committee.

Subarea 88.3

2.204 The Scientific Committee noted that WG-FSA-2023/20 Rev. 1 presented an updated research plan for Subarea 88.3. The combined vessel research plan, which began in 2021/22, proposed to continue the research on *Dissostichus* spp. in Subarea 88.3 in 2023/24.

2.205 The Scientific Committee noted that the research had made much progress, and that the research plan made no significant changes to that which had previously been agreed.

Advice to the Commission

2.206 The Scientific Committee recommended that the catch limit for the Ross Sea region (Subarea 88.1 and SSRUs 882A–B) be set at 3 499 tonnes for the 2023/24 season, with 69 tonnes allocated for the Ross Sea shelf survey in 2023/24 based on the outcome of the assessment.

2.207 The Scientific Committee noted that Method 1 in Table 5 for allocating of catch for the Ross Sea shelf survey was consistent with the requirements of CM 91-05 (noting that the catch split defined in CM 91-05, paragraph 28, only applied for the 2017/18, 2018/19 and 2019/20 seasons) and allocated 15% of the total catch limit to the Special Research Zone (SRZ) (CM 91-05, paragraph 8).

2.208 The Scientific Committee recommended that the values given as Method 1 in Table 5 be used to update the catch limits in the Ross Sea region for the 2023/24 year.

2.209 The Scientific Committee requested that a revised stock assessment addressing the issues identified in the workplan (WG-FSA-2023, paragraphs 4.53 to 4.59) be provided to WG-FSA in 2024.

2.210 The Scientific Committee recommended that the existing measures in CM 41-10, paragraph 12 to spread effort in SSRU 882H remain in place for a further two seasons to allow for further evaluation of their effectiveness.

2.211 The Scientific Committee recommended that the catch limits for Subarea 88.2 SSRUs 882C–H be based on the trend analysis as shown in Table 4.

2.212 The Scientific Committee recommended continuing the research in Subarea 88.3 outlined in WG-FSA-2023/20 Rev. 1 for the 2023/24 season.

2.213 The Scientific Committee recommended that the catch limits for Subarea 88.3 be based on the trend analysis as shown in Table 4.

Non-target catch and ecosystem impacts of fishing operations

Fish and invertebrate by-catch

3.1 The Scientific Committee noted the discussions on the management of *macrourid* by-catch at WG-FSA-2023 (WG-FSA-2023, paragraphs 5.15 to 5.34), including the implementation of by-catch rules, the fishing cessation rule in CM 41-09 and on the identification of macrourids.

3.2 The Scientific Committee recommended maintaining the current fishing cessation rule for Subarea 88.1 at the scale of SSRU, as specified in CM 41-09, paragraph 6, and the removal of CM 33-03, paragraph 6 (WG-FSA-2023, paragraphs 5.25 and 5.27).

3.3 The Scientific Committee welcomed the work on estimating biomass of macrourids (WG-FSA-2023, paragraph 5.28) and noted that additional work to determine appropriate approaches for setting catch limits in the different management areas of the Ross Sea region will be developed. The Scientific Committee also noted that the timeseries of biomass surveys in the Ross Sea region could be analysed to evaluate the impact of the introduction of the Ross Sea region MPA (RSRMPA) on *macrourid* abundance.

3.4 Noting the three different methods of biomass estimation for macrourids in the Ross Sea region outlined in WG-FSA-2023/27, the Scientific Committee recommended using the constant density biomass estimate to develop future management advice (WG-FSA-2023, paragraph 5.17).

3.5 The Scientific Committee recommended further work to evaluate the choice of the escapement level in applying the CCAMLR decision rules for macrourids and noted that there were differing views on the appropriate choice of either 50% or 75% escapement for calculating the γ for macrourids (WG-FSA-2023, paragraph 5.20).

3.6 The Scientific Committee recommended that the current catch limits for macrourids in Subarea 88.1 remain unchanged, acknowledging that this is considered precautionary based on the work that has been carried out (WG-FSA-2023, paragraph 5.22).

3.7 The Scientific Committee noted the WG-FSA discussion of the progress made on the identification of macrourids using molecular analysis. The Scientific Committee acknowledged the recommendation of WG-FSA that a likelihood or Bayesian approach could be considered to progress the molecular analysis, and that as there is currently no phylogeny based on nuclear markers for Antarctic macrourids to assist in the analysis of mitochondrial marker datasets, this could be an important avenue for future research. The Scientific Committee also noted the suggestion that otolith shape morphology might assist with refining the differentiation between these two species taking account of the impact of allometry (WG-FSA-23, paragraph 5.3).

3.8 The Scientific Committee noted the discussion at WG-FSA on shark and skate by-catch (WG-FSA-2023, paragraphs 5.35 to 5.50), noting that skates are vulnerable to overfishing, that it was useful to see the work on skate by-catch continuing. The Scientific Committee noted that development of qualitative and quantitative risk assessments for sharks and skates are useful to determine the impacts of the shark and skate by-catch and encouraged further work by Members across CCAMLR to evaluate status and trends in skates and update advice on conservation measures for these taxa.

3.9 The Scientific Committee recommended that skate injury codes be incorporated into the observer logbooks and C2 forms for the 2024/25 season on the tag release, tag recapture and biological data collection sheets, including allowing multiple injury codes to be recorded for each skate (WG-FSA-2023, paragraph 2.21).

3.10 ASOC noted that they support the advice of the WG-FSA to reinstate the fields to record skate injury codes and to allow the recording of multiple injuries. ASOC also noted that the WG-FSA report (WG-FSA-2023, paragraph 5.46) indicates that current estimates of an acceptable exploitation rate for skates are based on parameters that are currently supported by limited data. ASOC further noted that under Article II of the Convention, fisheries are only supposed to take place if they do not have an impact on the broader ecosystem, and as such it is very important to obtain better information on skates to eliminate any uncertainty about the fishery's compliance with this requirement.

3.11 The Scientific Committee noted the discussion on fish by-catch in the krill fishery (WG-FSA-2023, paragraphs 5.1 to 5.14) and recommended that the Secretariat include figures of estimated observer-derived fish by-catch by species in the krill fishery report.

3.12 The Scientific Committee noted the discussion on the cohort progression of *C. gunnari* in Subarea 48.2 (WG-FSA-2023, paragraphs 5.13 and 5.14) and that the short life span of this species may result in periodic pulses of high by-catch rates until the next large recruitment event in this area. The Scientific Committee noted that the detection of a large cohort of young icefish may be used to predict large catches of older fish in subsequent seasons.

3.13 The Scientific Committee noted that the selectivity of by-catch species in the krill fishery may depend on vessel's gear configuration, fishing location, season and fishing strategy, and that future research on evaluating the effect of gear selectivity on length frequency distributions would be beneficial. A UK funded project studying by-catch in the krill fishery

(WG-FSA-2023, paragraph 5.16) was noted and the Scientific Committee encouraged members to collaborate with the principal investigator Dr Hollyman in this project.

Incidental mortality of seabirds and marine mammals associated with fisheries

3.14 The Working Group on Incidental Mortality Associated with Fishing (WG-IMAF-2023) was held in Hobart, Australia, from 5 to 10 October 2023.

3.15 Thirty-six participants registered for the meeting, including the invited experts Dr I. Debski (ACAP), Dr M. Double (ACAP), Mr B. Milic (COLTO), Mr R. Arangio (COLTO), Dr J. Arata (ARK) and Dr I. Staniland (IWC), some of whom attended online and some in person.

Review of incidental mortality in CCAMLR fisheries

3.16 The Scientific Committee noted that the Working Group addressed a range of aspects of incidental mortality requiring attention, including cryptic mortality, the need of accounting for spatial and temporal stratification in estimating interactions with seabird and marine mammals, conducting risks analysis at a smaller scale and possible estimation biases in warp strike rates caused by the concentration of observations in high-risk periods or observations focused on one warp cable. Seabird strikes on net monitoring and warp cables were discussed, as well as marine mammal interaction and mitigation measures.

3.17 The Scientific Committee noted that the total per-vessel-cruise extrapolated figures for seabird mortality in longline fisheries was 132 seabirds caught as of 2 October 2023, higher than the 15 recorded in 2022, but lower than the 142 in 2021. Twelve elephant seals and one unidentified seal were recorded as marine mammal incidental mortalities in longline fisheries. WG-IMAF-2023/03 Rev. 1 provided more detail on incidental mortalities and warp strikes in fisheries in the Convention Area.

3.18 The Scientific Committee recommended that the Secretariat: (i) continue summarising data at spatial scale of 40 000 km^2 cells, (ii) not apply an extrapolation approach from observation periods for cetacean mortalities given that such events are unlikely to be un-noticed even if occurring outside of an observation period, and (iii) clearly define the unit of observation effort to undertake extrapolations.

3.19 The Scientific Committee noted the low level of warp strikes recorded for conventional trawlers in recent years. Given that warp strikes are observed on continuous trawling vessels, it encouraged members to investigate as to whether this results from effective avoidance of warp strikes due to the mode of fishing or errors in the way observations have been recorded. It noted that as warp strike severity will be recorded by observers from the fishing season 2024, this may further clarify this matter.

3.20 The Scientific Committee requested the Secretariat include warp strikes estimates categorised by severity in future papers. The Scientific Committee recommended that future versions of extrapolations should include estimates of uncertainty and encouraged members to submit papers to WG-SAM on undertaking approaches to estimate uncertainty to inform the development of advice.

3.21 The Scientific Committee noted the WG-IMAF paper WG-IMAF-2023/15 analysing the interaction between Antarctic fur seals and krill trawling gear. The paper noted that fur seal behaviour appears to be dependent on the vertical distribution of the krill swarm and level of krill recruitment. The Scientific Committee also noted the brief discussion on potential move-on rules for vessels and that the design and implementation of such rules could be complex.

Incidental mortality and risk assessments of marine mammals in CCAMLR fisheries

3.22 The Scientific Committee noted the decline of the subpopulation of Antarctic fur seals at the South Shetland Islands (WG-IMAF-2023/15). It noted that the decline is attributed largely to predation by leopard seals, but resource competition and potential incidental mortality in krill fisheries were also considered threats.

3.23 The Scientific Committee discussed the potential implementation of a temporary krill fishing time-area closure to minimise overlap with juvenile fur seals from the South Shetland Islands. The Scientific Committee noted that there is very little fishing in the proposed closed area, therefore this would not be complex to implement from the fisheries management side. However, concerns were expressed regarding the large size of the area, the potential consequential concentration of fishing effort in other areas and that the closure should be considered in the harmonisation of krill fishery management in Subarea 48.1 / D1MPA proposal. The Scientific Committee did not reach consensus on the proposal and requested that Members work together in the intersessional period to refine a proposal to ensure harvesting does not significantly increase the risk that this subpopulation of fur seals declines irreversibly.

Mitigation methods for marine mammals

3.24 The Scientific Committee welcomed the development of the CCAMLR gear library by the Secretariat for collating detailed information on fishing gear configuration, including marine mammal exclusion devices (WG-FSA-2023/72). The Scientific Committee noted that additional information in the C1 form would be useful to define and link net configurations and marine mammal excluder devices to the trawl nets used for a particular fishing event and requested the Secretariat prepare a paper for consideration at a future meeting.

3.25 The Scientific Committee noted that although a marine mammal exclusion device is a mandatory requirement in CCAMLR fisheries (CM 51-01, paragraph 7), there is no specification of what constitutes such a device.

3.26 The Scientific Committee noted WG-IMAF discussed a list of data fields to specify marine mammal exclusion devices (SC-CAMLR-42/16 Rev. 1, Appendix D) and requested that the proposed trawl vessel workshop (SC-CAMLR-41, Table 1) consider these fields for inclusion in vessel notifications or a revised C1 form.

3.27 The Scientific Committee noted the importance of appropriate mitigation measures for both seals and cetaceans, acknowledging the detail available on exclusion devices used across the fleet is variable.

3.28 The Scientific Committee recommended that cetacean exclusion devices and seal exclusion devices be described in separate sections within the Fishery Notification, as they represent two distinct mitigation measures. The Scientific Committee recommended that Members provide detail of any exclusion devices they are using, including an overall diagram of the exclusion devices for seals and cetaceans in situ and diagrams that show the detail of each device, e.g. mesh size, location of escape holes, etc. The Scientific Committee also recommended that this information is included in the CCAMLR gear library.

3.29 The Scientific Committee noted the review of the use of cetacean mitigation devices on Norwegian continuous krill trawl vessels. The Scientific Committee welcomed the report of no mortalities reported during the 2023 season and no observations of marine mammals contacting trawls.

3.30 The Scientific Committee encouraged Members to develop systems such as underwater cameras, stretch sensors and acoustic systems to detect cetaceans, and encouraged further research into the behaviour of cetaceans around krill trawl operations.

Seabird incidental mortality

3.31 The Scientific Committee welcomed a global seabird-fisheries overlap analysis conducted on nine ACAP Priority Populations, of which seven overlap with the Convention Area, recognising that continued efforts to minimise seabird incidental mortality should remain a high priority as even low levels of incidental mortality of the affected species can result in population declines.

3.32 The Scientific Committee recommended: (i) improving engagement and coordination among Members and with ACAP Parties, and (ii) emphasising CCAMLR’s performance history at relevant regional fisheries meetings given that CCAMLR’s seabird incidental mortality mitigation efforts in demersal longline fisheries are an exemplar of best practice and of what can be achieved.

Seabird incidental mortality and risk assessments in CCAMLR fisheries

3.33 The Scientific Committee recognised the significant amount of work undertaken by WG-IMAF at its recent meetings, noting the importance of improved understanding of seabird interactions with trawl vessels (including estimates of bird strikes and mortality) and the necessary methods to mitigate such interactions and incidental mortality.

3.34 The Scientific Committee noted examples from other fisheries on mitigating warp strikes in trawl fisheries, and the need for best practice guidelines and implementation of these on all trawl vessels.

3.35 Recognising that an increased level of observations is required to improve the precision of estimates of warp strike rates, the Scientific Committee recommended:

(i) introducing an increase in the level of warp strike observations to 2.5% of fishing time on a per-vessel basis for the 2023/24 season

(ii) the level of warp strike observations be a minimum of 5% of fishing time on a per-vessel basis from the 2024/25 season onwards.

(iii) development and use of warp and net monitoring cable mitigation measures on trawl vessels for the 2023/24 fishing season, and the introduction of mandatory mitigation measures on trawl vessels once suitable mitigation specifications have been developed

(iv) the development and implementation of a standardised observation procedure that reflects the potential variability in warp strike risks during trawling, to allow for a better estimation of overall warp strike rates.

3.36 Some members noted that the report by WG-IMAF indicated that bird strike rates in the krill trawl fishery are potentially very high and considered that the level of warp strike observations should be increased to at least 5% of fishing time on a per-vessel basis for the 2023/24 season. This would allow for an evaluation of whether the current and improved mitigation measures are successful in reducing bird strike rates.

3.37 The Scientific Committee noted that it considered that the collection of accurate data on warp strikes was a priority for krill observers, and the time taken to conduct 5% observation was unlikely to impact significantly on time for other priority tasks during commercial fishing (paragraph 7.11).

3.38 The Scientific Committee noted that the recording of warp strikes has changed over time, recognising this makes it difficult to extrapolate the data. The Scientific Committee encourages Members to submit analyses to WG-SAM on extrapolation from observations to inform mortality estimates.

3.39 ARK supported the increasing of observation coverage to improve estimates of bird strikes and the elaboration of mitigation measures. ARK also underscored that the species involved in bird strikes observed during the monitoring cable derogation trials are not included within the Priority Populations identified by ACAP and that this distinction is important when formulating management advice.

3.40 The Scientific Committee noted a range of species are involved in these interactions, referring to papers provided by the Secretariat (WG-FSA-21/04 and WG-IMAF-22/07). The WG-IMAF work plan includes the need for a risk assessment approach to better understand the species involved and their vulnerability.

Mitigation methods for seabirds

3.41 The Scientific Committee noted the update from Norway on trials of mitigation measures in krill continuous trawl fisheries where a net monitoring cable was used. The 'sock' mitigation measure was extended in length to be closer to the sea surface. Video observations recorded 147 bird strikes per 1 000 hours and direct observations reported 108 bird strikes per 1 000 hours, varying among the three continuous trawlers. An extrapolated total of 747 bird strikes in 188 days was estimated.

3.42 The Scientific Committee encouraged Norway to work with the Secretariat to ensure archiving of the video records of warp strikes collected during the derogation trials.

3.43 The Scientific Committee noted the information from China on the preliminary results of the trial of a net monitoring cable seabird-strike mitigation measure ('sock' with pennants, and streamer lines) for continuous trawling on the vessel *Shen Lan*. Continuous trawling was conducted only from 22 December 2022 to 15 January 2023 and observations totalled 65.5 h (7.8% of total fishing hours) with no seabird interactions observed. For conventional trawl, standard warp strike observation protocols were followed, which comprised 44.5 h (2.2% of total fishing hours) with no seabird interactions observed. The trial will continue in the 2023/24 season.

3.44 The Scientific Committee recommended:

(i) maintaining the existing derogation of the prohibition on use of the net monitoring cable in Conservation Measure 25-03, paragraph 1, footnote 2, in the 2023/24 season

(ii) clarifying in the second footnote to paragraph 1 of CM 25-03 that 'on-vessel observation coverage' includes both on deck observations and review of video footage in meeting the observer coverage requirements.

3.45 The Scientific Committee noted the importance of assessing the effect of changes in 'sock' mitigation design and encouraged continuous trawl vessel operators to continue to develop mitigation devices to deter birds from the area where warp and net monitoring cables are deployed.

3.46 The Scientific Committee noted that (i) typical streamer lines may not be effective for continuous trawl operations where speed is under 2 kt, (ii) the use of 'jigglers', lighter streamer lines and improved drogue designs may have application to continuous trawlers for improving aerial extent of streamer lines to deter birds, and (iii) previous studies into seabird olfactory sense suggest that 'stick water' may be attractive to seabirds and increase the risk of warp strikes if discharged near warps.

3.47 The Scientific Committee noted the WG-IMAF discussions about existing mitigation measures that have proven effective in other trawl fisheries outside of CCAMLR but noted the need to adapt the mitigation measures to CCAMLR fisheries. The Scientific Committee encouraged Members to conduct research to adapt streamer lines for use in CCAMLR trawl fisheries and to consider issues with 'stick water', and report back to WG-IMAF in future meetings.

3.48 Based on inconsistencies and ambiguities in current seabird Conservation Measures, the Scientific Committee recommended the inclusion of a definition of 'night' in paragraph 5 of Conservation Measure 25-02 to reduce ambiguity.

3.49 The Scientific Committee requested the Secretariat work intersessionally to align the gear details specified in paragraphs 3 and 4 of CM 25-02 with the indicative figures in Annex 25-02/C.

Light pollution effects on seabirds

3.50 The Scientific Committee noted WG-IMAF's analyses of light pollution guidelines for wildlife and mitigation standards for reducing light-induced vessel strikes of seabirds with fishing vessels developed by Australia and New Zealand, noting that the guidelines, endorsed by ACAP and CMS, are highly relevant for CCAMLR.

3.51 The Scientific Committee noted systematic recording of light-induced vessel strikes does not currently take place and that the level of mortalities from light-induced strikes may be considerable and encouraged Members to (i) apply these light pollution guidelines, (ii) collect data regarding their effectiveness, and (iii) present reports on light-induced vessel strikes in the Convention Area.

3.52 The Scientific Committee further noted that light pollution is not just an issue for fishing vessels and encourages the application of light pollution guidelines on all vessels in the Convention Area.

3.53 The Scientific Committee endorsed the WG-IMAF updated intersessional work program evaluation of progress against the strategic plan as described in Annex 15.

3.54 The Scientific Committee endorsed the updated WG-IMAF terms of reference in Annex 16 with the deletion of the text in point (iii) on the source of marine debris.

3.55 The Scientific Committee thanked WG-IMAF for the important work they have undertaken, and the Secretariat for support intersessionally and during the meetings.

3.56 The Scientific Committee noted that the Secretariat had informed WG-IMAF on logistical and management issues concerning the meeting of WG-IMAF currently overlapping with WG-FSA. The Scientific Committee agreed that WG-IMAF will be held jointly with WG-FSA in 2024, with a reduced WG-IMAF agenda focused mainly on effective mitigation of incidental mortality associated with trawl fisheries, the review of updated estimates of incidental mortality, and use of mitigation when using a net monitoring cable (paragraph 9.32).

3.57 ASOC welcomed the IMAF report and the reporting on seabird and marine mammal strikes and incidental mortalities in different fisheries, noting that these estimates do not account for cryptic (unobserved) mortality. The amount of observation time to detect incidental mortality from strikes in warp and net monitoring cables, which are currently permitted under a CM derogation, is very low (as low as 2.2%) compared to the total time the continuous trawls are operating, as already discussed. ASOC urges members using continuous trawls to increase the amount of observation time and welcomed the recommendations in WG-IMAF-2023, paragraph 4.17, for a higher level of observation. On fur seals, ASOC welcomed the precautionary proposal for a temporal and spatial closure to protect the threatened South Shetland Antarctic fur seal population. This is a pro-active measure which deserves support by

CCAMLR Members. The report of elephant seal deaths in the longline fishery needs more investigation by members and reporting to identify why this is happening and identify appropriate mitigation measures.

Bottom fishing and vulnerable marine ecosystems

3.58 The Scientific Committee considered the reports of WG-FSA-2023 (WG-FSA-2023, paragraphs 5.52 and 5.55) and WG-EMM-2023 (WG-EMM-2023, paragraphs 7.66 to 7.73) on the protection of the icefish species *Neopagetopsis ionah* in the southern Weddell Sea.

3.59 The Scientific Committee agreed that *Neopagetopsis ionah* nests area in the southern Weddell Sea represent an essential habitat that needs protection.

3.60 The Scientific Committee recommended a review process for the *Neopagetopsis ionah* nests area by which an update of the area is provided for consideration by the Scientific Committee in the fifth year.

3.61 The Scientific Committee further recommended a more general mechanism to protect essential habitats for AMLR be developed in the future.

3.62 The Scientific Committee considered a revised version of the CCAMLR VME Taxa Classification Guide for the toothfish fishery (WG-FSA-2023, Appendix H) and recommended that it replaces the existing guide (https://www.ccamlr.org/node/74322) for use by observers aboard fishing vessels throughout the Convention Area. It was further noted that some taxa may not be represented in this guide and that further work is needed to develop a more comprehensive Convention Area guide.

3.63 The Scientific Committee noted WG-FSA-2023, paragraph 5.64, which highlighted discrepancies between observer- and vessel-reported VME data, noting that there are instances where observers reported data surpassed thresholds that would have triggered VME risk areas and considered that the discrepancies require further investigation by the Secretariat.

Marine debris

3.64 The Scientific Committee considered WG-FSA-2023, paragraphs 2.30 to 2.37, on marine debris and considered whether marine debris should be reported in vessel data forms (C1, C2 and C5) or on a separate form.

3.65 The Scientific Committee noted that an opportunistic marine debris data collection form (https://www.ccamlr.org/en/node/106080) had been developed by the Secretariat and that non-fishing vessels could use this form to report marine debris on a voluntary basis.

3.66 The Scientific Committee could not reach consensus on the inclusion of marine debris data collection fields within vessel forms, or by using a separate form, and requested that the Secretariat liaise with Members and relevant organisations intersessionally to refine reporting of marine debris by fishing vessels within the Convention Area.

Advice to the Commission

3.67 The Scientific Committee recommended the Commission consider the adoption of a conservation measure to provide protection to the *Neopagetopsis ionah* fish nest areas in the Southern Weddell Sea and promote non-destructive research to understand their importance in the CAMLR Convention Area.

Spatial management of impacts on the Antarctic ecosystem

Marine protected areas (MPAs)

4.1 In SC-CAMLR-42/BG/15, ASOC considered the state of affairs of marine protected area discussions after CCAMLR-SM-III earlier this year, and repeated earlier recommendations indicating that the system of CCAMLR MPAs should be completed as a matter of priority, and the adoption of a roadmap to achieve that objective. ASOC proposed several specific elements of the roadmap including the adoption of research and monitoring plans, the harmonisation of fisheries and MPAs particularly in the Antarctic Peninsula, and the development of new MPA proposals. Significantly, the authors concluded that MPAs should not be subjected to a higher level of scientific scrutiny than that required for fisheries.

4.2 ASOC made the following statement:

> *'ASOC further proposes that, in accordance with global agreements (CBD, BBNJ) already endorsed by most CCAMLR Members, a roadmap should aim to achieve at least 30% protection of the Convention Area by 2030. ASOC also contends that no new fisheries proposals or increase of total allowable catches for current fisheries should be adopted by CCAMLR until tangible progress has been made on the adoption of new MPAs as well as Research and Management Plans for all MPAs, current or new. ASOC recognizes that consensus among Members cannot be forced, yet the objective of CCAMLR is not to achieve the lowest common denominator, with a low bar for fishing and a high bar for protection. Rather, the objective of CCAMLR is to ensure the conservation of Antarctic "marine living resources" which, as defined in Article I, mean the conservation of marine life, ecosystems, and environment in the Convention Area.'*

4.3 The Scientific Committee thanked ASOC for their contributions to the discussions on MPAs.

Review of scientific analysis relevant to existing MPAs, including research and monitoring plans for MPAs

4.4 The Scientific Committee noted but did not discuss CCAMLR-SM-III/08 and CCAMLR-SM-III/09, however noted summaries of the papers are respectively available in paragraphs 2.2 and 4.5 of CCAMLR-SM-III.

4.5 SC-CAMLR-42/BG/03 presented phylodiversity as an important facet of biodiversity and underlined the need to consider it as part of CCAMLR's conservation strategies. Phylodiversity was presented under multiple uses: as a measure complementary to studies investigating taxonomic diversity; as an indicator variable with spatial and temporal distribution; as a conservation target, allowing to account for evolutionary history events; and as a proxy for biodiversity option values, reflecting the contribution of biodiversity-as-variety in maintaining its possible benefits for future generations.

4.6 The Scientific Committee requested the authors present the published phylodiversity results to WG-EMM-2024, to advise on how to incorporate them into the work of the Scientific Committee.

4.7 SC-CAMLR-42/BG/08 and CCAMLR-42/44 presented a prioritised list of SMART (Specific, Measurable, Achievable, Relevant and Time-bound) criteria supporting the implementation of the RSRMPA Research and Monitoring Plan (RMP), and a proposed revision to the RSRMPA RMP incorporating these criteria. The prioritised list presented in SC-CAMLR-42/BG/08 included at least one SMART criterion for each zone of the RSRMPA and each specific objective listed in CM 91-05, paragraph 3, together with a decision rule to apply if the status of each SMART indicator suggests consequential mitigation is required.

4.8 The Scientific Committee welcomed the work presented and noted discussions on the SMART criteria, including how they could be prioritised, at WG-EMM-2023 (WG-EMM-2023, paragraphs 7.50 to 7.60).

4.9 Mr Y. Lei (China) noted the need for further improvement of the baseline data, and the use of indicators on harvesting activities together with indicators on ecosystem status and indicators on the results of the scientific research.

4.10 Mr Lei emphasised it was important to focus on the connections between the specific management measures of the MPA with the change of ecosystem status indicators to assess the extent to which the objectives of the MPA have been met and did not support the use of MPA coverage or boundaries as equivalent to the effectiveness of the MPA.

4.11 Mr Lei further noted that the minimum desired outcome was much lower than the baseline condition for most of the indicators for the MPA objectives, as shown in the proposed Addendum 1 Priority SMART Criteria for Assess the RSRMPA (CCAMLR-42/44). For example, the minimum desired outcome for the population of key species (emperor penguins, Adélie penguins, Weddell seals) can be a 30% reduction from their baseline condition. 94% of the identified core distribution of crystal krill are now covered by the MPA, while the desired minimum outcome will be as low as 51% with the MPA boundaries unchanged. He noted that such standards are much lower than the traditional CCAMLR conservation measures and cautioned about the implication of such a proposed target.

4.12 The authors of SC-CAMLR-42/BG/08 and CCAMLR-42/44 noted the number of papers cited when developing the SMART criteria reflected the best available science for the RSRMPA. The authors further noted that because SMART criteria are supposed to be relevant to the area, the design must focus on boundaries and coverage and that thresholds were set according to what the Commission has asked to achieve in CM 91-05 and international standards.

4.13 Mr Lei noted that the scientific information presented in the proposal didn't represent the best available science even in comparison with scientific information presented before 2017.

4.14 Many Members recalled that the Scientific Committee had adopted the RSRMPA RMP (SC-CAMLR-XXXVI/20) which remains to be adopted by the Commission.

4.15 The Scientific Committee supported future consideration of the inclusion of the SMART criteria in a revised RSRMPA RMP.

4.16 The Scientific Committee recalled that the consideration of SMART criteria when developing future RMPs was proposed by China. However, the Scientific Committee did not reach consensus on how to use SMART criteria to update the RSRMPA RMP. The Scientific Committee encouraged Members to address issues intersessionally and continue the discussions in WG-EMM, and in particular encouraged members unable to join consensus on an updated RSRMPA RMP to send experts to participate in intersessional discussions to progress this issue.

Review of the scientific elements of proposals for new MPAs

4.17 The Scientific Committee considered paper SC-CAMLR-42/13 that presented how ecosystems in the Western Antarctic Peninsula face various pressures, including those from climate change and the concentration of the krill fishery. The authors noted that the D1MPA is designed to contribute to the revised krill fishery management approach with an ecosystem-based and precautionary approach. It presented key points for consideration in the harmonisation process of the spatial management strategies taking those pressures into consideration. Those points included:

(i) to protect priority conservation targets within general protection zones

(ii) to ensure fishery management through periodic adjustments of krill catch limits and integration with the krill stock hypothesis

(iii) continuing cooperation for monitoring.

4.18 The Scientific Committee agreed that the spatial configuration of the proposed D1MPA could contribute to a spatial management framework to minimize effects on predators and krill in association with the revised krill fishery management approach. The Scientific Committee also recalled the discussions of revision of CM 51-07, the harmonisation symposium and issues related to climate change (paragraphs 2.19, 2.82 and 5.1).

4.19 SC-CAMLR-42/BG/17 outlined the history of the scientific and political process behind the proposal for a D1MPA. The document presented how the project had been shaped by the feedback from Members and stakeholders. The harmonisation of the revised krill fishery management approach, especially in the areas overlapping with the proposed D1MPA has been under discussion for many years. The D1MPA could serve as a mechanism to mitigate the impacts of climate change and fishing, and its integration with the revised krill fishery management approach was envisioned for enhanced ecosystem protection.

4.20 The Scientific Committee highlighted the changing patterns in sea-ice distribution and emphasised the urgent need for research, monitoring and appropriate conservation systems to ensure that CCAMLR can continue to achieve its objective in the face of rapid climate change. Furthermore, the Scientific Committee underscored the educational value of SC-CAMLR-42/BG/17 in explaining the evolution of the project and the decision-making processes.

4.21 Norway proposed a new Conservation Measure (CCAMLR-42/01 Rev. 2) on the establishment of Phase 2 of an MPA in the Eastern Weddell Sea. Background documents on science and responses to WG-EMM-2023 recommendations (WG-FSA-2023, paragraph 7.17) were also submitted (SC-CAMLR-42/BG/02 and SC-CAMLR-42/BG/05). The proposal aims to preserve biodiversity and marine ecosystems in response to environmental changes in the Eastern Weddell Sea. In addition to the new development of the proposal, an online atlas and an interactive tool were developed to evaluate different scenarios to design an MPA for Phase 2.

4.22 The proposal CCAMLR-42/01 Rev. 2 consists of five zones (A to E) – each with specific objectives for protection and research. The proponents indicated that the proposal incorporates responses to recommendations from WG-EMM-2023. On Recommendation 3, for the protection of the Antarctic petrel, a recent update with new scientific elements was presented with a proposal of adding a new zone 'F'. This high-priority area will be beneficial for all predators, not only Antarctic petrels, as protection of krill, whales, and cetaceans would be improved.

4.23 The Scientific Committee welcomed the proposal by Norway and acknowledged the substantial work put into its development. It further thanked Norway for considering other Members' comments and updating the proposal accordingly. The Scientific Committee considered that further discussions were needed to improve the proposal. It recommended that clarifications should be provided regarding any additional new data for Antarctic petrels, Adélie and emperor penguins and the consequences of these additions for the management of the MPA. It also recommended to clarify which activities would be allowed or not within each zone to better understand how conservation objectives would be achieved.

4.24 Many Members recognised that Norway's proposal had successfully compiled the best available science and encouraged further progress on this proposal in the Scientific Committee and the Commission.

4.25 The Scientific Committee noted the addition of Zone F was considered an appropriate response to the EMM recommendations regarding Antarctic petrels, as well as for other species. It requested a recalculation of protection achieved taking into account the addition of Zone F.

4.26 Norway pointed out that the proposal included all available data to support the proposed MPA objectives and for further discussions on the management zones.

4.27 Some Members suggested Norway consider revising the management provisions of the Special Research Zones to better distinguish them from typical fishery Research Blocks and potentially improve the ability of these zones to achieve the specific objective of improving knowledge of toothfish stock dynamics, perhaps by structuring fishing to minimise spatial bias in results from the toothfish tagging program. Some Members also suggested that the baseline conditions from which 'protection achieved' should be assessed in future attempts to evaluate the proposed MPA should not include the Special Research Zones.

4.28 Mr Lei thanked Norway for the efforts made in developing this proposal and highlighted the need for a more comprehensive collection of baseline data on the status of the ecosystem. He suggested not to conclude at this stage whether the proposal constitutes the best science available to provide advice to the Commission on MPAs in this region, but to focus on whether there is adequate data that can support the rationale of the proposed objective and management measures.

4.29 The Scientific Committee Chair reminded the Scientific Committee of the fact that the best available science is determined based on an evaluation by the scientific experts in the Scientific Committee and its working groups. If a Member knows that data are missing, or alternative scientific evidence is available, he encouraged that Member to bring that information to the attention of the Scientific Committee for it to be incorporated into its advice and work constructively with Members developing proposals, such as the Weddell Sea Phase 2 MPA.

4.30 The Scientific Committee did not achieve consensus for the proposal in its current state. Norway has made significant progress in compiling the best available science to inform the design of the MPA in support of its stated objectives.

4.31 In paper SC-CAMLR-42/14, Norway proposed conducting a workshop to develop the research and monitoring plan for Phase 2 of the Weddell Sea MPA. The workshop aims to develop a detailed RMP which includes the development of performance indicators and decision criteria to evaluate the achievement of the MPA's objectives.

4.32 The Scientific Committee supported the proposal of the workshop put forward by Norway. The Scientific Committee emphasised the importance of gathering the appropriate experts to ensure informed discussions during the workshop and encouraged Norway to include in the agenda of the workshop consideration of the collection of quantitative baseline data of ecosystem status that support this proposal. The Scientific Committee looked forward to seeing the advancements that would be made during the workshop at the next meeting of the Scientific Committee.

4.33 ASOC thanked Norway for presenting the Phase 2 proposal and the extensive scientific work that has gone into it. ASOC stated that until there was a definition on best available science, there should not be fishing either, since fishing CMs have to be established based on best available science.

Other spatial management issues

4.34 The 2019 expert workshop on pelagic eco-regionalisation in the sub-Antarctic region outlined a preliminary workplan in the Indian sector of the Southern Ocean (SC-CAMLR-38/BG/29). A subsequent Paris workshop in 2023 revised the work plan as described by SC-CAMLR-42/08 which now includes Integrated Ocean Management and Research and Monitoring as key components. The workshop entailed the creation of atlases for zooplankton, mesopelagic fish, seabirds, and marine mammals, with plans for the development of synthetic species assemblage data through predictive modelling techniques.

4.35 Future work resulting from the workshop will cover aspects such as connectivity, climate change impacts, integrated ocean management, research, and education to university students. Recommendations underscored the importance of considering subtropical areas because of climate impacts and clarifying the legal framework with management tools of EEZ MPAs, future CCAMLR MPAs and potential future MPAs in the subtropical zone under the BBNJ treaty. The project aims to involve Members involved in the Indian sub-Antarctic area and establish a steering committee. The project aims to integrate early-career ocean professionals within the three-year plan.

4.36 The Scientific Committee welcomed the progress made on pelagic eco-regionalisation in the Indian Sector of the Southern Ocean and thanked the authors for their work.

4.37 The Scientific Committee noted the planned work for the eco-regionalisation of Planning Domains 4, 5, 6, and Northern part of Domain 7, and requested the Secretariat to add information on this region to the CCAMLR MPA Information Repository (CMIR). The Scientific Committee noted the significance of the project and invited Members to contribute to the different work packages, sharing knowledge and methodologies for the study area. Dr Makhado and Prof. Koubbi may be contacted directly.

4.38 During the 2022 CEP XXIV meeting, the USA proposed combining two Antarctic protected areas (ASPAs No. 152 and No. 153) due to their shared objectives and similar scientific values to be protected, intending to establish them as a single, unified ASPA. The 2022 Scientific Committee meeting failed to reach a consensus on this proposal. The revised management plan and maps were presented in SC-CAMLR-42/12. The 2023 CEP endorsed the revised plan, including keeping the two protected subareas at their original sizes and making vertical boundary adjustments to establish a subsurface boundary at 20 m, which allows freedom of vessel transit above the area.

4.39 The Scientific Committee recommended that the Commission approve the ASPA management plan and forward to the ATCM for final approval.

4.40 SC-CAMLR-42/BG/24 presented by ASOC noted several examples in which consensus had not been achieved on important conservation proposals in recent years, despite their strong scientific content and sometimes Scientific Committee endorsement. In contrast, the adoption of fishing conservation measures had largely continued as usual.

4.41 ASOC suggested that it is time to reset the relation between conservation and fishing. Fishing is only one element for the consideration of CCAMLR bodies contributing their expertise to achieve the specific objective of the Convention.

4.42 ASOC made several recommendations to put this fishing reset into effect. Of particular relevance for the Scientific Committee is a recommendation to strengthen scientific requirements for approving conservation measures for fisheries.

Advice to the Commission

4.43 The Scientific Committee noted that there are no MPA proposals in progress in Planning Domain 9 and encouraged Members to undertake such work to implement a future MPA. There is an urgent need to develop studies and develop targeted conservation strategies to ensure the resilience of the marine ecosystems in this area because of the environmental changes occurring.

4.44 ASOC informed the Scientific Committee that the PEW Charitable Trust has supported preliminary work by the Centre for Conservation Geography on a Marine Protected Area technical discussion paper in Domain 9. The report of this work can be found at conservationgeography.org.

4.45 Ukraine reported on its work concerning establishing a new ASPA in the Argentine Islands and surrounding archipelagos close to Vernadsky station (Antarctic Peninsula). The planned multi-site ASPA consists of a combination of mainly terrestrial and comparatively small marine components. The Scientific Committee considered the preliminary proposal on the ASPA in 2019 (SC-CAMLR-38/BG/21 Rev. 1) and appreciated that this newly proposed ASPA could be harmonised with the proposed D1MPA, in particular, its marine component could serve as one of the reference areas of the proposed D1MPA for assessing the effects of climate change on benthic communities, penguin populations and distribution. The updated proposal on ASPA's terrestrial component has been considered at the CEP meeting (Helsinki, 2023) applying the CEP guidelines on prior assessment process for the designation of ASPAs and ASMAs. While expressing general support for the prior assessment, the CEP noted that some Members raised concerns about the core values to be protected, the number of sites incorporated, and its representativeness. Ukraine noted that the draft ASPA Management Plan will be submitted to the Scientific Committee for further consideration after developing a clearer framework for the area's protection.

4.46 The Scientific Committee expressed gratitude to Ukraine for providing the latest information regarding the ASPA in the Argentine islands and the surrounding archipelagos.

Climate change

Report of the Climate Change Workshop (WS-CC-2023)

5.1 The Co-conveners of the Workshop on Climate Change, Dr Cavanagh and Mr E. Pardo (New Zealand), presented the outcomes of the Workshop detailed in SC-CAMLR-42/11. The Workshop took place between 4 and 8 September 2023, in a hybrid format, with attendance online and in-person in Cambridge, UK and Wellington, New Zealand. The UK hub also had two sub-hubs, with participants in Qingdao, China and Paris, France. 129 participants from 21 Members and 8 Observers registered for the meeting. Most participants attended one hub and the plenary sessions, and report adoption was attended by 106 participants. The co-conveners thanked all participants, including keynote speakers and invited experts, regional hub teams and Secretariat support in helping achieve a successful Workshop.

5.2 The Scientific Committee noted that the hub-based, hybrid format was implemented as a trial. Benefits included minimal carbon footprint, greatly increased number of participants/broader perspectives, including presentations by expert scientists who do not usually engage with CCAMLR, and participation of Observers. The Scientific Committee noted that the Workshop report included feedback from participants about the format which will be taken into account for future events (WS-CC-2023, Attachment I).

5.3 The Scientific Committee thanked the co-conveners, New Zealand and the UK for leading such an important and successful Workshop and noted the high level of participation from a large number of Members. The recommendations to the Scientific Committee arising from the Workshop are provided in Tables 6a to 6c and in the report from WS-CC-2023. The Scientific Committee considered each of these recommendations and how best they might be integrated into the work of the Scientific Committee and its working groups. All recommendations were endorsed by the Scientific Committee.

5.4 The Scientific Committee noted that the Secretariat is already addressing the recommendation to liaise with the Southern Ocean Observing System (SOOS) to develop information for use by CCAMLR in the context of climate change via the SOOS map data discovery tool (SC-CAMLR-42/11, paragraph 1.15).

5.5 The Scientific Committee noted the recommendation to collate a list of important variables to be monitored following an extreme event (WS-CC-2023, paragraph 1.28) and their physical/biological effects both on marine components and land-based predators and recommended that WG-EMM consider extreme events (SC-CAMLR-42/11, paragraphs 1.28, 1.52 and 3.25) in the forthcoming CEMP review. In addition, the CEMP review should consider specific climate variables and metrics for which data are already, or could be, collected, that would be useful in communicating the status of AMLR through time (WS-CC-2023, paragraph 3.15).

5.6 The Scientific Committee noted the recommendations for further engagement with SCAR and IWC (SC-CAMLR-42/11, paragraphs 1.32, 1.39 and 1.48) and recalled that there is increasing cooperation with these organisations who are both observers at the Scientific Committee and encouraged further engagement on issues related to climate change to facilitate the work of the Scientific Committee. The Scientific Committee noted that Dr T. Bracegirdle (UK) a participant in the climate change workshop is leading work on extreme events within SCAR.

5.7 The Scientific Committee considered the recommendations arising from the Workshop related to the integration of climate change into the CCAMLR fisheries management processes (SC-CAMLR-42/11, paragraphs 2.11, 2.24 and 2.26). It noted that during its 2023 meeting, WG-FSA had considered these recommendations and has begun to integrate them into their work (WG-FSA-2023, paragraphs 4.41 to 4.46 and Table 5, see also SC-CAMLR-42/11, paragraph 3.35) using the Ross Sea as a preliminary example (paragraph 2.149).

5.8 In relation to the Workshop recommendation on toothfish recruitment (SC-CAMLR-42/11, paragraph 3.29), the Scientific Committee noted that the intersessional work plan developed by WG-FSA for toothfish (WG-FSA-2023, paragraphs 4.57 and 4.58) included a consideration of assumptions about future recruitment in stock projections and potential alternative decision rules. The Scientific Committee welcomed the progress on this topic that had already been made and recalled that climate change was a standing item for consideration for all the working groups.

5.9 The Scientific Committee noted that MoUs with neighbouring RFMOs are already in place and that, as Observers, they are represented at meetings of the Scientific Committee and encouraged further exchange of information with these organisations to facilitate the integration work on climate change in fisheries management processes. The Scientific Committee recommended that the Secretariat be tasked with engaging with neighbouring RFMOs to exchange data and seek information on climate related range shifts for species that are of mutual interest (SC-CAMLR-42/11, paragraph 2.24).

5.10 SCAR informed the Scientific Committee that there are ongoing discussions concerning the development of a SCAR Fish Action Group, analogous to the SKEG and encouraged all interested parties to consider joining. The Scientific Committee noted that this group could provide information to the Scientific Committee on issues such as climate change effects on fish ecology and physiology in the Southern Ocean.

5.11 In relation to the Workshop recommendation on the need to provide information on the Workshop outputs and recommendations to the CEP (SC-CAMLR-42/11, paragraph 3.18), the Scientific Committee noted that the report of the Scientific Committee Chair regarding SC-CAMLR activities to the next CEP meeting should include a summary of the Workshop and its recommendations. The Scientific Committee noted that the WS-CC-2023 report will be a key input into the planned joint CEP – SC-CAMLR Climate Change Workshop (paragraph 5.29 and Annex 17; SC-CAMLR-41, paragraph 7.6).

5.12 The Scientific Committee endorsed the recommendation to develop a glossary of climate-related terms, definitions, best practices and standards to aid in the selection and communication of essential variables, climate models and emission scenarios (SC-CAMLR-42/11, paragraph 3.22). The Scientific Committee noted that definitions of many climate-related terms have already been developed within the IPCC and SCAR (Marine Ecosystem Assessment for the Southern Ocean (MEASO)) and these should be considered for use within CCAMLR. The Scientific Committee recommended that an e-group would be the best mechanism to develop a glossary for use within SC-CAMLR.

5.13 The Scientific Committee noted the Workshop recommendation (WS-CC-2023, paragraph 3.40) to develop a web page to explain CCAMLR's response to climate change to the public and requested the working groups consider the content to place on such a webpage.

5.14 The Scientific Committee agreed to circulate the report of WS-CC-2023 to relevant working groups to address the recommendations in the report (also summarised in Table 1 of WS-CC-2023) and consider the additional tasks included in Table 2 of the WS-CC-2023.

5.15 ASOC made the following statement in relation to climate change:

> *'We would like to make a general reflection on climate change action, based on a contribution we made at the climate change workshop. ASOC was pleased to participate in this workshop and agrees with many of its recommendations. We take the opportunity to thank the organisers and conveners of the climate change workshop for their excellent work. CCAMLR cannot directly influence the main causes of climate change, but it can enact a climate mitigation strategy that supports the mandate of Article II in conserving Antarctica's rich marine biodiversity – as defined in Article I of the Convention. In this context, CCAMLR should complete the planned representative system of MPAs under CM 91-04, including areas designed to enhance climate resilience. Within fisheries, CCAMLR can reduce fishing pressure in areas most affected by climate change. This is a particularly important action to take in the krill fishery in Subarea 48.1. Additionally, CCAMLR should take action to institute a robust system of acquiring up-to-date and relevant information and data on how climate change is affecting the Southern Ocean. CCAMLR needs to strengthen CEMP so that it is fit for purpose in a rapidly warming climate, including by adding whales to the list of monitored species. Finally, ASOC suggests that it is time to "turn the page" on CCAMLR's response to climate change, by undertaking more tangible and faster actions targeted at conservation.'*

5.16 SC-CAMLR-42/BG/09 was presented by Oceanites. Oceanites continues to work with the tourism industry and other stakeholders to understand the consequences of the warming trend that has occurred in the western Antarctic Peninsula by monitoring penguin populations in the region. This work contributes to Oceanites' continent-wide penguin database known as MAPPPD. Continuing significant declines at important chinstrap and Adélie penguin colonies have been recorded, while gentoo penguin populations are tending to remain stable or increasing. However, during the 2021/22 and 2022/23 breeding seasons, heavy snow throughout the Gerlache strait led to delayed or interrupted breeding at many gentoo penguin colonies. The cumulative effects of these unprecedented climate events and other stressors are not yet fully understood in terms of population dynamics.

5.17 Oceanites also noted that HPAI poses a severe threat to the Antarctic ecosystem. Oceanites are working closely with SCAR's Antarctic Wildlife Health Network, Penguin Watch and Stony Brook University to build a system that will allow for near instantaneous reporting of suspected HPAI instances for real-time management actions by the tourism industry.

5.18 SC-CAMLR-42/BG/11 presented an update by SCAR on recent research and advances in understanding of climate change in the Antarctic physical environment, and the biological implications of these changes – summarising key developments that are likely to be of interest to CCAMLR. Research published in the short time since SCAR's Antarctic Climate Change and the Environment Decadal Synopsis in 2022 is largely in line with its key messages, noting in particular record high global ocean temperatures in 2022 and record low Antarctic sea ice extent in 2023. Currently observed changes are also largely bearing out projections made in recent IPCC assessment reports.

5.19 SCAR reiterated its commitment to provide regular scientific updates to CCAMLR on the current understanding of, and projections for, climate change and its impacts in Antarctica and the Convention Area and encouraged Members to make further specific requests for information from SCAR where relevant to future work on climate change.

5.20 The Scientific Committee thanked SCAR and Oceanites for their considerable contributions and expertise in helping understanding of climatic impacts in the Antarctic which are a global cause for concern.

5.21 The Scientific Committee considered SC-CAMLR-42/BG/12, a peer reviewed paper by the UK on Antarctic extreme events (Siegert et al. (2023)) and noted that it had been considered at the Climate Change Workshop (SC-CAMLR-42/11, paragraphs 1.28, 1.52 and 3.25). The paper seeks to describe the kind of extreme environmental events that have been observed in Antarctica in recent years that are significantly different to the average ranges of variability across a variety of realms (ocean, atmosphere, cryosphere, biosphere etc). The paper considers the likely causes and implications of such phenomena and concludes that such extreme events are virtually certain to become more frequent and more intense if the ambition of the Paris Climate Agreement is not met.

5.22 SCAR presented SC-CAMLR-42/BG/18 which documented new research on reproductive development which suggests that female Antarctic krill in the northern and western regions of the Antarctic Peninsula may mature and initiate reproduction at the end of winter in response to environmental and climate conditions. Early maturation could increase reproductive output by lengthening the spawning season and increasing the number of spawning events in a given season. This paper adds insight for the krill stock hypothesis, informing the reproductive dynamics of krill in Subarea 48.1.

5.23 The Scientific Committee welcomed this research which will contribute to the development of a krill stock hypothesis by the SKEG group. It also noted that research was undertaken by a recipient of a SCAR scholarship for early mid-career scientists and it was very pleasing to see the outputs of this scheme adding to the work of CCAMLR.

5.24 SCAR presented SC-CAMLR-42/BG/28 on behalf of SCAR, SCOR and the MEASO community, on the MEASO Summary for Policy Makers which was launched on 18 October 2023. Key findings were presented at the recent climate change workshop. SC-CAMLR-42/BG/28 identified areas in which the SCAR, ICED and MEASO communities could support the work of the Scientific Committee and its working groups, particularly in assessing current change, and for supporting assessment of future change. Many of these topics were also highlighted during the recent Workshop on Climate Change, and include developing and quantifying:

(i) trends in environmental change that could impact species and ecosystems

(ii) pathways of ecosystem impacts from environmental change and fisheries pressures

(iii) changing ecologies of species and how those ecologies may impact food webs

(iv) modelled future change in species, food webs and ecosystems based on relevant climate scenarios and earth system projections

(v) assessments of risks associated with environmental change

(vi) evaluation of the representation of species, food web and ecosystem ecologies in projection models

(vii) ensembles of models coupled to Earth System Models to assist in assessing risks and the development of management strategies.

5.25 In particular, the MEASO report (SC-CAMLR-42/BG/28) noted a need for investment in sustained, year-round and ocean-wide scientific assessment and monitoring of the health of the ocean by the international community.

5.26 The Scientific Committee welcomed this work and recommended that it be considered by WG-EMM and further encouraged Members to submit such summaries to the relevant working groups as there is insufficient time in the Scientific Committee to consider such work in detail.

5.27 In addition, Dr A. Van de Putte (Belgium) noted ongoing efforts by the SCAR Antarctic Biodiversity Portal and partners, including SOOS to develop a system of essential variables tools that can help monitor environmental and biological change in the CCAMLR area as described in SC-CAMLR-42/BG/20.

5.28 SC-CAMLR-42/BG/27 provided an overview of a New Zealand trial program using fishing vessels to deploy oceanographic sensors in the Ross Sea (paragraph 8.8). The program was built on a government/industry partnership that developed and implemented low-cost ocean sensor deployments to capture temperature and depth information throughout New Zealand's EEZ from industry vessels.

5.29 The Scientific Committee noted that such programs offer a low cost and effective method of collecting sea temperature data in regions where research vessel coverage is sparse and encouraged wider collaboration between Members and COLTO to consider using such sensors. The Scientific Committee noted the benefits of such data being collated and available through organisations such as SOOS.

Proposal for a joint workshop on climate change between SC-CAMLR and CEP

5.30 The Scientific Committee endorsed the proposal for a joint workshop on climate change between SC-CAMLR and CEP and reviewed the draft terms of reference for the meeting developed by the CEP. The Scientific Committee endorsed the nomination of Dr Cavanagh as the Scientific Committee representative to co-convene the meeting with Ms M. Jolly (France) for the CEP and thanked both co-conveners for taking on these roles. The Scientific Committee endorsed the terms of reference in Annex 17. Dr Van de Putte indicated he would be happy to engage in the formation of the steering committee and help with the Workshop.

Illegal, unreported and unregulated (IUU) fishing in the Convention Area

6.1 The Scientific Committee noted the discussions held at WG-FSA-2023 in relation to illegal, unreported and unregulated (IUU) fishing (WG-FSA-2023, paragraphs 2.23 to 2.29). The Working Group had welcomed the summary of information held by the Secretariat in relation to IUU fishing in 2022/23 relevant to CCAMLR, as well as unidentified gear retrieved from October 2022 to August 2023, including proposed updates, amendments, inclusions and removals from IUU vessel lists. The Scientific Committee also welcomed this contribution and noted the challenges with attributing unidentified fishing gear to IUU activity and agreed that future reporting separate observations of fishing gear into different gear types to enable the identification of IUU activity using gill nets, and that improvements to vessel forms for lost gear and observer forms for recovered gear would provide greater insight into IUU activity.

6.2 WG-FSA-2023/21 presented evidence from albatrosses equipped with GPS and a radar-detection device of a possible detection of IUU activity in the BANZARE Bank region in Division 58.4.3b in 2018 and 2019, as collected by the ‘Ocean Sentinels’ project. The area where detections were made was nearby where Australian RV *Aurora Australis* found illegal fishing gear in 2020.

6.3 The Scientific Committee welcomed the study and noted the region where the IUU detections were made was also near the location in Division 58.4.3b where CCAMLR-42/15 Rev. 1 reported IUU activity in 2017 and 2018. The Scientific Committee suggested that existing animal tracking and tagging databases, such as SCAR’s Retrospective Analysis of Antarctic Tracking Data (RAATD), or Movebank.org might be an appropriate place to host data generated by this project, and encouraged the authors to engage with the SCAR expert group on birds and marine mammals to explore this and other options. The Scientific Committee further noted the potential that the use of evidence from tagged albatrosses to detect IUU vessels may increase the mortality risk to all albatrosses interacting with IUU vessels and encouraged Members to submit associated work to the next meeting of WG-IMAF for consideration.

CCAMLR Scheme of International Scientific Observation

7.1 The Scientific Committee noted SC-CAMLR-42/06, which reported on a workshop for training Russian scientific observers and inspectors working in the Convention Area. The workshop program covered a wide range of aspects related to scientific observation and inspection in CCAMLR fisheries for krill, toothfish and crabs. The topic and outcomes of SC-CAMLR-41, the Third Special Meeting of the Commission (CCAMLR-SM-III), the Krill Fishery Observer Workshop (WS-KFO-2023), and the COLTO–CCAMLR Tagging Workshop (WS-TAG-2023) were considered within the workshop program.

7.2 The Scientific Committee noted the report from the Krill Fishery Observer Workshop (WS-KFO-2023, SC-CAMLR-42/05), held at Shanghai Ocean University, China, 19 to 21 July 2023, and thanked the Co-conveners, Prof. G. Zhu (China) and Dr Kawaguchi, for a successful meeting which produced a considerable number of recommendations and pertinent advice to the Scientific Committee. The Scientific Committee thanked all scientific observers deployed on krill vessels for their hard work.

7.3 The Scientific Committee further noted the following recommendations of the Krill Observer Workshop:

(i) allocation of observer tasks (WS-KFO-2023, Table 1)

(ii) sampling protocols and forms for krill observation, especially sampling frequency and number (WS-KFO-2023, paragraphs 4.6, 6.7 and 4.7)

(iii) sampling protocols and forms for cetacean incidental mortality (WS-KFO-2023, paragraphs 6.2; WG-IMAF-2023/10), and fish by-catch (WS-KFO-2023, paragraph 6.3)

(iv) data collection plan (WS-KFO-2023, paragraph 6.10; SC-CAMLR-41, Table 11)

(v) observer and vessel tasks, training and support required (WS-KFO-2023, paragraphs 6.4, 6.5, 6.8 and 6.9).

7.4 The Scientific Committee encouraged the development of a prize to recognise the contribution of experienced krill observers (WS-KFO-2023, paragraph 3.11), and tasked the Secretariat to work intersessionally with interested parties to develop this.

7.5 The Scientific Committee noted providing a clear direction that observers can follow will support the acquisition of priority data. The Scientific Committee further suggested refining the table by including time estimate for each data collection listed as this information will help in managing observers' workload.

7.6 The Scientific Committee reviewed the krill observer tasks identified in Table 7 and noted that there was overlap between the requirements of the different working groups. The Scientific Committee also noted that the WG-ASAM tasks are only required during acoustic transects undertaken by fishing vessels, and observers should not be required to undertake routine sampling tasks in paragraph 7.7 during this time.

7.7 The Scientific Committee recommended that the daily priorities for SISO observers on krill fishing vessels during commercial fishing activity should be:

(i) collection of krill length and maturity data from 200 individuals randomly sampled from one haul according to revised krill protocol 2023 to inform krill status and inform the krill stock hypothesis

(ii) identification of all by-catch species, their weight and number present from one 25 kg sample from an individual haul

(iii) conducting warp-strike observation for at least 2.5% of trawl time (2023/24) and 5% of trawl time (2024/25 season onwards).

7.8 The Scientific Committee noted that other krill observer tasks, such as recording seabird or marine mammal mortality were conducted as the events occur.

7.9 The Scientific Committee requested the working groups to review planned analyses and evaluate the effective sample size required to estimate key parameters using scientific observer data on board krill vessels.

7.10 The Scientific Committee endorsed the recommendations of WG-EMM-2023 (WG-EMM-2023, paragraph 4.33) and WS-KFO-2023 (WS-KFO-2023, Appendix D) with regard to implementing changes to the data collection protocol for krill sampling, and the need to conduct regular krill staging workshops for observers.

7.11 The Scientific Committee endorsed the recommendations of WG-IMAF-2023 relating SISO issues, including:

(i) the development of a dedicated cetacean data collection form for SISO observers to complete in the event of a cetacean mortality (WG-IMAF-2023, paragraph 2.18)

(ii) the modification of observer data collection forms to change ‘band’ into ‘band/tag,’ and to add to the ‘samples taken’ field in the trawl observer forms to include categories appropriate for seals (WG-IMAF-2023, paragraph 3.13)

(iii) increase the level of warp strike observations to 2.5% of fishing time on a per-vessel basis for the 2023/24 season and 5% of fishing time on a per-vessel basis from the 2024/25 season onwards (WG-IMAF-2023, paragraph 4.17)

(iv) the modification of the warp strike recording form information on the angle of the warp and which warp was sampled (WG-IMAF-2023, paragraph 5.8)

(v) the collection of species-specific estimation of bird abundance around the vessel prior to each observation (WG-IMAF-2023, paragraph 5.8)

(vi) the definition of ‘heavy strikes’ be more clearly defined using ACAP guidelines for ‘water’ and ‘sinker’ categories (WG-IMAF-2023, paragraph 5.8).

7.12 The Scientific Committee endorsed the recommendations of WG-FSA-2023, paragraph 3.41:

(i) to remove the ‘feeding colour’ column from the ‘krill biological’ tab

(ii) to add 'unknown,' and make it a default, in the 'krill biological' tab under the 'maturity stage' pulldown menu

(iii) to add 'subsampled number and weight' columns in the 'by-catch sampling' tab to make extrapolation possible in case the observer encounters high numbers of by-catch and needs to subsample the species.

Cooperation with other organisations

8.1 The Scientific Committee noted the demonstrated effectiveness of the collaboration between WG-IMAF and other organisations, including RFMOs, ACAP and IWC (paragraphs 8.4 and 8.5; WG-IMAF-2023, paragraphs 9.1 to 9.6).

8.2 ACAP thanked the Scientific Committee for the opportunity to share its expertise on the latest ACAP best practice advice and guidelines, including through its participation in WG-IMAF. ACAP welcomed the consideration of improving the coordination of engagement between ACAP and its Parties, CCAMLR and its Members, and other relevant organisations. ACAP indicated that it had developed a strategy for engagement with RFMOs and CCAMLR and would welcome continued and enhanced collaboration with CCAMLR and its Members. ACAP highlighted the value of CCAMLR's efforts to reduce incidental mortality of seabirds in demersal longline fisheries as an example of best practice, which could be given increased emphasis at relevant regional fisheries meetings. ACAP encouraged CCAMLR Members who are not ACAP Parties to consider attending ACAP meetings as observers, where ACAP best practice is reviewed.

8.3 The Scientific Committee noted the advice from ACAP on mitigation measures for demersal longline and trawl fisheries and that the requirements under the current CCAMLR conservation measures for demersal longline fisheries closely matched the ACAP best practice guidelines. The Scientific Committee supported ACAP in its engagement with other RFMOs noting that understanding the incidental mortalities occurring outside the Convention Area was valuable to CCAMLR.

8.4 The Scientific Committee noted the effective collaboration between WG-IMAF and IWC and the importance of marine mammal by-catch mitigation approaches given the recent increase in baleen whale abundance. It also noted IWC's contribution to the work of WG-EMM (WG-EMM-2023, paragraph 5.14), and recommended that the Secretariat participate in future meetings of the Scientific Committee of the IWC (IWC SC) by conveying information on the practicalities of CCAMLR procedural and administrative matters relevant to IWC discussions and support the SC-CAMLR observer to IWC SC.

8.5 The Scientific Committee highlighted the importance of effective collaboration between WG-IMAF and other organisations, noting that the collaboration with invited experts at the meeting had greatly improved the understanding of participants on relevant issues and enhanced the provision of advice to the Scientific Committee.

8.6 The Scientific Committee considered SC-CAMLR-42/BG/26 and SC-CAMLR-42/BG/27 which provided updates on SOOS and its tools. The recent SOOS Symposium resulted in the release of a 'Southern Ocean community statement' calling for the urgent need of a sustained and integrated Southern Ocean observing system to understand current conditions, predict future states and inform evidence-based decision making. SOOS reminded the Scientific Committee of the SOOS data discovery product, SOOSmap, and that SOOS is keen to continue working with CCAMLR Members to provide missing datasets and add additional datasets to SOOSmap that would be of benefit to CCAMLR. SOOS presented preliminary maps of regional observational coverage and gaps and invited the Scientific Committee's feedback on these maps. SOOS highlighted programs it is partnering with that are of relevance to the Scientific Committee, including the Southern Ocean activities for the UN Decade of Ocean Science, the MEASO Summary for Policy Makers and the recent Antarctic bioDiVersity data infrastructure (ADVANCE) project (the latter is led by the Institute of Natural Sciences, Belgium, and referenced in SC-CAMLR-42/BG/20).

8.7 The Scientific Committee thanked SOOS for its important contributions and data-sharing tools.

8.8 COLTO indicated that its members were collaborating with the SOOS community to utilize toothfish fishing vessels as vessels of opportunity for the collection of high-quality oceanographic data and that they looked forward to presenting this information to the Scientific Committee in 2024 (WG-FSA-2023, paragraphs 4.172 and 4.181).

8.9 Mr Arangio announced the winners of the 2022/23 COLTO–CCAMLR toothfish tag return lottery and thanked all crews and observers for their continued at-sea efforts. First place went to the Australian-flagged vessel *Antarctic Discovery*, second place went to the Korean-flagged vessel *Blue Ocean* and third place went to the Ukrainian-flagged vessel *Koreiz*. COLTO reported that these Antarctic toothfish were recaptured in Subareas 88.1 and 88.2, had been at liberty between 2 and 3 years, and were recaptured between 10 and 210 km away from their release location.

8.10 The Scientific Committee thanked COLTO for its sustained support for science in CCAMLR, including the tag lottery, the tagging workshop and its project to use fishing vessels to collect oceanographic data (paragraph 5.28).

Cooperation within the Antarctic Treaty System

Committee for Environmental Protection

8.11 The Scientific Committee considered SC-CAMLR-42/BG/07 which provided the annual report of the CEP observer to the CCAMLR Scientific Committee. The report noted the steady increase in cooperation between the Scientific Committee and the CEP and provided a summary of the discussion at CEP XXV, held in Helsinki, Finland, from 28 May to 1 June 2023 which considered five topics (climate change, biodiversity and non-native species, species of conservation concern, spatial management and land protection, and ecosystem and environmental monitoring) to be of common interest with the Scientific Committee. Of particular note was progress made in the CEP's planning for the future CEP–SC-CAMLR joint workshop on climate change (paragraph 8.23).

8.12 The Scientific Committee thanked the CEP observer (Dr P. Penhale (USA)) for her informative report and highlighted the importance of the CEP's work to CCAMLR.

Scientific Committee for Antarctic Research

8.13 The Scientific Committee considered SC-CAMLR-42/BG/30 outlining SCAR's recent activities and initiatives, as well as recent research results relevant to the Scientific Committee discussions. SCAR’s Antarctic Environments Portal (www.environments.aq) provides a web-based source of independent and objective scientific information to support the work of decision-makers in the Antarctic Treaty System and has recently published new information summaries on Southern Ocean warming, Antarctic sea ice, krill, and baleen whale recovery. SCAR's scientific research programmes (AntClimNow, INSTANT and AntICON) and subsidiary groups have undertaken a wide range of activities and aim to mobilise the international scientific community to deepen understanding of the impacts of climate change in and around Antarctica and its global implications. SCAR encouraged the Scientific Committee to consider the AntICON project described in SC-CAMLR-42/BG/16 to develop mechanisms to provide information relevant to State of the Environment Reporting – also noting the parallels with recent Scientific Committee discussions on the need for information on the state of Antarctic marine living resources. SCAR also announced that its Open Science Conference with the theme ‘Antarctic Science: Crossroads for a New Hope’ will be held in Pucón, Chile, 19 to 23 August 2024 and welcomed all participants to join.

8.14 SCAR highlighted recent work by its Antarctic Wildlife Health Network (AWHN) in collaboration with COMNAP, the CEP, IAATO and the wider Antarctic community, to develop detailed recommendations and guidelines in preparation for likely outbreaks of HPAI during the coming Antarctic summer season. The AWHN has published a Risk Assessment[1] explaining the heightened risk, with guidelines focused on the protection of human life, prevention of inadvertent spread of the disease through human activity, and surveillance and monitoring. A central reporting database is also being set up by the AWHN with Stony Brook University, PenguinWatch and Oceanites. SCAR encouraged the Scientific Committee to consider this heightened risk and the need for reporting on observed cases, in the context of CCAMLR activities in the Southern Ocean during the coming season.

8.15 SCAR reported in paper SC-CAMLR-42/BG/32 that, in conjunction with the Southern Ocean Task Force, it had recently received support for a Decadal Collaborative Centre for the Southern Ocean, which will facilitate collaboration and coordination and seek to link Southern Ocean science with global ocean science.

8.16 The Scientific Committee noted the range of relevant work being undertaken by SCAR, also highlighting the SKEG Virtual Workshop (20 to 24 March 2023), and the effective collaboration between CCAMLR and SKEG as evidenced by the development of a krill stock hypothesis and its related information collection plan (WG-EMM-2023, Table 1), which will enhance the revision of the krill fishery management approach.

[1] https://scar.org/library/science-4/life-sciences/antarctic-wildlife-health-network-awhn/5973-risk-assessment-avian-influenza/file/

Reports of observers from other international organisations

8.17 The Scientific Committee considered SC-CAMLR-42/BG/13 which highlighted ASOC and its member organisations' intersessional activities in support of Antarctic conservation. ASOC participated in the board annual meeting of the AWR to award grants for research in support of ecosystem-based management of the krill fishery. ASOC partnered with the National Centre for Scientific Research/Museum of Natural History (France) to assess the phylogenetic diversity of the Southern Ocean to aid in conservation planning.

8.18 ASOC indicated that its member organisations supported critical research on Antarctic marine ecosystems. The Pew Bertarelli Ocean Legacy (PBOL) program produced the document 'Connect to Protect: Southern Ocean Conservation for Global Benefits'. In addition, PBOL funded research led by the University of Colorado, Boulder diving into Southern Ocean applications of management for climate resilient fisheries. A summary of this paper was submitted to the CCAMLR climate change meeting (WS-CC-2023/P03). PBOL supported the SKEG virtual workshop in March 2023 and the MEASO summary for policymakers. The World Wide Fund for Nature (WWF) partnered with University of California Santa Cruz and Intrepid Travel in February 2023 to research baleen whales around the Antarctic Peninsula to continue mapping key foraging areas and impacts of climate change on ecosystem health. Furthermore, WWF provided support to the Wildlife from Space initiative (led by the British Antarctic Survey), which discovered a previously unknown emperor penguin colony near Verleger Point in January 2023.

8.19 The Scientific Committee thank ASOC for its valuable contributions to its work.

8.20 Dr K. Reid (FAO) introduced the FAO Deep Sea Fisheries Project (DSF Project), which is a component project of the FAO's Common Ocean's Programme, that is working with fishery management bodies to promote the sustainable management of deep-sea fisheries in Areas Beyond National Jurisdiction. He outlined aspects of the project of particular relevance to the Scientific Committee, including the development of data-limited stock assessment methods for deep-sea fisheries, approaches for the inclusion of the effects of climate change which can be incorporated into fishery assessments and a joint FAO-NAFO symposium in early 2025 on the 'Implementation of the Ecosystem Approach to Fisheries Management'. Dr Reid acknowledged the very extensive expertise that exists in the CCAMLR scientific community on these topics and encouraged scientists with relevant experience and expertise on these topics to contribute to the DSF Project and to help to promote the sustainable management of deep-sea fisheries globally.

8.21 The Scientific Committee thanked FAO for the information on the Deep Sea Fisheries Project and welcomed further collaboration with FAO on these topics.

Reports of representatives at meetings of other international organisations

8.22 The Scientific Committee considered SC-CAMLR-42/BG/34, titled 'Observer's Report for the SC69A Meeting of the Scientific Committee of the International Whaling Commission, Bled, Slovenia, 24 April-6 May 2023', which provided an overview of the recent Southern Ocean-focussed activities of the International Whaling Commission's Scientific Committee (IWC SC), as covered during its 2023 meeting. The Observer's report also provided extracts of meeting report text which reflected the ongoing collaboration between IWC and CCAMLR. The Scientific Committee thanked Dr Kelly and endorsed them as SC-CAMLR's observer to IWC SC and noted its appreciation of the IWC's contribution to the work of CCAMLR.

Future cooperation

8.23 The Scientific Committee noted the joint CEP–SC-CAMLR workshop on climate change expected to be held in 2025 (paragraph 5.30).

Scientific Committee activities

9.1 The Scientific Committee thanked the hosts from Japan and India for organising this year's productive and collaborative meetings of WG-ASAM in Tokyo, and WG-SAM and WG-EMM in Kochi.

9.2 The Scientific Committee commented on the updated version of the work plan from each of the working groups and acknowledged the significant amount of work and progress achieved by the different working groups against their workplans and the 5-year strategic plan for the Scientific Committee approved at SC-CAMLR-42.

9.3 The conveners of the Working Groups highlighted the progress of different tasks, including, for instance, the revised krill fishery management approach (WG-EMM-2023) and the transition from CASAL to Casal2 (WG-FSA-2023) in the assessments for *Dissostichus* spp.

9.4 The Scientific Committee highlighted the importance and urgency of the tasks related with harmonisation of different spatial management initiatives within Subarea 48.1 including the development of diagnostic tools as part of the preparation of stock assessments to implement decision rules for krill (WG-EMM-2023) and an analysis of current and alternative decision rules (WG-FSA-2023). The Scientific Committee noted the significant progress achieved in the last two meetings of WG-IMAF and discussed the necessity of this Working Group to meet every year (paragraph 9.33).

9.5 The Scientific Committee discussed the importance of clear definition of the appropriate working group that will address the revised krill fishery management approach, recognising that discussions on krill have proliferated across the different working groups. It was noted that the importance of this for Members to plan and decide the composition of the delegation that will participate in the different working groups.

9.6 The Scientific Committee noted that WG-EMM was the appropriate Working Group to lead discussions of the different components of the revised krill fishery management approach, while WG-FSA was the group for discussions about specific issues related to stock assessments.

9.7 The Scientific Committee discussed ways of rearranging the current schedule of the working groups to follow the progression of the discussions on the revised krill fishery management approach.

9.8 The Scientific Committee acknowledged the valuable contribution of Dr Chris Darby (UK) during the development of the revised krill fishery management approach, leading of this work and bringing together the different parts of the approach, and wished him well in his retirement.

9.9 The Scientific Committee noted the progress of the detailed tasks of the working groups and encouraged Members to submit papers addressing cross-cutting themes identified by the Scientific Committee in its strategic plan (SC-CAMLR-41, Annex 4) such as the development of ways to improve science communication, mentor newcomers from different backgrounds and also improve inclusion and diversity of representation, perspectives, experiences and cultural backgrounds to the work of the Scientific Committee.

Scientific Committee strategic plan

9.10 CCAMLR-42/06, submitted by the Secretariat, presented a summary of the outcomes to the Second Performance Review, which was conducted in 2017.

9.11 The Scientific Committee welcomed the paper and highlighted this work and noted that the document provides detailed responses by the Scientific Committee to the review through the work conducted as part of the Strategic Plan (SC-CAMLR-41, Annex 4). It endorsed the proposed text for inclusion on the CCAMLR website.

CCAMLR Scientific Scholarships Scheme

9.12 Dr Schaafsma introduced SC-CAMLR-42/BG/36 which presented the outcomes of the review conducted by the Scientific scholarship review panel in 2023. It was noted that the Scientific scholarship review panel reviewed four applications received in this year’s round.

9.13 The Scientific Committee endorsed the recommendations of the Scientific scholarship review panel to award scholarships to Dr X. Mu (China) for work on spatial population characteristics of krill, whose work will be mentored by Drs X. Zhao and S. Kawaguchi. It also recommended to award a scholarship to Ms K. Hoszek (Poland) for work on potential effects of pollutants on trophic dynamics of krill and penguins. Ms. Hoszek will have Drs M. Szymanski (Poland) and J. Hinke (USA) as her mentors.

9.14 The Scientific Committee congratulated Dr Mu and Ms Hoszek and highlighted the importance of the work that will be developed and will contribute to the work conducted by CCAMLR.

9.15 The Scientific Committee noted the importance of the scheme and thanked the Secretariat for the summary showing the large amount of work that the recipients (17 scholarships and 20 papers submitted to working groups) have contributed through the years. It also noted the importance of this scheme in bringing in early career researchers into the work of CCAMLR, highlighting that some of them have taken key roles such as conveners of the working groups or national representatives in Scientific Committee (Figure 7).

Science Fund reporting

9.16 SC-CAMLR-42/BG/04 presented a proposal for the CCAMLR General Capacity Building Fund (GCBF) to support the development of integrated stock assessments for CCAMLR data limited toothfish research fisheries (Cap-DLISA). The proposal aims to request support for training for an in-person session in Cape Town, South Africa in 2024.

9.17 The Scientific Committee noted the importance of the work and the need to build capacity in this area and endorsed the proposal.

9.18 SC-CAMLR-42/BG/25 presented the annual reporting of income and expenditures from the science special funds.

9.19 The Scientific Committee thanked the Secretariat for preparing this comprehensive report and highlighted the success of this fund building capacity for activities within the work of the Scientific Committee. It noted the forecast showing that the GSCF fund will be exhausted after two years' time, highlighting the need for the Commission and Members to consider the maintenance of the funding as it provides key support for conveners and scholarships among other things.

9.20 SC-CAMLR-42/BG/35 presented the summary of the review of a proposal submitted to this year's round of the CEMP Special Fund.

9.21 The review panel reviewed the proposal by Dr S. Labrousse (France) to study the use of tagging crabeater seals to document their under-ice foraging behaviour and the characteristics of krill swarms they hunt.

9.22 The Scientific Committee endorsed the recommendation of the management panel to award partial funding for the proposed research, which will be conducted for two field seasons (A$94 511).

9.23 The Scientific Committee noted the importance of funding these types of studies that consider species that are not necessarily considered as CEMP species. It noted that A$17 600 was requested for maintenance of the CEMP camera network.

9.24 Dr Schaafsma also summarised projects that are receiving funding from the CEMP Special Fund.

9.25 The Scientific Committee noted the importance of exploring ways of increasing diversity for the membership of the management panel. It agreed to invite the incoming Vice-chair Dr L. Ghigliotti (Italy), and Dr M.-A. Lea (SCAR) to join the panel for the next two years to enhance the depth of experience and perspectives in this group.

Modalities of Scientific Committee working group meetings

9.26 SC-CAMLR-42/01 was presented by the Secretariat to inform a discussion by the Scientific Committee on the approach for future intersessional meetings, which could potentially be in-person, AV-streamed, hybrid or online. The paper highlighted the pros and cons of the several meeting forms and provided information regarding the costs of different options. Benefits of hybrid and online meetings include decreased travel expenses, a decreased carbon footprint, and an increased number of people who can participate. Drawbacks of hybrid or AV-streamed meetings include the increased meeting requirements for the host, extra workload for the Secretariat, risk of technology failure and security risks that arise from using online platforms such as Zoom. It was further noted that, if the Scientific Committee would prefer meeting in a hybrid manner in the future, the Secretariat would require an extra person to attend meetings outside Hobart and that this would affect the progress of the regular work of the Secretariat in the CCAMLR Headquarters. It should further be noted that the online and hybrid meetings are very challenging for the Chair and Conveners to manage.

9.27 The Scientific Committee welcomed the paper and mentioned that it was very timely and useful. Members expressed a variety of views regarding the different forms of meetings. Several Members highlighted that hybrid or online meetings generally aid capacity building and allow for the participation of particularly early-career researchers who do not have the funding to join the meetings in person. On the other hand, differences in time zones were regarded as a drawback of online and potentially hybrid meetings, as some of the Members will need to participate at very inconvenient times and there is inequity in how often this occurs among Members. In addition, Members expressed their concerns regarding security during streaming or online meetings, since it is also not possible to know who or how many people are watching, and requested caution when using online platforms. Most Members acknowledged the benefits of meeting in-person, particularly for difficult topics, as it allows for personal interactions in break-out groups and there is more opportunity for dialogue. However, many Members think it is valuable to continue to explore the possibilities of hybrid meetings, especially for focused workshops.

9.28 Several suggestions were made by Members for practical solutions allowing for meetings to be hybrid. One suggestion was that people attending an in-person meeting via an online platform could be enabled to participate in the discussion for certain time frames or to submit papers and discuss these, while they would only be able to listen to discussions during the rest of the meeting. Another suggestion made was that people could send in a recording of their presentation and have someone else present it on their behalf, when unable to attend in-person working group meetings. It was furthermore suggested to focus solutions for online interaction possibilities on meetings held in Hobart, since travelling costs are particularly high for these meetings.

9.29 The Scientific Committee agreed to continue having working group and Scientific Committee meetings in-person. AV-streaming, without interaction possibilities, could be offered for meetings in Hobart, although this should not be expected as default as it requires significant behind-the-scenes administration for the Secretariat, which may have other priorities at certain times. For ad-hoc proposed workshops, the Scientific Committee recommended that the best modality for those can be decided depending on the workshop. The next Scientific Committee symposium was suggested as a good opportunity to review the technology and revisit this topic.

Priorities for work of the Scientific Committee and its working groups

9.30 The Scientific Committee considered the workplans of the working groups which were updated by the working group conveners (Annex 15). The Scientific Committee agreed that the conveners should develop their agendas based on these tables and the strategic plan for the Scientific Committee. Further recommendations to the working groups regarding priority work can be found throughout the report of SC-CAMLR-42.

9.31 The Scientific Committee will use its strategic plan to develop the agenda for next year. The Scientific Committee will add a separate agenda item on Ecosystem Monitoring and Management to this agenda to capture broader discussions on status and trends such as the CEMP review and climate change, and related items within these topics.

Summary of SC-CAMLR supported meetings for 2023/24

9.32 The Scientific Committee endorsed the following meetings and workshops in 2024:

(i) Age Determination Workshop in the USA (22 to 26 April 2024)

(ii) Weddell Sea Phase 2 MPA RMP workshop in Norway (April 2024 TBD)

(iii) WG-ASAM in Cambridge, UK (20 to 24 May 2024)

(iv) WG-SAM in the Netherlands (24 to 28 June 2024)

(v) WG-EMM in the Netherlands (1 to12 July 2024)

(vi) Harmonisation Symposium (TBD) after WG-EMM-2024

(vii) CEMP review focus topic (part of WG-EMM-2024)

(viii) Joint meeting of WG-IMAF and WG-FSA in Hobart (30 September to 11 October 2024)

(ix) Scientific Committee in Hobart (14 to 18 October 2024).

Invitation of experts and observers to meetings of working groups and workshops

9.33 The Scientific Committee agreed that WG-IMAF and WG-FSA will be convened as a joint meeting in 2024, noting that WG-IMAF will address a more focused agenda.

9.34 The Scientific Committee encouraged Members to provide acoustic experts for participation in WG-ASAM and invite ARK to send experts to discussions at WG-ASAM. The Scientific Committee also recommended that ACAP, IWC, COLTO, and ARK be invited to send experts to contribute to discussions relating to WG-IMAF.

9.35 The Scientific Committee discussed the value of providing additional Member scientists and invited experts with meeting-specific access to the CCAMLR website for specific workshops and working groups, noting that this could facilitate greater participation. The Secretariat noted that this may be possible when the website is upgraded.

9.36 The Scientific Committee noted that terms of reference for the working groups have been updated and recommended that the Secretariat make them (as well as their previous versions) available associated with each respective meeting website. The Scientific Committee also agreed that the terms of reference for each group should be made available at each meeting.

Next meeting

9.37 The next meeting of the Scientific Committee will be held at the CCAMLR Headquarters building (181 Macquarie Street) in Hobart, Australia, from 14 to 18 October 2024.

Secretariat supported activities

10.1 The Scientific Committee considered CCAMLR-42/BG/07 which summarised the update on data system improvements prepared by the Secretariat. The Scientific Committee noted that while this is still work in progress, a significant improvement had been accomplished in specific compliance-related data systems and in the Secretariat's ability to load vessel data into its databases. The Scientific Committee also noted that this work had been supported by a grant provided by the EU (Ref. 101092707).

10.2 The Scientific Committee considered CCAMLR-42/BG/33 Rev. 1 which summarised the science support provided by the Secretariat. An update of activities tasked by the Scientific Committee in 2022 (SC-CAMLR-41, paragraph 11.6 and Table 12) was provided in Table 1 of the paper.

10.3 The Scientific Committee noted the successful development of an agreement with SIOFA in 2022 on a procedure for sharing toothfish data and endorsed a similar arrangement the Secretariat developed with the SPRFMO Secretariat (Annex 18).

10.4 The Scientific Committee noted that, following the request in SC-CAMLR-41, paragraph 3.20, the Secretariat had liaised with Peru during the intersessional period to seek access to their historical acoustic survey data. The Scientific Committee welcomed the development of a MoU between Peru and CCAMLR to share data consistent with CCAMLR's data access rules.

10.5 The Scientific Committee thanked Peru for its valuable cooperation and noted the interest of Peru to be further involved in CCAMLR working groups. The Scientific Committee invited experts from Peru to participate in the ASAM and EMM Working Groups to further engage with and support the work of CCAMLR.

10.6 The Scientific Committee noted that the Secretariat had made the data submitted to the CMIR public (SC-CAMLR-41, paragraph 6.19) and recommended that the Secretariat modify the existing CMIR to maintain user access and simplify storage of baseline data.

10.7 The Scientific Committee noted that several CCAMLR science papers have been peer reviewed, edited, converted to journal format and are in the process of posting on the CCAMLR website as the components of a new issue of *CCAMLR Science*. Additional papers are being finalised in the review and layout processes and will be posted as they are completed.

10.8 The Scientific Committee thanked the Secretariat for its efficient work of CCAMLR activities.

10.9 The Scientific Committed considered SC-CAMLR-42/BG/06 which introduced the implementation of the CCAMLR data request procedure and the CCAMLR procedure for publication of derived materials in the public domain.

10.10 The Scientific Committee discussed the process and considered that it will be useful to continue to report the number of data requests processed and their outcomes and considered that it will be useful to understand the reasons for any request rejections.

10.11 The Secretariat noted that there were no systematic issues causing rejections and that the reasons for rejections were case specific.

10.12 The Scientific Committee refined the diagrams of data access procedures tabled in SC-CAMLR-42/BG/06 (Annex 19) and requested that Members develop these preliminary diagrams in the intersessional period and further update them so that they can be published on the CCAMLR website.

Budget for 2023/24

11.1 The Scientific Committee noted paper CCAMLR-42/04 and thanked the Secretariat for providing a review of the 2023 budget and forecasted budget for 2024. They noted the format of the paper had been revised to present the budget in a simpler and more comprehensive way than in previous years.

Advice to SCIC and SCAF

12.1 The Chair of the Scientific Committee attended a session of SCIC to discuss scientific elements of SCIC's business.

12.2 The Chair of the Scientific Committee reported to SCAF on several topics, including:

(i) a CEMP Special Fund Proposal recommendation (A$94 511 over 2 years, max A$50 000 in one year)

(ii) a summary of the General Science Capacity Fund which included supporting scholarships for 2024, Convener's travel assistance, and travel assistance for experts to the Age Determination Workshop.

(iii) endorsement of a GCBF proposal (SC-CAMLR-42/BG/04) for A$30 000 as an important item to progress stock assessment development.

Election of Scientific Committee Chair

13.1 The Scientific Committee noted that following rule 8 of the Scientific Committee Rules of Procedure a new Chair and one of the two Vice-Chair positions were to be elected at this meeting.

13.2 The Senior Vice-Chair, Dr Schaafsma, opened the floor to nominations for a new Chair. Dr Cárdenas was elected by acclamation to the position as Chair. The Scientific Committee noted Dr Cárdenas had done an excellent job convening WG-EMM from 2019 to 2023 and was looking forward to his chairing of the Scientific Committee.

13.3 Dr Cárdenas gratefully accepted the position and thanked the Chair and the Scientific Committee for their support. Dr Cárdenas recognised the importance of the task and the honour given to him, and indicated he looked forward to collaboratively achieving sound scientific advice for the Commission.

13.4 As his term as WG-EMM Convener had ended, Dr Cárdenas nominated Dr Hinke to replace him in this role. The Scientific Committee endorsed this, enthusiastically welcomed Dr Hinke in his new role and looked forward to working with him.

13.5 Dr Schaafsma's term as Senior Vice-Chair ended with this meeting and the Junior Vice-Chair, Dr A. Lowther became Senior Vice-Chair for 2024.

13.6 The Scientific Committee thanked Dr Schaafsma for her excellent work, including her chairing when the Chair was reporting to SCIC and SCAF, and welcomed Dr Lowther to his new role.

13.7 The Scientific Committee sought nominations for a new Junior Vice-Chair. Dr Ghigliotti was unanimously elected to the position for a term of two regular meetings (2024 and 2025). A very warm welcome was extended to the incoming Junior Vice-Chair, who thanked the Scientific Committee for this honour.

Other business

14.1 The Scientific Committee noted CCAMLR-42/24 Rev. 1 which presented a draft Code of Conduct for CCAMLR in-person and virtual meetings, workshops, working groups, and events. Recalling that CCAMLR-41/02 had noted that there were no specific policies in place covering behaviours of attendees at CCAMLR meetings, and that the Secretariat had received occasional reports where either staff or other attendees of CCAMLR meetings were subject to inappropriate behaviour, the Code was collaboratively developed via an e-group led by Australia. The draft Code of Conduct defines expected professional behaviours, as well as unacceptable behaviours at CCAMLR events. A reporting process and remediation actions are outlined for CCAMLR events taking place at CCAMLR Headquarters or elsewhere in Australia.

14.2 Although the Scientific Committee welcomed the document and noted it was important to have clear expectations on how participants worked together during meetings, it did not have time to discuss it.

14.3 The Scientific Committee discussed its working group's terms of reference and requested the Secretariat make them available on an easily accessible page on the CCAMLR website, along with their past versions, as browsing their history would be valuable.

14.4 The Scientific Committee discussed the benefits and drawbacks of the current e-group system and requested that the Secretariat investigate online platforms for engagement between Members that would improve the current e-group platform for intersessional collaboration, as well as having the ability to control read and write access for Members and invited experts across the various e-groups.

14.5 The Scientific Committee recognised Sandra Hale for her 30 years' experience as English/Spanish interpreter supporting many CCAMLR meetings and warmly thanked her, noting the crucial contribution of interpreters to CCAMLR's work.

14.6 The Scientific Committee recognised Floride Pavlovic (French Translator/Coordinator at the Secretariat) for her outstanding service. It noted that this was her 34th and last Scientific Committee meeting, recalled her attention to detail and passion, and wished her well in her retirement.

14.7 The Scientific Committee enthusiastically thanked Dr Enrique Marschoff (Argentina) for his enormous contribution to the conservation of Antarctic marine living resources, his wise and humorous personality, and his mentoring of early career scientists. The Scientific Committee wished him well in his retirement.

Adoption of the report of the forty-second meeting

15.1 The report of the meeting was adopted requiring 8 h and 37 min of discussion.

15.2 The Scientific Committee congratulated Dr Watters for his significant contributions now spanning 30 years of CCAMLR meetings, noting the Commission acknowledged his long and dedicated service with a coveted 'Wombat' award.

15.3 At the close of the meeting, Dr Watters took off his hat to Dr Penhale in celebration of her many contributions to CCAMLR and the CEP and joined the Scientific Committee in thanking her for all she has done throughout her career for the Antarctic and the Southern Ocean and wishing her a happy retirement.

15.4 Dr Penhale thanked Dr Watters and the Scientific Committee for the opportunities to build a career from contributions to Antarctic conservation.

15.5 Dr Watters thanked Dr Welsford, on the occasion of completing his last Scientific Committee meeting as Chair, for his leadership, focus on tasks, significant scientific contributions. He was joined by many others, recalling Dr Welsford's scientific leadership, integrity, challenges of chairing meetings during the Covid-19 pandemic, progress made on important issues through his ability to foster consensus, and distinguished service to fulfilling the objective of the Convention.

15.6 Mr Walker along with thanking Dr Watters, Dr Penhale and Dr Welsford also recognised the dedication of Members to the work of the Scientific Committee, including those who are experiencing conflict in their country, have suffered personal loss during the meetings or have family issues, but are still attending and contributing to the work of the Scientific Committee.

15.7 Dr Welsford thanked the Scientific Committee for their kind words and the privilege of chairing the Scientific Committee in discussions concerning such important conservation topics. He thanked the many people supporting him in his role and providing him the opportunities to contribute. He noted that although Antarctica is an abstract concept to many in CCAMLR, the collegial scientific interactions and unique passion among participants binds everyone together to progress conservation in Antarctica.

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Table 1. Precautionary catch limits for *Euphausia superba* in Division 58.4.1.

Division	Subregion	Longitude range	Biomass (million tonnes)[1]	Precautionary harvest rate	Catch limit (t)
58.4.1	West	80–103°E	1.567	0.0847	132 725
58.4.1	Middle	103–123°E	0.643	0.0847	54 462
58.4.1	East	123–150°E	2.114	0.0847	179 056
58.4.1	Total	80–150°E			366 243

[1]Biomass estimates from Abe et al. (2023a, Table 1).

Table 2. Precautionary catch limits for *Euphausia superba* in Division 58.4.2.

Division	Subregion	Longitude range	Biomass (million tonnes)[1]	Precautionary harvest rate	Catch limit (t)
58.4.2	West	30-55°E			1 448 000*
58.4.2	East	55-80°E	6.480	0.0860	557 280
58.4.2	Total	30-80°E			2 005 280

* Catch limit from Conservation Measure 51-03, paragraph 3.
[1] Biomass estimate from Cox et al. (2022).

Table 3: Proposed precautionary krill catch limits (tonnes) for consideration by the Commission.

Subarea/ division	Fishing area	Target species	Catch limit		Trigger level		Conservation measure
			current	proposed	current	proposed	
58.4.1[1]	58.4.1 West (80°E to 103°E)	*E. superba*	440 000[1]	132 725	-	-	51-02
	58.4.1 Middle (103°E to 123°E)	*E. superba*		54 462	-	-	51-02
	58.4.1 East (123°E to 150°E)	*E. superba*		179 056	-	-	51-02
58.4.2	58.4.2 West (30°E to 55°E)	*E. superba*	1 448 000	1 448 000	260 000	260 000	51-03
	58.4.2 East (55°E to 80°E)	*E. superba*	1 080 000	557 280	192 000	192 000	51-03

[1] In CM 51-02 (2008) the catch limit of 440 000 tonnes for *E. superba* in 58.4.1 was split into 277 000 tonnes West of 115°E and 163 000 tonnes east of 115°

Table 4: Proposed precautionary finfish catch limits (tonnes) for consideration by the Commission for 2023/2024. AUS – Australia; CHL – Chile; ESP – Spain; FRA – France; GBR– United Kingdom; JPN – Japan; KOR – Republic of Korea; NAM – Namibia; NOR – Norway; NZL – New Zealand; RUS – Russian Federation; UKR – Ukraine; URY – Uruguay.

Subarea/ division	Fishing area	Target species	Target species catch limit (t) 2022/23	Target species catch limit (t) 2023/24	*Macrourus* spp. Catch limit (t)	Skates and rays Catch limit (t)	Other species (t)	Conservation measure	Notified Members (2023/24)
48.3	48.3	*C. gunnari*	1 708	5 138			See CM 33-01	33-01, 42-01	Not applicable
48.3	48.3A	*D. eleginoides*	-	-	-	-	See CM 33-01		Not applicable
	48.3B	*D. eleginoides*	-	600	-	-	See CM 33-01		Not applicable
	48.3C	*D. eleginoides*	-	1 400	-	-	See CM 33-01		Not applicable
	Total	*D. eleginoides*	-	2 000	-	-	See CM 33-01		Not applicable
48.4	48.4_SSI	*D. eleginoides*	23	19				41-03	Not applicable
	48.4_SSI	*D. mawsoni*	42	43				41-03	Not applicable
48.6	48.6_2	*D. mawsoni*	123	148	23	7	23	33-03, 41-04	ESP, JPN
	48.6_3	*D. mawsoni*	37	42	6	2	6	33-03, 41-04	ESP, JPN
	48.6_4	*D. mawsoni*	157	126	20	6	20	33-03, 41-04	ESP, JPN
	48.6_5	*D. mawsoni*	168	202	32	10	32	33-03, 41-04	ESP, JPN
	Total	*D. mawsoni*	485	518	-	-	-		
58.4.1	58.4.1_1[1]	*D. mawsoni*	138	112 (50 sets)	17	5	17	33-03, 41-11	AUS, ESP, FRA, JPN, KOR
	58.4.1_2[1]	*D. mawsoni*	139	80 (50 sets)	12	4	12	33-03, 41-11	AUS, ESP, FRA, JPN, KOR
	58.4.1_3[1]	*D. mawsoni*	79	79 (60 sets)	12	3	12	33-03, 41-11	AUS, ESP, FRA, JPN, KOR
	58.4.1_4[1]	*D. mawsoni*	46	46 (30 sets)	7	2	7	33-03, 41-11	AUS, ESP, FRA, JPN, KOR
	58.4.1_5[1]	*D. mawsoni*	60	116 (50 sets)	18	5	18	33-03, 41-11	AUS, ESP, FRA, JPN, KOR
	58.4.1_6[1]	*D. mawsoni*	104	50 (50 sets)	8	2	8	33-03, 41-11	AUS, ESP, FRA, JPN, KOR
	Total	*D. mawsoni*	566	483	-	-	-	33-03, 41-11	AUS, ESP, FRA, JPN, KOR
58.4.2	58.4.2_1	*D. mawsoni*	86	103	16	5	16	33-03, 41-05	AUS, FRA
	58.4.2_2	*D. mawsoni*	258	206	32	10	32	33-03, 41-05	AUS, FRA
	Total	*D. mawsoni*	344	309	-	-	-	33-03, 41-05	AUS, FRA

(continued)

Table 4 (continued)

Subarea/ division	Fishing area	Target species	Target species catch limit (t)		*Macrourus* spp.	Skates and rays	Other species (t)	Conservation measure	Notified Members (2023/24)
			2022/23	2023/24	Catch limit (t)	Catch limit (t)			
58.5.2	HIMI	*C. gunnari*	2616	714			See CM 33-02	42-02, 33-02	Not applicable
	HIMI	*D. eleginoides*	3 010	2 660			See CM 33-02	41-08, 33-02	Not applicable
88.1	North of 70° S	*D. mawsoni*	664	649	103	32	32	41-09	AUS, CHL, ESP, FRA, GBR, JPN, KOR, NAM, NZL, RUS, UKR, URY
	South of 70° S	*D. mawsoni*	2 307	2 256	316	112	112	41-09	AUS, CHL, ESP, FRA, GBR, JPN, KOR, NAM, NZL, RUS, UKR, URY
	SRZ	*D. mawsoni*	425	525	72	26	26	41-09	AUS, CHL, ESP, FRA, GBR, JPN, KOR, NAM, NZL, RUS, UKR, URY
	Shelf Survey	*D. mawsoni*	99	69	-	-	-	41-09	NZL
	Total	*D. mawsoni*	3 495	3 499	491	169	169	41-09	
88.2	88.2_1	*D. mawsoni*	230	184	29	9	29	33-03, 41-10	AUS, CHL, ESP, FRA, GBR, JPN, KOR, NAM, NZL, RUS, UKR, URY
	88.2_2	*D. mawsoni*	268	322	53	16	53	33-03, 41-10	AUS, CHL, ESP, FRA, GBR, JPN, KOR, NAM, NZL, RUS, UKR, URY
	88.2_3	*D. mawsoni*	208	242	38	12	38	33-03, 41-10	AUS, CHL, ESP, FRA, GBR, JPN, KOR, NAM, NZL, RUS, UKR, URY
	88.2_4	*D. mawsoni*	185	222	35	11	35	33-03, 41-10	AUS, CHL, ESP, FRA, GBR, JPN, KOR, NAM, NZL, RUS, UKR, URY
	88.2H	*D. mawsoni*	122	146	23	7	23	33-03, 41-10	AUS, CHL, ESP, FRA, GBR, JPN, KOR, NAM, NZL, RUS, UKR, URY
	Total	*D. mawsoni*	1 013	1116					

(continued)

Table 4 (continued)

Subarea/ division	Fishing area	Target species	Target species catch limit (t)		*Macrourus* spp.	Skates and rays	Other species (t)	Conservation measure	Notified Members (2023/24)
			2022/23	2023/24	Catch limit (t)	Catch limit (t)			
88.3	88.3_1	*D. mawsoni*	16	13	2	0.6	2	24-05	KOR, UKR
	88.3_2	*D. mawsoni*	20	20	3	1	3	24-05	KOR, UKR
	88.3_3	*D. mawsoni*	48	38	6	1	6	24-05	KOR, UKR
	88.3_4	*D. mawsoni*	48	38	6	1	6	24-05	KOR, UKR
	88.3_5	*D. mawsoni*	8	8	1	0.4	1	24-05	KOR, UKR
	88.3_6[2]	*D. mawsoni*	36	43 (15 sets)	6	2	6	24-05	KOR, UKR
	88.3_7[2]	*D. mawsoni*	36	43 (15 sets)	6	2	6	24-05	KOR, UKR
	88.3_8[2]	*D. mawsoni*	10	10 (10 sets)	1	0.5	1	24-05	KOR, UKR
	88.3_9[2]	*D. mawsoni*	10	10 (10 sets)	1	0.5	1	24-05	KOR, UKR
	88.3_10[2]	*D. mawsoni*	10	10 (10 sets)	1	0.5	1	24-05	KOR, UKR
	Total	*D. mawsoni*	242	233	-	-	-		

[1] Catch limit for effort-limited research fishing as per WG-SAM-2023/03.
[2] Catch limit for effort-limited research fishing as per WG-FSA-2023/20.

Table 5: Catch allocation options in the Ross Sea region. N70 – North of 70° South latitude management area; S70 – South of 70° South latitude management area; SRZ – special research zone.

Area		Method 1	Method 2	Method 3
		Method consistent with CM 24-01 and CM 91-05	Method used in 2017/18–2018/19	Method used in 2019/20–2022/23
North of 70° S		649	652	665
South of 70° S		2 256	2 263	2 309
SRZ		525	515	456
Shelf Survey		69	69	69
Total	3499	3 499	3 499	3 499
N70	Skates (5%)	32	32	33
	Macrourids (16%)	103	104	106
	Other (5%)	32	32	33
S70	Skates (5%)	112	113	115
	Macrourids (388 t)	316	316	316
	Other (5%)	112	113	115
SRZ	Skates (5%)	26	25	22
	Macrourids (388 t)	72	72	72
	Other (5%)	26	25	22
Total	*Macrourids*	491	492	494

Table 6a: Expected effects and risks of climate change on Antarctic Marine Living Resources from the 2023 Climate Change Workshop.

WS-CC-23 paragraph	Advice
1.15	The Workshop encouraged Members to supply relevant data to SOOS noting that SOOSmap is a data discovery tool, comprising circumpolar standardised and curated data. The Workshop recommended that the Scientific Committee tasks the Secretariat with liaising with SOOS to develop information for use by CCAMLR.
1.28	The Workshop recommended that Scientific Committee collate a list of important variables to be monitored following an extreme event to facilitate a coordinated and timely response to such events and their physical/biological effects both on marine components and land-based predators.
1.32	The Workshop recommended the Scientific Committee continue the collaboration with SCAR to address CCAMLR specific science needs, by making further requests for specific information from SCAR.
1.39	The Workshop welcomed the paper and recognised the importance of collaboration between IWC and CCAMLR, noting that Dr N. Kelly (Australia) is the SC-IWC observer to SC-CAMLR and vice versa, and recommended that the collaboration continues, especially noting the importance of considering marine mammals in the current enhancement of the CCAMLR Ecosystem Monitoring Program (CEMP) (WG-EMM-2023, paragraph 5.14).
1.48	The Workshop recommended that the Scientific Committee request advice from SCAR to help develop a framework for using climate models to drive ecological projections for AMLR and dependent and related species.
1.52	The Workshop recommended that the Scientific Committee develop a catalogue of the different types of extreme events, their time scales and the species and life stages that they are likely to affect (building for example on information in WS-CC-2023/12) which would be a useful aid to communicating data needs to climate modellers.

Table 6b: Recommendations on spatial management approaches to ensure objective of the Convention is met from the 2023 Climate Change Workshop.

WS-CC-23 paragraph	Advice
2.11	The Workshop recommended that Scientific Committee review this[1] approach for the adaptation of fisheries management to climate change within CCAMLR.
2.24	The Workshop noted that the paper (WS-CC-2023/2) raised useful issues and actions for consideration by Scientific Committee (WS-CC-2023, Table 1) for integrating climate change into the CCAMLR fisheries management processes, including: (i) Work with adjacent RFMOs and RMBs to identify potential for range shifts due to climate change of exploited species/species of interest, and produce a list of species/stocks straddling or likely to straddle CAMLR Convention Area, as well as identifying data sharing needs; (ii) Work with relevant RFMOs/RMBs to exchange knowledge of ecosystem impacts of climate change, and lessons learned in incorporating climate change into their activities; (iii) Identify any non-target species within the CAMLR Convention Area likely to increase in commercial importance; (iv) Review data collection programmes related to the fisheries to ensure they are adequate to detect significant changes in species life history parameters and distribution that affect management; (v) Develop methods to incorporate the effects of projected climate change on assumed recruitment patterns or uncertainty for toothfish recruitment into assessment projections; (vi) Develop a workflow to incorporate information on the effects of climate change in management advice and alternative management approaches, including long term change in spatial distributions and inclusion of climate change projections.
2.26	The Workshop recommended that the Scientific Committee consider how often stock assessment parameters should be updated and noted that reference points may be non-stationary under the effects of climate change (Szuwalski et al., 2023).

[1] WS-CC-2023/02 - Adaptation of fisheries management Handbook to climate change

Table 6c: Recommendations related to Information, including monitoring and metrics, needed to support management decisions, and mechanisms to develop and integrate these from the 2023 Climate Change Workshop.

WS-CC-23 paragraph	Advice
3.15	The Workshop recommended that the Scientific Committee identify specific climate variables and metrics for which data are already, or could be, collected, that would be useful in communicating the status of AMLR through time. These should be prioritised in terms of their relevance to CCAMLR and may be specific to individual regions as environmental drivers and marine ecology may vary spatially.
3.18	The Workshop recommended that the Scientific Committee consider forwarding the report from this Workshop to the CEP in order to assist with planning for the proposed joint CEP/SC-CAMLR workshop.
3.22	The Workshop recommended the Scientific Committee consider ways to develop a glossary of climate related terms, definitions, best practices, and standards to aid in the selection and communication of essential variables, climate models and emission scenarios.
3.25	The Workshop recommended that the Scientific Committee consider the development of a risk assessment for management responses to extreme events. It would be useful to seek further information on whether such assessments are already being undertaken, recognising the considerable resources required for such work. The Workshop noted that there is value in running multiple scenarios, including examining 'large ensemble' datasets (for which climate models are run up to 50-100 times) to examine the probability and frequency of extreme events, and that it is useful to understand shorter temporal variability as well as longer term projections.
3.29	The Workshop recommended that the Scientific Committee considers how information on projected short-term (interannual, multi-year) and long-term (decadal) changes to the recruitment of toothfish should be taken into account in the context of CCAMLR's principles of conservation and decision rules.
3.35	The Workshop recommended that SC develop a template report for monitoring the potential effects of environmental variability and climate change on stock assessments and key stock productivity parameters, for inclusion in the annual CCAMLR Fishery Reports (WS-CC-2023/20, Table 1).
3.39	The Workshop recommended that the Scientific Committee include further detail on tasks relevant to climate change in its work plan, with the objective of identifying and progressing the work necessary to ensure that CCAMLR can continue to meet its objectives as stated in Article II of the CAMLR Convention in a changing climate. This work is likely to include research and modelling as well as testing and possible refinement of management approaches. In developing this work plan, the SC should consider the elements summarised in WS-CC-2023 Tables 5.1 and 5.2.
3.40	The Workshop further recommended that the Scientific Committee identify ways to address the following immediate priorities: (i) Update the fishery reports to include more information on the potential effects of climate change on harvested species and stocks, and management response to these effects (paragraph 3.35); (ii) Develop a web page to explain CCAMLR's response to climate change to the public.

Table 7: Data collection requests for scientific observers in krill fishery relating to Working Groups' Terms of References.

Working Group	Priority questions from WG terms of reference to be addressed by krill fishery observer data	Details of data requirements (number of samples, the spatial and temporal scales required) to address these questions
EMM	(i) The status of krill	Krill length and maturity, 200 individuals randomly sampled everyday according to revised krill protocol 2023 to inform krill status and inform KSH
	(ii) To evaluate predator/prey/fisheries interactions and their relationships to environmental features and including the role of fish in the ecosystem	Identify all by-catch species, their weight and number present from one 25 kg sample from an individual haul.
FSA	(i) The status and management of fish stocks in the Convention Area, including ecological risk assessments	Identify all by-catch species, their weight and number present from one 25 kg sample from an individual haul.
ASAM	To provide advice to the Scientific Committee, its Members, and its working groups on: (iii) technical advice for the collection of acoustic data on board fishing vessels (iv) analyses of acoustic data collected from CCAMLR-nominated transects and submitted to the Secretariat.	Krill length samples to be collected by observers during sampling trawls conducted during a nominated acoustic transect, and 2 trawls (1 stratified, 1 target if an opening/closing net, and 2 stratified if an open net) a day along acoustic transects following the CCAMLR 2000 recommendation. Krill morphological data, for example, sex, maturity stages and weight (wet mass), to be collected, because they also influence TS as well as ecological studies. All krill should be measured in samples with fewer than 150 individuals. For larger krill catches, a minimum of 150 krill should be measured and stage determined.
	(1) Target Species: Krill (a) Develop methods to estimate biomass for krill	
	(2) Target Species: Fish (c) Develop methods to estimate biomass for finfish	Biological information of the targeted fish species and by-catch species (i.e. catch composition, length and weight) to be collected.
ASAM	*(3) Ecosystem impacts* (a) Ecosystem monitoring (i) Structured ecosystem monitoring programs	All krill should be measured in samples with fewer than 150 individuals. For larger krill catches, a minimum of 150 krill should be measured and stage determined. (WG-ASAM-2023, paragraph 4.17)

(continued)

Table 7 (continued)

Working Group	Priority questions from WG ToR to be addressed by krill fishery observer data	Details of data requirements (number of samples, the spatial and temporal scales required) to address these questions
IMAF	(i) The level and significance of direct impacts of interactions and incidental mortality associated with fishing (seabirds)	Trawl warp strikes. Conduct warp-strike observation for at least 2.5% of trawl time (2023/24) and 5% of trawl time (2024/25 season onwards).
	(i) The level and significance of direct impacts of interactions and incidental mortality associated with fishing (seabirds)	Record mortality, injury and entanglement of seabirds. The level of observation will vary between fisheries, and on the tasking of the observer. It is essential that the proportion of fishing effort observed is recorded to allow estimation of total incidental mortality.
	(i) The level and significance of direct impacts of interactions and incidental mortality associated with fishing (marine mammals)	Record mortality, injury and entanglement of marine mammals. The level of observation will vary between fisheries, and on the tasking of the observer. It is essential that the proportion of fishing effort observed is recorded to allow estimation of total incidental mortality.
	(i) The efficacy of mitigation measures and avoidance techniques currently in use, and improvements to them, taking into account experience from both inside and outside the Convention Area	Record interaction of marine mammals with fishing vessels and gear. During each haul or trawl observation period, record any interactions with the vessel that do not result in mortality, injury or entanglement.

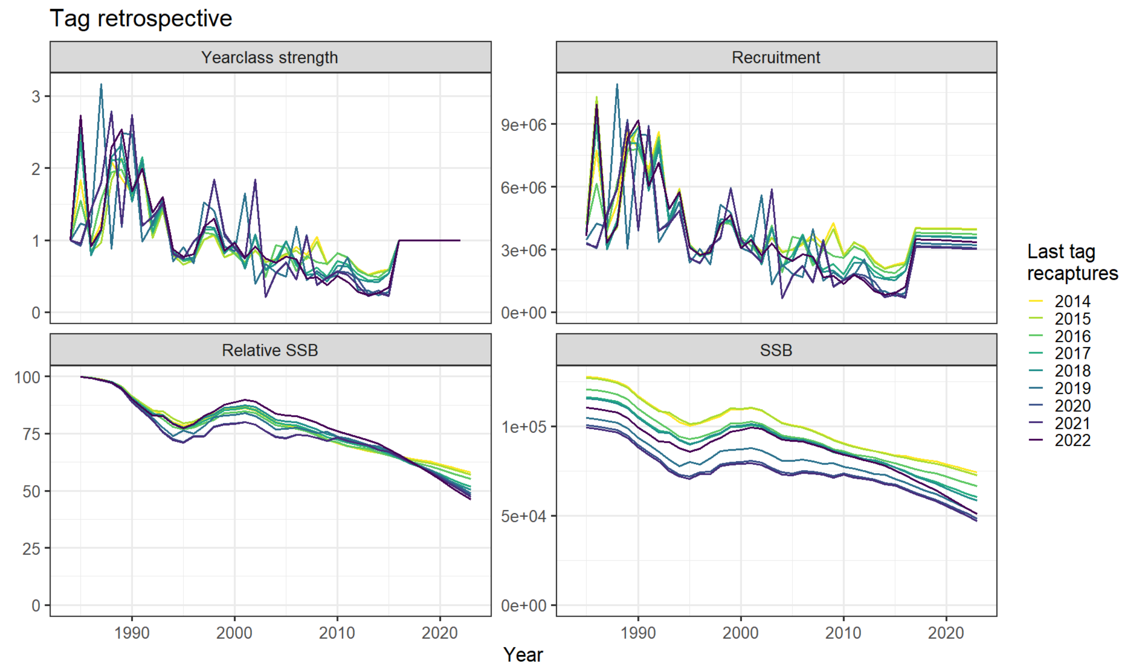

Figure 1: Estimated year class strength, recruitment, relative spawning stock biomass and spawning stock biomass, from the tagging retrospective analysis for the *D. eleginoides* stock assessment in Subarea 48.3 where tagging data were removed year-by-year from the 2023 stock assessment. Note that the 2023 stock assessment used tag recapture data up to 2022.

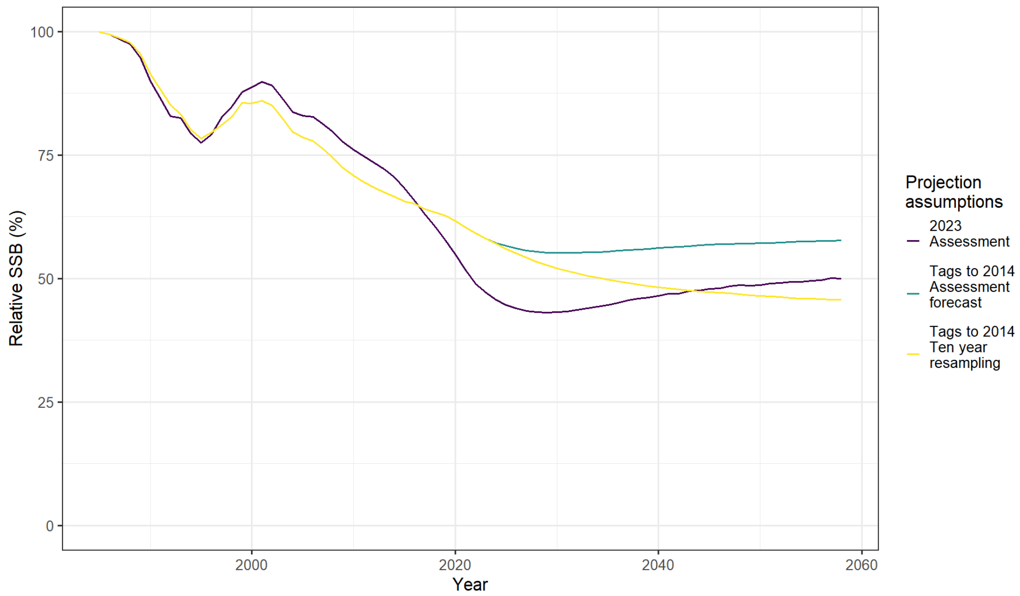

Figure 2: Maximum of the posterior distribution (MPD) from the toothfish stock assessment in WG-FSA-2023/15 Rev. 1 and median projection forward applying a 0.85 multiplier to the lognormal-empirical distribution from 1993-2016 estimated year class strength time series (purple line) for *D. eleginoides* in Subarea 48.3, and the retrospective run with tagging data up to 2014 and median projection forward with the same recruitment assumption as in WG-FSA-2023/15 Rev. 1 (green line) and resampling the last ten years of estimated recruitment (yellow line). All projections assume the proposed catch limit of 2 000 tonnes and 98 tonnes of depredation from WG-FSA-2023/15 Rev.1.

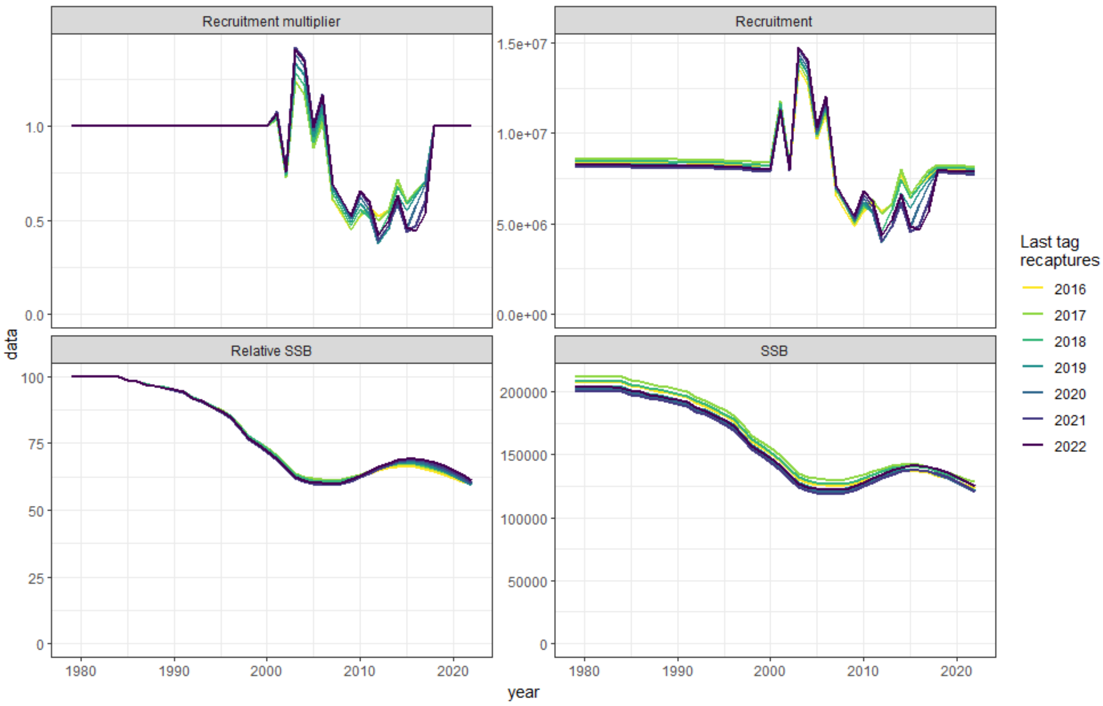

Figure 3: Estimated recruitment multiplier, recruitment, relative spawning stock biomass and spawning stock biomass from the tagging retrospective analysis for *D. eleginoides* in Division 58.5.1 where tagging data were removed year-by-year from the 2023 stock assessment. Note that the 2023 assessment used tag recapture data up to 2022.

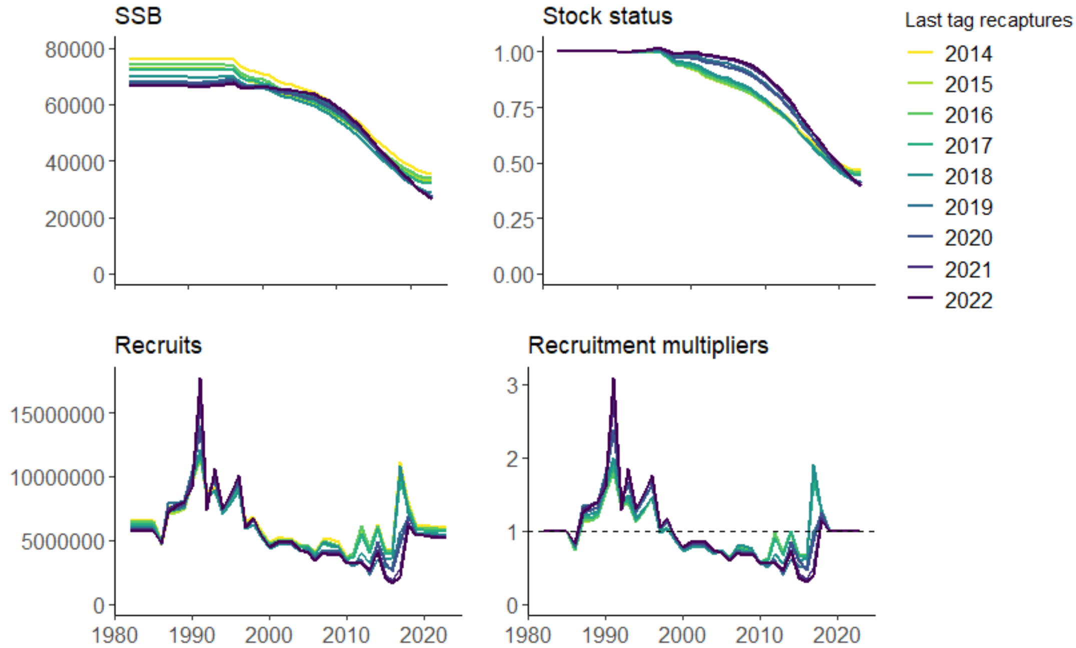

Figure 4: Estimated spawning stock biomass, relative spawning stock biomass (stock status), recruitment and recruitment multipliers from the tagging retrospective analysis for the *D. eleginoides* stock assessment in Division 58.5.2 where tagging data were removed year-by-year from the 2023 stock assessment. Note that the 2023 stock assessment used tag recapture data up to 2022.

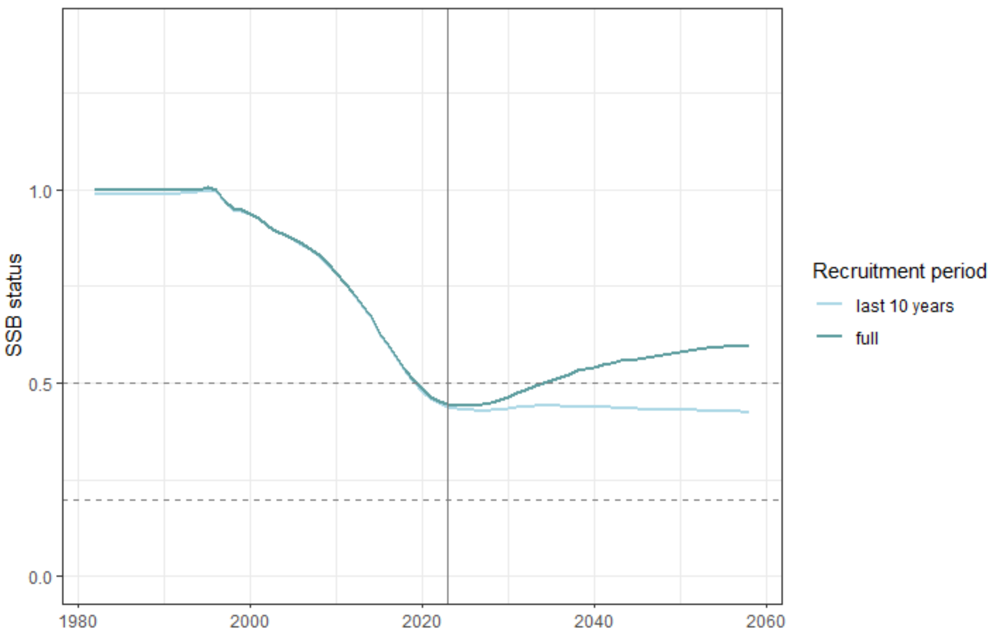

Figure 5: Maximum of the posterior distribution (MPD) of the retrospective run with tagging data up to 2018 and median projection forward with the catch limit of 2 660 tonnes proposed by WG-FSA-2023/26 Rev. 1 and recruitment sampled from either the full estimated recruitment time series (1986-2017) or from only the last 10 years of estimated recruitment (2008-2017) for *D. eleginoides* in Division 58.5.2.

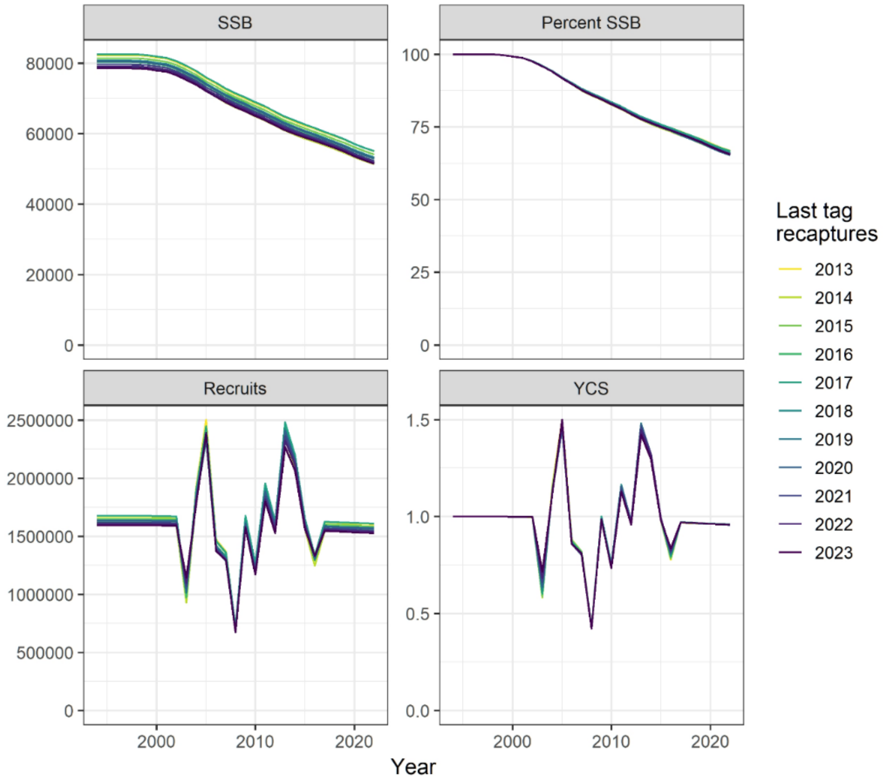

Figure 6: Estimated spawning stock biomass, percent spawning stock biomass, recruitment, and relative year class strength from the tagging retrospective analysis for *D. mawsoni* in Subareas 88.1 and 88.2AB where tagging data were removed year-by-year from the 2023 stock assessment.

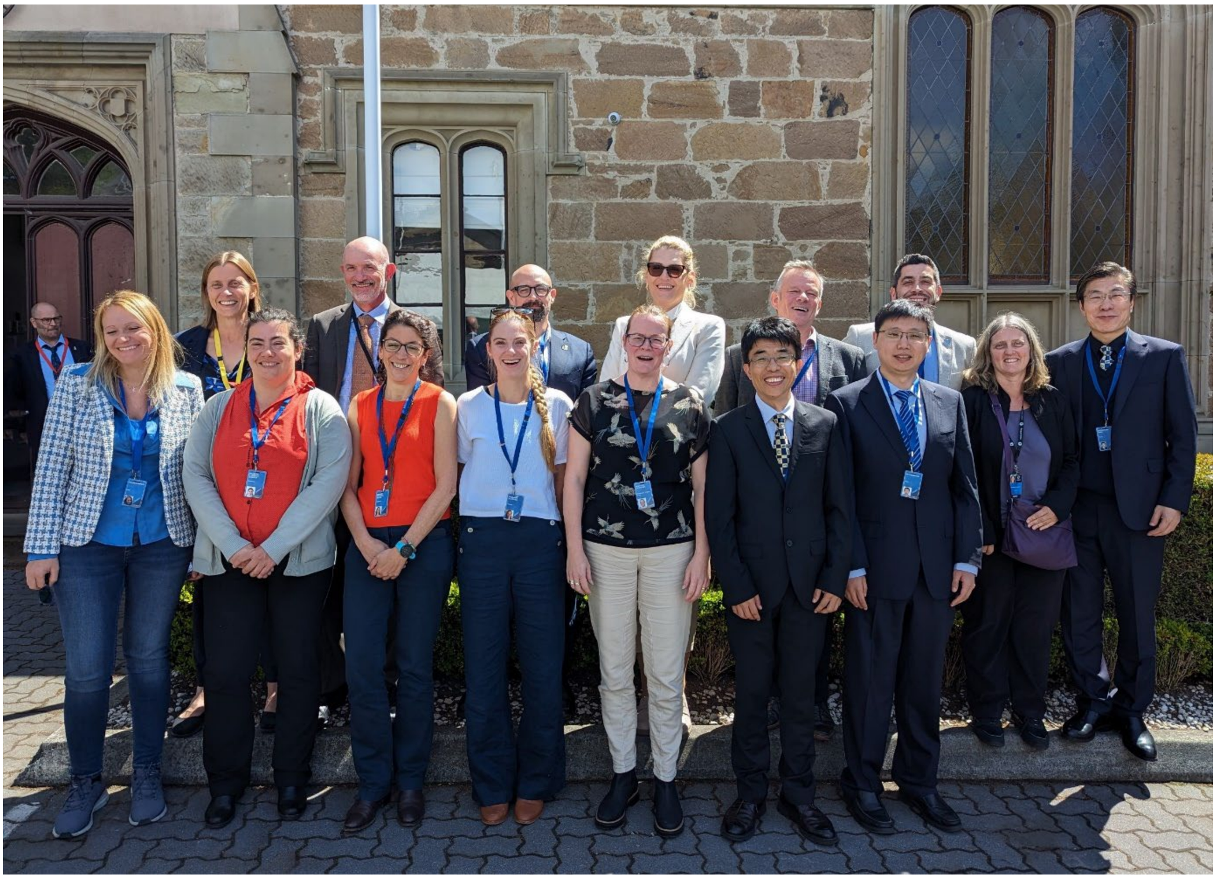

Figure 7: CCAMLR Scientific Scholarship Scheme recipients and mentors present at SC-CAMLR-42.

Annex 1

List of Registered Participants

List of Registered Participants

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		Dr Yeadong Kim Korea Polar Research Institute
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Ms Silvia Martinez
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Dr Marc Orlando
Ms Rebeca Paredes-Nieto

Annex 2

List of Documents

List of Documents

SC-CAMLR-42/01	Meeting modalities for the Scientific Committee working groups CCAMLR Secretariat
SC-CAMLR-42/02 Rev. 1	Chair's summary of independent toothfish assessment review Dirk Welsford, Chair of the Independent Review Panel
SC-CAMLR-42/03	Report of the COLTO–CCAMLR Tagging Workshop (Hobart, Australia, 14 to 17 March 2023)
SC-CAMLR-42/04	Report of the Working Group on Acoustic Survey and Analysis Methods (Tokyo, Japan, 22 to 26 May 2023)
SC-CAMLR-42/05	Report of the Krill Fishery Observer Workshop (Shanghai, People's Republic of China, 19 to 21 July 2023)
SC-CAMLR-42/06	Information about a Workshop for Training Russian Scientific Observers and Inspectors to Work in Fisheries in the CCAMLR Convention Area (Kaliningrad, Russia, 14-18 August 2023) Delegation of the Russian Federation
SC-CAMLR-42/07	Comments on the Krill Management Approach in Area 48 (On the Issue of Ecosystem Effects of Krill Fishery) Kasatkina, S.
SC-CAMLR-42/08	Ecoregionalisation of the pelagic zone in the Subantarctic and Subtropical Indian Ocean Makhado, A, P. Koubbi, J.A. Huggett, C. Cotte, R. Reisinger, K.M. Swadling, C. Azarian, C. Barnerias, F. d'Ovidio, L. Gauthier, E. Goberville, B. Leroy, A.T. Lombard, L.ne Muller, A. van de Putte and workshop participants
SC-CAMLR-42/09	Report of the Working Group on Statistics, Assessment and Modelling (Kochi, India, 26 to 30 June 2023)
SC-CAMLR-42/10	Report of the Working Group on Ecosystem Monitoring and Management (Kochi, India, 3 to 14 July 2023)

SC-CAMLR-42/11	Workshop on Climate Change (Cambridge, UK and Wellington, New Zealand, 3 to 8 September 2023)
SC-CAMLR-42/12	ASPA No. XXX Western Bransfield Strait and Eastern Dallmann Bay for Review by CCAMLR Delegation of the United States of America
SC-CAMLR-42/13	Integration of different spatial management initiatives in the Antarctic Peninsula Region in a climate change scenario Delegations of Argentina and Chile
SC-CAMLR-42/14	Proposal for a Workshop to contribute to the further development of the RMP for WSMPA Phase 2 Delegation of Norway
SC-CAMLR-42/15 Rev. 1	Report of the Groundfish Survey at South Georgias Islands (CCAMLR- Subarea 48.3) in 2023 (Executive Summary) Delegation of Argentina
SC-CAMLR-42/16 Rev. 1	Report of the Working Group on Incidental Mortality Associated with Fishing (Hobart, Australia, 5 to 10 October 2023)
SC-CAMLR-42/17	Report of the Working Group on Fish Stock Assessment (Hobart, Australia, 2 to 10 October 2023)
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SC-CAMLR-42/BG/01	Catches of target species in the Convention Area CCAMLR Secretariat
SC-CAMLR-42/BG/02	Scientific evidence in support of a Weddell Sea Marine Protected Area Phase 2 Delegation of Norway
SC-CAMLR-42/BG/03	Assessing phylodiversity spatial patterns of Southern Ocean fauna for biodiversity conservation Delegation of France
SC-CAMLR-42/BG/04	Cap-DLISA: A pilot approach to capacity building to support the development of integrated stock assessments for CCAMLR data limited toothfish research fisheries Somhlaba, S., T. Okuda, and R. Sarralde.

SC-CAMLR-42/BG/05	Addressing the recommendations from WG-EMM 2023 on the science supporting the proposal for the Weddell Marine Protected Area Phase 2 Delegation of Norway
SC-CAMLR-42/BG/06	Process diagram of the implementation of the Rules for Access and Use of CCAMLR Data Co-chairs of the Data Services Advisory Group (DSAG)
SC-CAMLR-42/BG/07	2023 Annual Report to the Scientific Committee of CCAMLR CEP Observer to SC-CAMLR 42 Dr P. Penhale (USA)
SC-CAMLR-42/BG/08	Priority SMART criteria for assessing the RSRMPA Delegation of the United States of America
SC-CAMLR-42/BG/09	2023 Report by Oceanites, Inc. — Monitoring Update Delegation of Oceanites, Inc.
SC-CAMLR-42/BG/10	2023 Report to SC-CAMLR-42 and CCAMLR-42 by the Association of Responsible Krill harvesting companies (ARK) Association of Responsible Krill harvesting companies (ARK)
SC-CAMLR-42/BG/11	Antarctic climate change and the environment: update on recent research relevant to CCAMLR SCAR
SC-CAMLR-42/BG/12	Antarctic Extreme Events Delegation of the United Kingdom
SC-CAMLR-42/BG/13	ASOC Report to CCAMLR ASOC
SC-CAMLR-42/BG/15	CCAMLR MPAs: Where do we go from here? ASOC
SC-CAMLR-42/BG/16	Contribution of information to inform State of the Antarctic Environment Reporting (SAER): a potential new SCAR initiative SCAR
SC-CAMLR-42/BG/17	D1MPA Process Dossier: Executive Summary and Highlights Delegations of Argentina and Chile

SC-CAMLR-42/BG/18	Early maturation and reproductive success in Antarctic krill in the Antarctic Peninsula region in response to environmental and climate conditions SCAR
SC-CAMLR-42/BG/19	Enhancing CCAMLR's Role in Whale Conservation ASOC
SC-CAMLR-42/BG/20	Essential Variables for Tracking Change in the Southern Ocean - The SCAR Antarctic Biodiversity Portal, update 2023 Delegation of Belgium, SCAR and SCOR
SC-CAMLR-42/BG/21	Is CCAMLR Krillin' It? Accelerated climate change and krill fishing effects on the Antarctic ecosystem necessitate urgent protection and precautionary management ASOC
SC-CAMLR-42/BG/22	Moving Forward with the New Krill Management Strategy The Association of Responsible Krill harvesting companies (ARK)
SC-CAMLR-42/BG/23	Report of the Groundfish Survey at South Georgias Islands (CCAMLR- Subarea 48.3) in 2023 Delegation of Argentina
SC-CAMLR-42/BG/24	Resetting the Relation Between Conservation and Fishing in CCAMLR ASOC
SC-CAMLR-42/BG/25	SC-CAMLR Special Fund annual reporting CCAMLR Secretariat
SC-CAMLR-42/BG/26	Southern Ocean Observing System (SOOS) Annual Report (2022-2023) SCOR
SC-CAMLR-42/BG/27	Southern Ocean Observing System (SOOS) data discovery tool and regional observational coverage mapping to support gap analyses SCOR
SC-CAMLR-42/BG/28 Rev. 1	Summary for Policy Makers from the first Marine Ecosystem Assessment for the Southern Ocean (MEASO) and recommendations for CCAMLR SCAR and SCOR

SC-CAMLR-42/BG/29	Temperature data by depth using demersal longlines. The New Zealand experience in the Ross Sea - first steps Fenaughty, J.M., M. Nyegaard, J. Jakoboski and K. Senga
SC-CAMLR-42/BG/30	The Scientific Committee on Antarctic Research (SCAR) Annual Report to CCAMLR 2023/24 SCAR
SC-CAMLR-42/BG/31	Update on the Antarctic Wildlife Research Fund (AWR) ASOC
SC-CAMLR-42/BG/32	Update on the Southern Ocean contribution to the United Nations Decade of Ocean Science for Sustainable Development SCAR and SCOR
SC-CAMLR-42/BG/33	Secretariat science support for the Scientific Committee in 2023 CCAMLR Secretariat
SC-CAMLR-42/BG/34	Observer's Report for the SC69A Meeting of the Scientific Committee of the International Whaling Commission, Bled, Slovenia, 24 April-6 May 2023 Kelly, N.
SC-CAMLR-42/BG/35	CEMP Special Fund activities 2023 CEMP Special Fund Management Panel
SC-CAMLR-42/BG/36	Scientific scholarship review panel recommendations in 2023 Scientific scholarship review panel
SC-CAMLR-42/BG/37	Implementation of the *Macrourus spp.* bycatch cessation rule for the Ross Sea exploratory fisheries CCAMLR Secretariat
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CCAMLR-42/37	Comments and suggestions on the Revised proposal for a Conservation Measure establishing a Marine Protected Area in Domain 1 (Western Antarctic Peninsula and South Scotia Arc) (CCAMLR-SM-III/06) Delegation of the Russian Federation
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CCAMLR-SM-III/08	Comments on the status of the South Orkney Islands southern shelf Marine Protected Area (SOISS MPA) Delegation of the Russian Federation

CCAMLR-SM-III/09	Comments and suggestions on the draft Ross Sea region MPA Research and Monitoring Plan Delegation of the Russian Federation
CCAMLR-SM-III/10	Suggestions for establishing Marine Protected Areas in the CCAMLR Convention Area: regulation of the uniform process for establishing MPAs and the Commission's management of MPAs Delegation of the Russian Federation

Annex 3

Agenda for the Forty-second Meeting
of the Scientific Committee

**Agenda for the Forty-second Meeting of the
Scientific Committee for the Conservation
of Antarctic Marine Living Resources**

1. Opening of the meeting

2. Harvested species

    2.1 Krill resources
        2.1.1 Status, trends and general issues
        2.1.2 Statistical Area 48
            2.1.2.1 Progress towards acoustic biomass estimates
            2.1.2.2 Progress towards a stock assessment
            2.1.2.3 Progress towards a spatial overlap assessment
            2.1.2.4 Ecosystem effects in the krill fishery

        2.1.3 Statistical Area 58
        2.1.4 Advice to the Commission

    2.2 Fish resources
        2.2.1 Status, trends and general issues
        2.2.2 Statistical Area 48
            2.2.2.1 Icefish
            2.2.2.2 Toothfish
            2.2.2.3 Advice to the Commission

        2.2.3 Statistical Area 58
            2.2.3.1 Icefish
            2.2.3.2 Toothfish
            2.2.3.3 Advice to the Commission

        2.2.4 Statistical Area 88
            2.2.4.1 Toothfish
            2.2.4.2 Advice to the Commission

3. Non-target catch and ecosystem impacts of fishing operations

    3.1 Fish and invertebrate by-catch

    3.2 Incidental mortality of seabirds and marine mammals associated with fisheries

    3.3 Bottom fishing and vulnerable marine ecosystems

    3.4 Marine debris

    3.5 Advice to the Commission

4. Spatial management of impacts on the Antarctic ecosystem

    4.1 Marine protected areas (MPAs)

4.1.1 Review of scientific analysis relevant to existing MPAs, including RMPs for MPAs
4.1.2 Review of the scientific elements of proposals for new MPAs

4.2 Other spatial management issues

4.3 Advice to the Commission

5. Climate change

5.1 Advice to the Commission

6. Illegal, unreported and unregulated (IUU) fishing in the Convention Area

7. CCAMLR Scheme of International Scientific Observation

7.1 Advice to the Commission

8. Cooperation with other organisations

8.1 Cooperation within the Antarctic Treaty System
8.1.1 Committee for Environmental Protection
8.1.2 Scientific Committee for Antarctic Research

8.2 Reports of observers from other international organisations

8.3 Reports of representatives at meetings of other international organisations

8.4 Future cooperation

9. Scientific Committee activities

9.1 Scientific Committee strategic plan

9.2 CCAMLR Scientific Scholarships Scheme

9.3 Science Fund reporting

9.4 Modalities of Scientific Committee working group meetings

9.5 Priorities for work of the Scientific Committee and its working groups

9.6 Summary of SC-CAMLR supported meetings for 2023/24

9.6.1 Invitation of experts and observers to meetings of working groups and workshops
9.6.2 Next meeting

10. Secretariat supported activities

11. Budget for 2023/24

12. Advice to SCIC and SCAF

13. Election of Scientific Committee Chair

14. Other business

15. Adoption of report of the Forty-second Meeting

16. Close of meeting

Annex 4

Report of the Working Group on Acoustic Survey and Analysis Methods 2023 (WG-ASAM-2023)
(Tokyo, Japan, 22 to 26 May 2023)

Contents

Report of the Working Group on Acoustic Survey and Analysis Methods 2023 (WG-ASAM-2023)
(Tokyo, Japan, 22 to 26 May 2023)

Introduction

1.1 The 2023 meeting of the Working Group on Acoustic Survey and Analysis Methods (WG-ASAM) was held at the Tokyo University of Marine Science and Technology from 22 to 26 May 2023 in Tokyo, Japan.

Opening of the meeting

1.2 The Convener, Dr X. Wang (China), welcomed the participants (Appendix A), noting that the Co-convener, Dr S. Fielding (UK), was unable to participate in this meeting. The Convener noted that this was the first in-person meeting of the group as a working group, and that it was a pleasure to have an in-person meeting because it had online meetings in 2020, 2021 and 2022 due to the COVID pandemic and had previously been a subgroup.

Adoption of the agenda

1.3 The meeting's provisional agenda was discussed and the Working Group adopted the agenda (Appendix B).

1.4 Documents submitted to the meeting are listed in Appendix C. The Working Group thanked the authors of papers and presentations for their valuable contributions to the work of the meeting. Acronyms used in this report are provided on the website.

1.5 This report was prepared by M. Cox (Australia), D. De Pooter (Secretariat), T. Dornan (UK), S. Menze (Norway), T. Okuda (Japan), S. Parker (Secretariat) and G. Zhu (China). Sections of the report detailing advice to the Scientific Committee and other working groups are highlighted in grey and summarised under 'Advice to the Scientific Committee'.

Review of the terms of reference and workplan

2.1 The Working Group reviewed the terms of reference agreed by SC-CAMLR-41, noting the inclusion of climate change in its advice. The Working Group noted that while a focus of WG-ASAM is to develop methods, it could include consideration of the impact of climate and environmental change, where relevant, in its advice. It also noted that acoustic data may be used to monitor and document other ecological aspects of the effects of environmental change.

2.2 The Working Group reviewed the workplan it developed in 2022, noting that the short-term tasks were included in its agenda for the 2023 meeting. The Working Group noted that krill length-frequency sampling is necessary for both catch length distribution and for length distribution data for converting acoustic backscatter data into biomass estimates. The Working Group noted that both of these sampling goals could be met by standardised length distribution sampling and provided advice to the 2023 Workshop on Krill Fishery Organisation (WS-KFO-2023) to align the length-frequency sampling with other observer tasking (paragraphs 4.16 to 4.19).

Standardised procedures for acoustic surveys and development of krill biomass estimates

3.1 WG-ASAM-2023/07 highlighted that because krill swarms may extend deeper than 250 m, the application of a depth integration limit of 250 m potentially misses biomass. However, data quality on 120 kHz could be insufficient to collect data deeper than 250 m, and at times was of too poor quality because of acoustic noise to be useable on some surveys. The paper also noted some discrepancies between the 120 kHz and 38 kHz biomass estimates that need further exploration. Noting that krill length-frequency has a large influence on biomass estimates, the authors suggested that additional work was needed to use variable length-frequency distributions in calculating biomass estimates.

3.2 The Working Group recalled that integrating data from deeper than 250 m may become problematic with use of 200 kHz using the 3-frequency dB differencing method. The Working Group noted that analyses could report both integration to 250 m and the maximum reliable depth of the dataset. The Working Group also noted that a constant depth of surface exclusion layer at 20 m will ignore biomass in the upper layer, and encouraged the development of autonomous methodologies that may be able to distinguish krill within this surface layer.

3.3 The Working Group recalled that the potential use of 70 kHz for krill identification and biomass estimates had been discussed before (SG-ASAM-2017, paragraphs 2.16 and 6.1). The Working Group also noted that krill are relatively weak acoustic targets and smaller krill may be undersampled at lower frequencies. The Working Group agreed that further research into the use of 38 and 70 kHz was required to test their validity in estimating krill biomass.

3.4 The Working Group noted that biology and seasonal depth distributions can influence krill detection and target strength (TS) estimation. Krill may move deeper to benthic habitats in autumn and winter, potentially out of the effective detection range of echosounders or the lower depth integration limit. Also, female krill in late summer are in spawning condition and are high in lipids, which may affect their acoustic properties.

3.5 The Working Group encouraged further investigation into the effect of the seasonal changes of krill biology and vertical distribution on its biomass estimates.

3.6 WG-ASAM-2023/01 presented an updated method for defining and calculating spatial polygons that could be dynamically updated as coastlines were updated, proposed thresholds for line densification and a standardised projection using the European Petroleum Survey Group (EPSG) code 6932.

3.7 The Working Group welcomed this standardised methodology and requested that both the spatial objects and the R code used to generate them (including the version of the coastline data) be made available via the CCAMLR GitHub repository.

3.8 The Working Group agreed that the defined protocol be used when planning surveys, as stratum areas will affect biomass estimates.

3.9 The Working Group endorsed the recommendations that:

(i) geographical information system (GIS) objects use the EPSG 6932 projection

(ii) lines of more than 0.1 degree of longitude be densified

(iii) polygon vertices be given clockwise in decimal degrees with at least five decimal places

(iv) vertices be added where polygons meet

(v) inland vertices be used for polygons that are bound by the coastline

(vi) areas be clipped to all coastlines (continent and islands) based on the most recent available coastline data, and that the bearing from the last vertex to the intersection with a coastline should be specified in the polygon definition

(vii) analyses cite CCAMLR geospatial data (i.e. shapefiles) as CCAMLR. [*Year*]. Geographical data layer: [*Layer name*]. Version [*Version*], URL: [*URL*].

3.10 WG-ASAM-2023/P02 presented a method of estimating Antarctic krill biomass on a weighted per-length basis using length to wet mass observations and krill length data from combined routine and target trawl data. Stage-based uncertainty of biomass estimates was difficult to estimate because of significant overlap in length-frequency distribution among juvenile, male and female krill.

3.11 The Working Group noted that a single length-to-weight relationship was applied to estimate biomass but that during summer spawning female krill bodies may be larger than males at the same length. However, without more detail on the ratios of krill developmental stages in the population, a single length-weight relationship was currently an adequate approach. It was also noted that time and resource pressures at sea were likely to limit the ability to collect the amount of data that stage-specific length-weight relationships would require.

3.12 The Working Group noted that to capture the overall krill size distribution, a combination of data from target and regular trawls was appropriate.

3.13 The Working Group noted that the Institute of Marine Research (IMR) in Norway's 'StoX' biomass estimation package for fish implements a per-length biomass for fish. However, the target strength (TS) to length relationship for fish is normally represented by a simple log-log regression while the krill TS to length relationship is nonlinear in log-log space so requires more parameters. The Working Group agreed that developing the StoX software to include functionality for a krill length-weight relationship to progress a standardised acoustic biomass estimation method for krill would be useful. Dr Menze offered to work with IMR to progress incorporating stochastic distorted-wave Born approximation (SDWBA) for krill into the StoX program.

Storage of acoustic data

3.14 WG-ASAM-2023/09 presented recent developments on the CCAMLR Acoustic Data Repository and highlighted the data submitted since the previous WG-ASAM meeting. The paper noted that the significant difficulties with low upload speeds experienced by Members while submitting these data could be addressed by moving towards a cloud-based exchange server. The paper also presented a newly developed data exploration tool and proposed modifications to the 'Instruction manual for the collection of fishing vessel-based acoustic data' as requested by WG-ASAM in 2022.

3.15 The Working Group thanked the Secretariat for the development of the Acoustic Data Repository and Members for submitting the data. The Working Group supported the proposal for the Secretariat to investigate a cloud-based solution for exchanging acoustic data. The Secretariat noted that the estimated total cost of the repository based on current data exchange volumes (A$1 500) will increase by at least one order of magnitude when accounting for the potential expansion of the fishery, expansion in data collected by the software and a potential increase in collection effort.

3.16 The Working Group noted that a standardised procedure for naming files would be useful in addition to the parameters that can be used to filter data using the acoustic data explorer tool. The Working Group also identified that criteria defining the completion of an adequate transect need to be developed.

3.17 The Working Group noted that krill length data are typically only collected by observers during fishing rather than acoustic transects. The Working Group recalled that both research and fishery trawls can catch representative length distributions and that length samples could be collected by observers during sampling trawls conducted during a nominated acoustic transect (SG-ASAM-2019, paragraph 2.37).

3.18 The Working Group welcomed the development of the acoustic data explorer tool and recommended that it be made available to Members though the Members-only section of the CCAMLR website.

Collection and analysis of acoustic data on board fishing vessels

Methods for calibrating echosounders on fishing vessels

4.1 On behalf of the authors, Dr Cox presented WG-ASAM-2023/05, which provided information on the calibration history between 2009 and 2023 of three New Zealand toothfish fishing vessels.

4.2 The Working Group expressed its gratitude for this useful summary of calibration and data collection. Noting that some calibration parameters (WG-ASAM-2023/05, Table 2) changed by a large magnitude between years the Working Group recommended that future calibrations present additional information, including water temperature at calibration site and the root mean square (RMS) error of the calibration results and whether the echosounder equipment had been upgraded, to help interpret these changes.

4.3 The Working Group also recommended that for ES80 and EK80 systems, regular monitoring of the impedance be carried out, for example, by recording the impedance whenever the vessel leaves port.

4.4 The Working Group also noted that in earlier years, echosounder settings (pulse duration and power) between calibrations were different than in recent years. It further noted that because calibration parameters are specific to these settings, changing settings between calibrations makes detecting any trend in calibration values difficult. However, the Working Group recognised that the calibration settings in WG-ASAM-2023/05 had not changed since 2015.

4.5 WG-ASAM-2023/08 presented the results of seafloor calibrations conducted over the last 10 years at two locations close to the Southern Orkney Islands by Norwegian vessels. The method was carried out at two sites with one transect per site as calibration reference targets. From the two sites, the deeper site 2 had longer term stability (WG-ASAM-2023/08, Figure 6).

4.6 The Working Group agreed with the study recommendation that near-concurrent completion of transects by a sphere-calibrated vessel and an uncalibrated vessel would improve the results of the calibration. The Working Group suggested that seabed substrate data could be collected at the two study sites (e.g. from multibeam information on both topography and backscatter) and used to help identify new suitable sites.

Survey design and data collection for fishing vessels

4.7 WG-ASAM-2023/02 presented a Python package (Krillscan) that automates the analysis of backscatter data. The analysis is carried out automatically on board vessels with the processed data being transmitted back to shore, currently using email.

4.8 The Working Group noted, through a motivating example, the enormous variation in the presented krill biomass time-series data at the South Orkney Islands. The snapshot vessel-based acoustic surveys may not sample the krill distribution sufficiently to represent the 'true' krill biomass. The Working Group recognised that autonomous data collection and analysis approaches will help to address this but will generate vastly bigger datasets. The Working Group noted that automated processing approaches will be essential to accommodate bigger datasets delivered from fishing vessels and autonomous platforms.

4.9 The Working Group commended Dr Menze for his work on the open-source automated processing software (the Krillscan Python module version 0.2.21). It noted that this software can be used on a variety of operating systems and is freely available on GitHub (github.com/sebastianmenze/krillscan; accessed: 23 May 2023).

4.10 The Working Group noted that there is a constant difference between Krillscan and large-scale survey system (LSSS) methods (WG-ASAM-2023/02, Figure 5). This difference is likely due to be the internal noise removal methods of the LSSS and the difference is subject to ongoing investigation.

4.11 The Working Group recommended that the Secretariat work with Dr Menze to test the Krillscan package using krill fishing vessel acoustic data collected along nominated transects.

4.12 To facilitate testing, the Working Group suggested it develop test datasets, as recommended in WG-ASAM-2022, paragraph 2.13, to benchmark processing software and methods.

4.13 The Working Group thanked the Secretariat for the proposed modifications to the 'Instruction manual for the collection of fishing vessel-based acoustic data' (Appendix D) and made additional updates in response to the additional sampling capacities of broadband echosounders (i.e. Simrad EK80 and ES80).

4.14 To keep the collected data volume within manageable transfer and processing limits, the Working Group agreed that data should continue to be collected in continuous wave (CW) mode and not frequency-modulated (FM) mode. Also, the Working Group agreed that data should be collected in 'Power/Angle samples' mode for ES80 and EK80 units. It also requested that file names of raw data should include a unique vessel identifier (e.g. International Maritime Organization (IMO) number) and the instrument type (e.g. EK80) as a prefix. The Working Group also revised the maximum raw file size to 100 MB.

4.15 The Working Group recommended that the updated instruction manual (Appendix D) be made available to fishing vessels and be available on the CCAMLR website.

Krill biological data collection

4.16 The Working Group considered the collection of krill length-frequency data to support the acoustic data collected by fishing vessels on nominated acoustic transects. The Working Group recognised that krill length data are a vital component for acoustic-based krill biomass estimation. Additionally, morphological data, for example, sex, maturity stages and weight (wet mass), are also useful because they may also influence TS as well as ecological studies.

4.17 The Working Group agreed that both oblique and target trawl methods can be used to collect krill samples during a nominated transect survey. For the nominated transects, both commercial and scientific nets can be used, with a preference to use scientific nets. In line with WG-EMM-18/23, all krill should be measured in samples with fewer than 150 individuals. For larger krill catches, a minimum of 150 krill should be measured and stage determined.

4.18 The Working Group suggested that other biological information (i.e. catch composition) should be collected for other species, for example, numerical sample size should be collected for the purposes of validating the composition of acoustic targets.

4.19 The Working Group encouraged the development and validation of new krill length-frequency sampling technologies (e.g. stereo cameras).

Krill biomass estimates

Area 48 biomass estimates

5.1 The Working Group recalled WG-EMM-2021/05 Rev. 1 which presented results from the 'Krill biomass estimates from acoustic surveys' intersessional e-group. The Working Group discussed the workflow used to calculate biomass estimates for each of the management strata as they are defined by WG-ASAM-23/01 (Appendix E).

5.2 The Working Group thanked Dr Dornan for creating the workflow document during the meeting, the updates to the krill biomass estimates in strata of Subarea 48.1 (Table 1), and the R code to calculate the revised estimates.

5.3 The Working Group suggested that the Secretariat make the metadata table, the R code and the workflow document available together to Members through a private section of the CCAMLR GitHub repository where updated versions can be maintained as additional survey data become available.

5.4 The Working Group noted that small deviations from biomass estimates compared with earlier calculations (WG-ASAM-2022, Table 9), and that deviations are attributed to the updated areal definitions of the management strata and to rounding of values in 2022.

5.5 WG-ASAM-2023/06 described the change in krill biomass and density at the start, middle and end (May, July and September respectively) of the 2022 fishing season at South Georgia. Diel patterns in biomass were detected, with significantly higher biomass being detected at night in July and September.

5.6 The Working Group welcomed this contribution and noted that the RMT1 net (610 µm mesh size, 1 m^2 mouth area) used in the survey may be more likely to catch smaller krill than the RMT8, which typically has a larger mesh size. The Working Group noted that net avoidance by larger krill may have occurred due to the small mouth area and encouraged the authors to compare their krill length-frequency data with those collected by the krill fishery operating in the area.

5.7 The Working Group discussed sampling of swarms deeper than 200 m, noting that the sensitivity analyses in WG-ASAM-2023/06 suggested that excluding krill at depths between 200 and 250 m had minor impact on the krill biomass estimates. However, even a 250 m depth threshold would not detect deeper swarms.

Area 58 biomass estimates

5.8 WG-ASAM-2023/10 provided corrections to the mean weighted areal krill biomass density and the degree of coverage values provided in Table 2 of WG-ASAM-2021/06. The authors noted that these were transcription errors and that the biomass estimate reported in WG-ASAM-2021/06 remains unchanged.

5.9 The Working Group thanked the authors for providing the corrections.

5.10 WG-ASAM-2023/P01 presented the result of an acoustic trawl survey carried out in February and March 2021 to estimate the krill biomass in the eastern sector of Division 58.4.2 (biomass = 6.48 million tonnes, areal biomass density = 8.3 g m^{-2}, coefficient of variation (CV) = 28.9%), based on daytime data in line with the CCAMLR 2000 Krill Synoptic Survey of Area 48, and assessed the efficacy of extrapolating smaller surveys to a wider area at a similar latitude.

5.11 The Working Group welcomed the study and noted that the heterogenous spatial distribution of krill density and length-frequency in the area might complicate upscaling the biomass estimates from several random small box areas to a wider area. The Working Group noted that a time series of small box area surveys may be useful to examine seasonal biomass trends within the box, but many small areas would be needed to capture spatial patterns in abundance in a wider area.

5.12 The Working Group noted that at night krill are detected shallower in the water column and potentially occur in the top 20 m, which may not be fully assessed using hull-mounted acoustic detection methods (paragraph 3.2). The Working Group noted that biomass estimate studies could be augmented using mooring-based echosounders (paragraph 6.2) which may be able to assess the region closer to the surface.

5.13 The Working Group requested that Members specify the method used to categorise day and night sampling and noted the nautical twilight calculator on the CCAMLR website (www.ccamlr.org/node/84096).

5.14 WG-ASAM-2023/P03 presented a study which used broadband acoustic data and length-frequency distribution data obtained from trawl samples to predict the length-averaged TS spectra of krill. The study found that the model worked well for krill aggregations dominated by krill smaller than 35 mm, but detected discrepancies for aggregations dominated by larger krill.

5.15 The Working Group welcomed the contribution and noted that the discrepancies observed were likely caused by differences in the orientation parameters used by the model, and encouraged Members to further investigate krill orientation distribution.

5.16 The Working Group recalled its recommendation that the results of acoustic krill biomass surveys presented to CCAMLR be accompanied with standardised metadata describing the data collection, including metadata tables (WG-ASAM-2022, paragraphs 2.13, 2.15 and Tables 2 to 8), and encouraged Members to include this information in future submissions.

Survey design using other platforms

6.1 WG-ASAM-2023/04 presented the deployment and results from moored 120 kHz EK80 echosounder data in Subarea 48.3 (South Georgia) between 13 January 2018 and 1 February 2022. These data indicate considerable seasonal and interannual variability in the presence, size and shape of krill swarms, and the diurnal variability of krill abundance, highlighting more acoustic backscatter during winter at night, which conventional daytime-only surveys would miss.

6.2 The Working Group welcomed the challenging study to increase opportunities for monitoring krill abundance and behaviour in the Southern Ocean. The Working Group noted that moored echosounders are a relatively cost-effective tool for the collection of long-term krill data with the capacity to measure temporal variability at high resolution.

6.3 The Working Group noted that similar projects exist in the surrounding areas, and noted the increasing value of autonomous systems for krill study and the potential to use autonomous vehicles and systems to elucidate not only temporal variation but also spatial variation.

Development of methods to estimate biomass of finfish using acoustic techniques

7.1 WG-ASAM-2023/03 presented an overview of a mackerel icefish (*Champsocephalus gunnari*) survey conducted with the *More Sodruzhestva* in February 2022 in Subarea 48.2, consisting of eight transects west of the South Orkney Islands. Acoustic data were gathered with an ES80 echosounder at 120 kHz and are currently being held securely by the UK. Catch data were gathered at 37 trawl stations, along with net-mounted conductivity temperature depth probe (CTD), camera and flowmeter data for each haul.

7.2 The Working Group noted that the echosounder was last calibrated in 2018, before the 2019 Area 48 Survey. The vessel plans to install a 38 kHz transceiver (provided by Australia) and calibrate the echosounder before the next survey. The Working Group encouraged possible cooperation and support with on-site calibration if the *More Sodruzhestva* was at the South Orkney Islands at the same time as other vessels.

7.3 The Working Group noted that relevant metadata should be collected and presented considering the CCAMLR protocols presented in tables in WG-ASAM-2022.

7.4 The Working Group supported the idea of a Ukrainian scientist to apply for a CCAMLR scholarship to analyse these survey data and the UK indicated it could provide mentors in support of this. Dr L. Pshenichnov (Ukraine) thanked participants for their assistance and equipment donations.

Future work

8.1 The Working Group agreed additions to the WG-ASAM workplan in Table 9 of SC-CAMLR-41 (see Table 2), to include that:

(i) the parameter values in the SDWBA model of TS (i.e. orientation and fatness, *g* and *h* values) be improved through a better understanding of the influence of krill length distribution and seasonal and regional effects of developmental stage on target strength

(ii) investigations be conducted on the effects of uncertainty in length distributions on biomass estimation

(iii) methods be developed to use acoustics to monitor biological change to the pelagic ecosystem and how this is communicated to the CCAMLR Ecosystem Monitoring Program (CEMP).

Advice to the Scientific Committee

9.1 The Working Group identified the following items relevant to providing advice to the Scientific Committee to inform its future work:

(i) standardised methodology for defining spatial objects (paragraph 3.9)

(ii) endorsed updates to the instruction manual for fishing vessel acoustic data collection (paragraph 4.15)

(iii) updates to the WG-ASAM workplan (paragraph 8.1).

Adoption of report and close of meeting

10.1 The report of the meeting was adopted.

10.2 At the close of the meeting, Dr Wang thanked all participants for their efficient work and collaborative data analysis that had contributed greatly to the successful outcomes from the meeting. In particular, he thanked the Japan Fisheries Research and Education Agency and the Tokyo University of Marine Science and Technology for hosting the meeting, the North Pacific Fisheries Commission for administrative support, all the coordination work performed by Dr Okuda and Dr H. Murase (Japan), support from the Secretariat, and the student volunteers who made the meeting function smoothly.

10.3 Dr Parker thanked Dr Wang for his leadership and technical guidance throughout the work of his first in-person meeting as Convener.

10.4 Dr Wang thanked all the meeting participants for their support during the meeting.

Table 1: Updated krill biomass estimates in strata of Subarea 48.1 using the strata areas provided in WG-ASAM-2023/01 for all available years 1996–2020. These values update the biomass estimates compared with those generated in 2022 even where stratum area did not change due to the use of rounded values in 2022. The R code and metadata used to generate the values is available upon request from the Secretariat GitHub. The workflow used to generate these values is described in Appendix D.

Stratum	Density ($g\ m^{-2}$)	Variance of weighted density	CV of weighted density (%)	Stratum area based on WG-ASAM-2023/01	Biomass (tonnes)	CV of biomass (%)	Number of surveys
Joinville (JI)	37.42	410.24	46.86	23 001	860 729	49.52	11
Elephant (EI)	65.49	487.64	26.69	51 648	3 382 317	26.92	27
Bransfield (BS)	34.19	343.83	41.28	35 180	1 202 654	42.83	30
South Shetland Islands West (SSIW)	53.45	326.48	32.86	47 118	2 518 544	36.26	29
Gerlache Strait (GS)[2]	58.53	1 364.44	63.11	44 616	839 494[3]	63.11	1
Powell Basin (PB)[1]	32.73	155.75	38.13	144 375	2 295 219[3]	38.13	1
Drake Passage (DP)[1]	41.53	40.53	15.33	294 079	9 059 380[3]	15.33	1

1 Single survey: 2019 Area 48 Survey (WG-ASAM-2019).

2 Single survey: 2020 *Atlantida* survey (WG-ASAM-2021/04 Rev. 1).

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

Table 2: Annotated table of WG-ASAM research priorities updated for 2023. CEMP – CCAMLR Ecosystem Monitoring Program, DSAG – Data Services Advisory Group, SISO – Scheme of International Scientific Observation.

Theme	Topic/task	Timeframe	Contributors	Secretariat participation
1. Target Species	(a) Develop methods to estimate biomass for krill			
	(i) Survey design standards for regional and synoptic surveys	Short/Medium	ASAM members	
	(ii) Develop methods to use fishing fleets as monitoring platforms:			
	Task 1: Methods for calibrating echosounders on fishing vessels	Short	Dr Macaulay, Dr Fielding	
	Task 2: Survey design for fishing fleets	Short	Linked to 1.a.i	
	Task 3: Develop the use of krill length frequency data in the estimation of target strength and krill weight for biomass estimates	Short	Dr Cox, Dr Zhao	
	(iii) Data collection – SISO, vessels and CEMP Specification for sample size and the use of krill length frequency data	Short	Annex 4, Table 2, 1.a.ii and 1.a.iv.4	Yes
	(iv) Acoustic data storage and processing			
	(1)(A) Identify metadata (B) Acoustic raw data storage requirements and processing	Short	ASAM	Yes
	(2) Automated data processing of acoustic data from fishing vessels, including frequency of updates to biomass updates	Long	Dr Menze, Dr Wang, Dr Fielding	
	(3) Standardised procedures to check and verify acoustic data	Medium	Dr Macaulay	
	(4) Develop the use of krill length frequency data in the estimation of target strength and krill weight for biomass estimates, including seasonal and regional effects of developmental stage	Medium	Dr Cox, Dr Wang	
	(5) Submission of acoustic data and the inclusion of metadata by Members in the repository held by the Secretariat	Annual	Annex 4, Table 2, 1.a.iv.1	Yes
	(6) Develop statistical approaches to acoustic data emerging from new acoustic observation platforms	Long	Dr Reiss, Dr Menze, Dr Dornan	
	(v) Biomass estimation			
	(4) Krill biomass estimate in Division 58.4.1	Long	Dr Cox, Dr Murase	
	(5) Krill biomass estimate in Division 58.4.2	Long		
	(b) Develop stock assessments to implement decision rules for krill			
	(i) Krill management approach (biomass estimates)			
	(1) Subarea 48.1	Short		
	(2) Subarea 48.2 etc.	Short	ASAM	
	(ii) Develop diagnostic tools			

(continued)

Table 2 (continued)

Theme	Topic/task	Timeframe	Contributors	Secretariat participation
	(iii) Develop ecosystem indicators to inform risk assessment framework			
	(iv) Methods to account for uncertainty in stock status			
	(1) Movement of krill (flux)	Medium	Dr Kasatkina	
	(2) Spatial structure within subareas		Dr Ying	
	(3) Interannual variability			
	(c) Develop methods to estimate biomass for finfish			
	(i) Survey design	Medium	Dr Kasatkina	
	(ii) Data collection – SISO and vessels			
	(iii) Improve biomass estimation methods	Long	Dr Wang	
2. Ecosystem impacts	(a) Ecosystem monitoring (Second Performance Review, recommendation 5)			
	(i) Structured ecosystem monitoring programs (CEMP, fishery)			
	(1) CEMP			
	(2) Fishery via SISO			
	(3) Research surveys			
	(b) Monitoring and adaptation to effects of climate change (see Table 2. SC-CAMLR-41/10)	Medium		
	(i) Develop methods to detect change in ecosystems given variability and uncertainty			
	(1) autonomous platforms		Dr Dornan	
Administrative topics	(a) Advise on database facilities required throughout DSAG	Annex 4, Table 2, 1.a.iv		
	(b) Advise on quality control and assurance processes for data provided to and supplied by the Secretariat	Annex 4, Table 2, 1.a.iv		
	(c) Refine SISO across all fisheries	Annex 4, Table 2, 1.a.iv		
	(d) Further develop data management systems	Annex 4, Table 2, 1.a.iv		
	(e) Communication of progress, internal and external			
	(f) Working group terms of reference	2022		
	(g) Scientific Committee Symposium in 2027			

Appendix A

List of Participants

Working Group on Acoustic Survey and Analysis Methods
(Tokyo, Japan, 21 to 26 May 2023)

Co-convener	Dr Sophie Fielding (did not attend the meeting) British Antarctic Survey
Co-convener	Dr Xinliang Wang Yellow Sea Fisheries Research Institute, Chinese Academy of Fishery Science
Australia	Dr Martin Cox Australian Antarctic Division, Department of Climate Change, Energy, the Environment and Water
China, People's Republic of	Mr Jichang Zhang Yellow Sea Fisheries Research Institute
	Professor Guoping Zhu Shanghai Ocean University
Japan	Dr Koki Abe Japan Fisheries Research and Education Agency
	Dr Kazuo Amakasu Tokyo University of Marine Science and Technology
	Dr Yoshiaki Fukuda Japan fisheries research and education agency
	Dr Tomohito Imaizumi National Research and Development Agency, Japan Fisheries Research and Education Agency
	Dr Tomohiko Matsuura Japan Fisheries Research and education agency
	Dr Hiroto Murase Tokyo University of Marine Science and Technology
	Dr Takehiro Okuda Fisheries Resources Institute, Japan Fisheries Research and Education Agency

Korea, Republic of	Dr Sangdeok Chung National Institute of Fisheries Science (NIFS)
	Dr Eunjung Kim National Institute of Fisheries Science
	Mr Jeongseok Park National Institute of Fisheries Science
Norway	Dr Sebastian Menze Institute of Marine Research
	Dr Guosong Zhang Institute of Marine Research
Ukraine	Mr Viktor Podhornyi Institute of Fisheries and Marine Ecology (IFME)
	Dr Leonid Pshenichnov Institute of Fisheries and Marine Ecology (IFME) of the State Agency of Melioration and Fisheries of Ukraine
United Kingdom	Dr Tracey Dornan British Antarctic Survey
CCAMLR Secretariat	Daphnis De Pooter Science Data Officer
	Dr Steve Parker Science Manager

Appendix B

Agenda

Working Group on Acoustic Survey and Analysis Methods
(Tokyo, Japan, 22 to 26 May 2023)

1. Introduction

   1.1 Opening of the meeting
   1.2 Adoption of the Agenda

2. Review Terms of Reference and workplan

3. Standardised procedures for acoustic surveys and development of krill biomass estimates

   3.1 Collection, processing and reporting of acoustic data
   3.2 Storage of acoustic data

4. Collection and analysis of acoustic data on board fishing vessels

   4.1 Methods for calibrating echosounders on fishing vessels
   4.2 Survey design and data collection for fishing vessels
   4.3 Krill biological data collection

5. Krill biomass estimates

   5.1 Area 48 biomass estimates
   5.2 Area 58 biomass estimates

6. Survey design and using other platforms

7. Develop methods to estimate biomass of finfish using acoustic techniques

8. Future work

9. Other business

10. Advice to the Scientific Committee

11 Adoption of report and close of meeting.

Appendix C

List of Documents

Working Group on Acoustic Survey and Analysis Methods
(Tokyo, Japan, 22 to 26 May 2023)

WG-ASAM-2023/01	Standardised rules for georeferenced polygons and lines Secretariat
WG-ASAM-2023/02	Using automatic open-source analysis of backscatter data from fishing vessels to implement feedback management of the Antarctic krill fishery S. Menze, G.J. Macaulay, G. Zhang, A. Lowther and B.A. Krafft
WG-ASAM-2023/03	Preliminary results of a local acoustic-trawl survey of *Champsocephalus gunnari* in Statistical Subarea 48.2 L. Pshenichnov, V. Podhornyi and K. Demianenko
WG-ASAM-2023/04	Temporal patterns in South Georgia (48.3) zooplankton: insights from a moored echosounder T. Dornan, S. Fielding and G.A. Tarling
WG-ASAM-2023/05	Echosounder settings and calibration parameters for New Zealand fishing vessels, 2009–2022 A. Wieczorek, Y. Ladroit, P. Escobar-Flores, R O'Driscoll and J. Devine
WG-ASAM-2023/06	Acoustic determination of Antarctic krill biomass at South Georgia (Subarea 48.3) during winter C.M. Liszka, S. Fielding, T. Dornan and M.A. Collins
WG-ASAM-2023/07	Some parameters for consideration regarding improvement of the CCAMLR protocol for calculating krill biomass G. Zhang, G. Skaret, R. Pedersen, S. Menze and B.A. Krafft
WG-ASAM-2023/08	Calibration of echosounders for biomass estimation using seafloor backscattering at fixed transects G. Macaulay, S. Menze and B. Krafft
WG-ASAM-2023/09	Repository of acoustic data collected by fishing vessels along CCAMLR nominated transects Secretariat

WG-ASAM-2023/10	Some corrections to Table 2 of WG-ASAM-2021/06 (Abe et al., 2021) K. Abe, R. Matsukura, N. Yamamoto, K. Amakasu, R. Nagata and H. Murase

Other Documents

WG-ASAM-2023/P01	Two scales of distribution and biomass of Antarctic krill (*Euphausia superba*) in the eastern sector of the CCAMLR Division 58.4.2 (55°E to 80°E) M.J. Cox, G. Macaulay, M.J. Brasier, A. Burns, O.J. Johnson, R. King, D. Maschette, J. Melvin, A.J.R. Smith, C.K. Weldrick, S. Wotherspoon and S. Kawaguchi PLOS ONE, 17(8): e0271078 (2022), doi: https://doi.org/10.1371/journal.pone.0271078
WG-ASAM-2023/P02	Per-length biomass estimates of Antarctic krill (Euphausia superba) A.J. Smith, S. Wotherspoon and M.J. Cox *Front. Mar. Sci., Sec. Marine Ecosystem Ecology*, 10 (2023), doi: https://doi.org/10.3389/fmars.2023.1107567
WG-ASAM-2023/P03	Volume backscattering spectra measurements of Antarctic krill using a broadband echosounder N. Yamamoto, K. Amakasu, K. Abe, R. Matsukura, T. Imaizumi, T. Matsuura and H. Murase *Fish. Sci.*, 89 (2023): 301–315, doi: https://doi.org/10.1007/s12562-023-01678-6

Appendix D

Instruction manual for the collection of fishing vessel-based acoustic data

Version 2.0

Preface

This manual is to be used by the person(s) who are responsible for the collection of raw acoustic data on board krill fishing vessels operating in the CAMLR Convention Area. The specific instruments covered by this manual are limited to Simrad ES60, Simrad ES70, Simrad EK60, Simrad ES80 and Simrad EK80 echosounders.

The data collected according to this manual, whether during specially designed surveys along nominated transits or during fishing operations (including searching for suitable fishing aggregations and steaming to another fishing area), are potentially very valuable and may be used to provide qualitative and quantifiable information on the distribution and relative abundance of Antarctic krill (*Euphausia superba*). This information is fundamental to CCAMLR's approach to management.

The manual consists of:

Chapter 1: A brief overview of what data should be collected, where and when they should be collected and finally how they should be collected.

Chapter 2: Data logging instructions.

Chapter 3: Validation of instrument performance.

Chapter 4: An overview of metadata to accompany data submissions to the Secretariat.

For further details, please contact your national technical coordinator or Scientific Committee Representative or contact the CCAMLR Secretariat (ccamlr@ccamlr.org).

Thank you for taking the time to record these important data.

Chapter 1

A brief overview of recommendations for data collection

What data should be collected: Raw acoustic data and supporting metadata describing the acoustic data, the acoustic instruments and cruise should be collected. The actual acoustic data needs to have the correct metadata (the data that describe the data) in order to be useable.

Where data should be collected: Acoustic data, together with supporting metadata, should be collected in all of the areas for which the vessel has been licenced to fish for krill. The acoustic data collected along the nominated transects (highlighted in bold in Table 1 and Figure 1), as well as in the areas in which fishing actually occurs, are a high priority.

When data should be collected: Acoustic data collection should begin as the vessel enters the Convention Area and be continued until the vessel leaves. Collecting data throughout the entire fishing trip is a prerequisite for building a picture of temporal variability in krill abundance and distribution. In particular, given the importance of the nominated transects in building patterns of temporal variability, repeating these nominated transects as often as possible during the cruise is recommended.

How data should be collected: Raw acoustic data should be logged to a hard drive. The echosounder should be configured using the key settings detailed in Table 2.

Table 1: Waypoints (dd mm.00) of the acoustic transects that are part of existing krill acoustic surveys in Subareas 48.1, 48.2 and 48.3 with the nominated transects highlighted in bold. Maps showing the location of the nominated transects are in Figure 1.

Subarea	Transect	Waypoint 1		Waypoint 2	
		Longitude	Latitude	Longitude	Latitude
48.1	T1	63°00.00'W	62°15.00'S	62°00.00'W	62°45.00'S
	T2	**62°30.00'W**	**62°00.00'S**	**61°30.00'W**	**62°30.00'S**
	T3	**62°00.00'W**	**61°45.00'S**	**61°00.00'W**	**62°15.00'S**
	T4	61°30.00'W	61°30.00'S	60°00.00'W	62°15.00'S
	T5	61°00.00'W	61°15.00'S	59°30.00'W	62°00.00'S
	T6	60°30.00'W	61°00.00'S	59°00.00'W	61°45.00'S
	T7	58°30.00'W	60°00.00'S	58°30.00'W	61°30.00'S
	T8	57°30.00'W	60°00.00'S	57°30.00'W	61°45.00'S
	T9	57°00.00'W	60°00.00'S	57°00.00'W	61°45.00'S
	T10	56°30.00'W	60°00.00'S	56°30.00'W	61°45.00'S
	T11	55°45.00'W	60°00.00'S	55°45.00'W	61°45.00'S
	T12	55°00.00'W	60°00.00'S	55°00.00'W	61°03.00'S
	T13	**54°30.00'W**	**60°00.00'S**	**54°30.00'W**	**61°45.00'S**
	T14	**54°00.00'W**	**60°00.00'S**	**54°00.00'W**	**61°03.00'S**
	T15	61°30.00'W	63°00.00'S	60°30.00'W	63°30.00'S
	T16	**60°30.00'W**	**63°00.00'S**	**59°30.00'W**	**63°30.00'S**
	T17	**60°00.00'W**	**62°45.00'S**	**59°00.00'W**	**63°15.00'S**
	T18	59°30.00'W	62°30.00'S	58°30.00'W	63°00.00'S
	T19	58°30.00'W	62°30.00'S	57°30.00'W	63°00.00'S

(continued)

Table 1 (continued)

Subarea	Transect	Waypoint 1		Waypoint 2	
		Longitude	Latitude	Longitude	Latitude
	T20	58°00.00'W	62°15.00'S	57°00.00'W	62°45.00'S
	T21	57°24.00'W	62°00.00'S	56°30.00'W	62°30.00'S
	T22	56°00.00'W	62°00.00'S	56°00.00'W	62°45.00'S
	T23	55°00.00'W	61°12.00'S	55°00.00'W	63°00.00'S
	T24	54°00.00'W	61°18.00'S	54°00.00'W	62°45.00'S
48.2	T1	48°30.00'W	59°40.20'S	48°30.00'W	62°00.00'S
	T2	47°30.00'W	59°40.20'S	47°30.00'W	62°00.00'S
	T3	**46°30.00'W**	**59°40.20'S**	**46°30.00'W**	**62°00.00'S***
	T4	**45°45.00'W**	**59°40.20'S**	**45°45.00'W**	**60°28.80'S**
	T5	45°00.00'W	59°40.20'S	45°00.00'W	60°36.60'S
	T6	44°00.00'W	59°40.20'S	44°00.00'W	62°00.00'S
	T7	45°45.00'W	60°42.00'S	45°45.00'W	62°00.00'S
	T8	45°00.00'W	60°58.80'S	45°00.00'W	62°00.00'S
48.3	T1	39°36.14'W	53°20.83'S	39°23.51'W	54°03.32'S
	T2	39°18.25'W	53°18.94'S	39°05.34'W	54°01.40'S
	T3	39°02.29'W	53°17.22'S	38°49.14'W	53°59.64'S
	T4	38°45.05'W	53°15.31'S	38°31.61'W	53°57.70'S
	T5	**38°26.94'W**	**53°13.25'S**	**38°13.22'W**	**53°55.61'S**
	T6	**38°08.42'W**	**53°11.11'S**	**37°54.40'W**	**53°53.42'S**
	T7	37°57.86'W	53°09.85'S	37°43.67'W	53°52.15'S
	T8	37°49.93'W	53°08.90'S	37°35.62'W	53°51.19'S
	T9	**36°15.62'W**	**54°05.73'S**	**35°15.19'W**	**53°41.49'S**
	T10	**36°10.50'W**	**54°10.35'S**	**35°09.80'W**	**53°46.26'S**
	T11	36°04.15'W	54°15.94'S	35°03.05'W	53°51.92'S
	T12	35°57.60'W	54°21.02'S	34°57.42'W	53°56.79'S
	T13	35°54.68'W	54°24.11'S	34°53.74'W	53°59.99'S
	T14	35°48.65'W	54°29.60'S	34°47.35'W	54°05.35'S
	T15	35°43.98'W	54°33.43'S	34°42.54'W	54°09.38'S
	T16	35°38.65'W	54°38.34'S	34°36.98'W	54°14.02'S
	T17	35°33.94'W	54°42.22'S	34°32.50'W	54°18.15'S
	T18	35°29.00'W	54°46.67'S	34°26.85'W	54°22.33'S

* Only the northern section (from 59°40.20'S to 60°28.80'S) is a nominated transect.

(a)

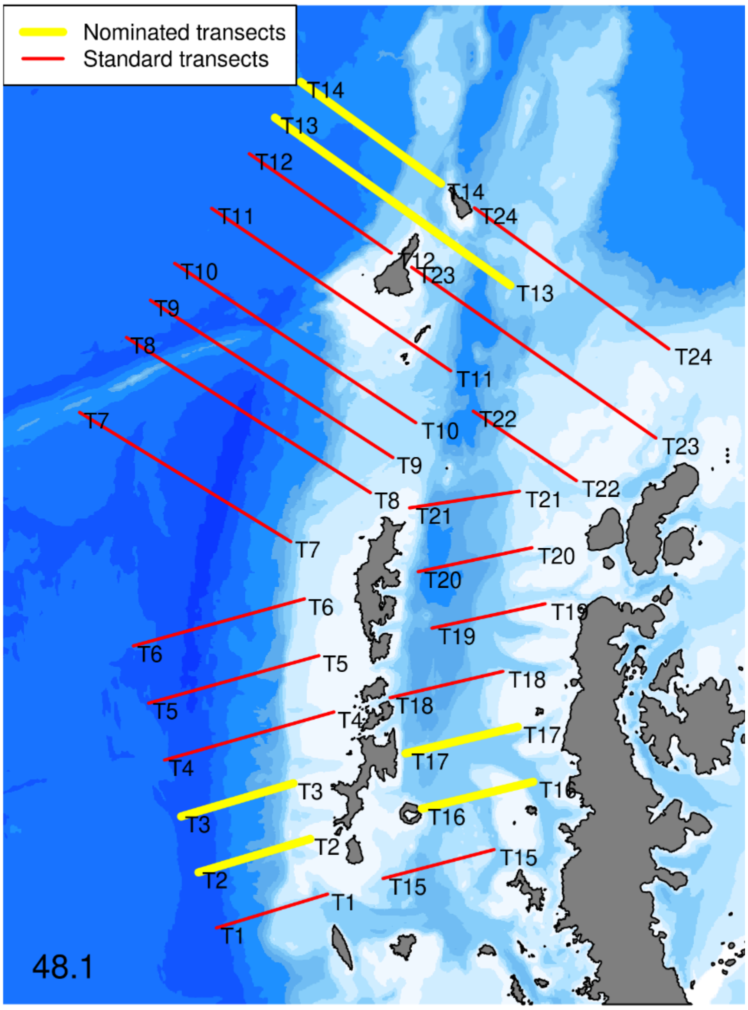
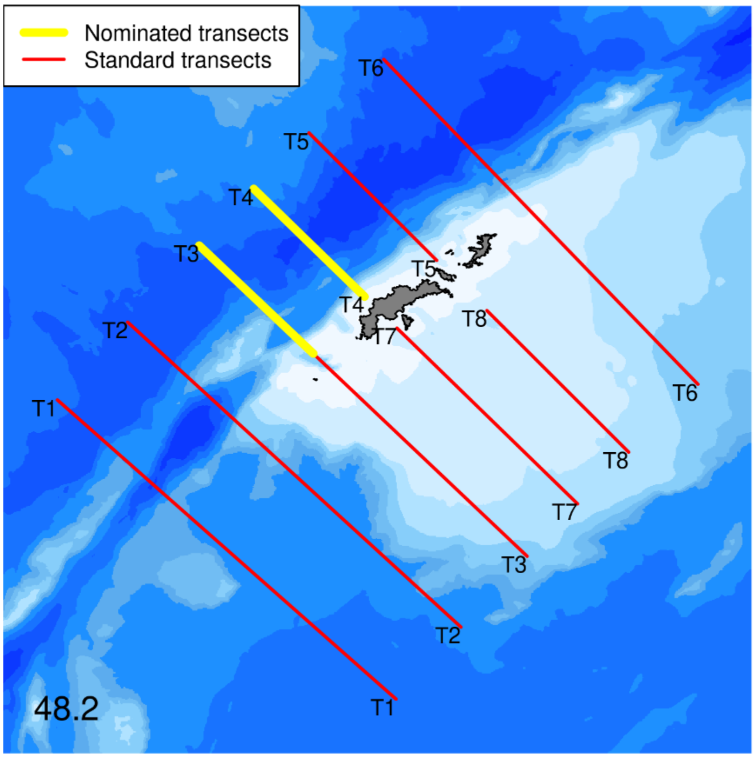


Figure 1: Location of nominated transects (thick yellow lines) and existing research transects for the collection of acoustic data in: (a) Subarea 48.1.

(continued)

(b)



(c)

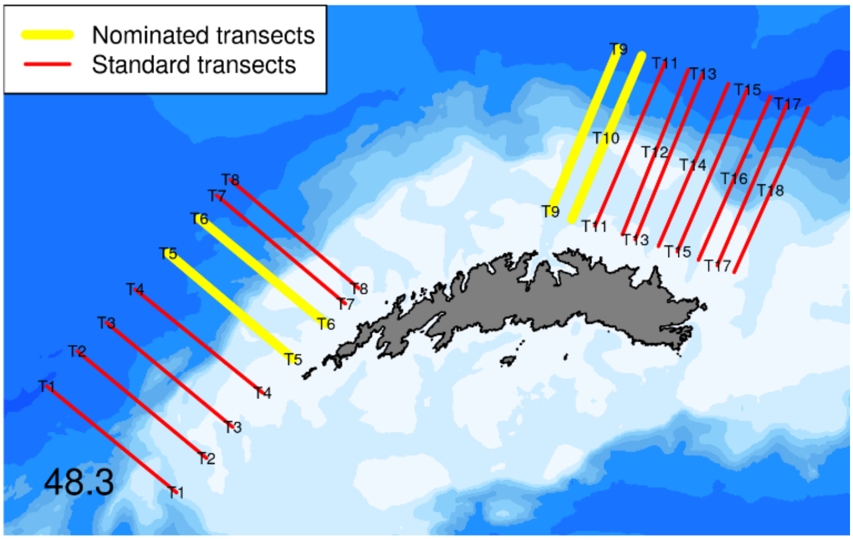


Figure 1 (continued): Location of nominated transects (thick yellow lines) and existing research transects for the collection of acoustic data in: (b) Subarea 48.2 and (c) Subarea 48.3.

Chapter 2

Data logging instructions

2.1. System requirements

Vessels are encouraged to regularly update the data acquisition software.

2.1.1 Echosounder

These instructions apply to Simrad ES60, Simrad ES70, Simrad EK60, Simrad ES80 or Simrad EK80 echosounders. A global positioning system (GPS) (with data output) should be connected to the echosounder. Please refer to the instruction manual of your echosounder to properly configure it according to the settings specified in this chapter.

2.1.2 Data logging device

An external hard drive with a minimum data storage capacity of 2 Tb. The actual volume of data stored depends on the number of frequencies used and the duration of the time in the Convention Area. The data should be stored as Power/Angle samples (ES80 and EK80). The file name should ideally have a unique vessel identifier (e.g. International Maritime Organization (IMO) number) and the instrument type (e.g. EK80) as prefix.

2.2 Instrument parameter settings

2.2.1 The instrument parameters should be set according to Table 2 and should not be changed, except the display range.

Table 2: Instrument setting for data collection.

Parameter	Unit	Setting			
Frequency	kHz:	38	70	120	200
Power[1]	W	2000	700	250	110
Pulse type[2]		CW	CW	CW	CW
Pulse duration	Microsecond	1024	1024	1024	1024
Ping interval	Second	2	2	2	2
Data collection range (min.–max.)	M	0–1100	0–1100	0–1100	0–1100
Bottom detection range (min.–max.)	M	5–1100	5–1100	5–1100	5–1100
Display range (min.–max.)	M	0–1100	0–1100	0–1100	0–1100

[1] Based on Korneliussen et al., 2008.
[2] Only for EK80 and ES80.

2.3 Operational instructions

- Please ensure your echosounder is operating in Coordinated Universal Time (UTC).
- Please ensure you log the acoustic data.
- The file size for storing acoustic data should be set to 100 MB.
- Where possible, other echosounders (except navigational echosounders) should be turned off to avoid unwanted interference.
- Please record the instrument and calibration attributes listed in Chapter 4 before data collection.
- When collecting data along transects:
    - pass through the waypoints of the transects in Table 1 in as straight a line as you can undertake. Transects can be undertaken in either direction (e.g. from N to S or vice versa)
    - maintain a constant vessel speed, ideally at 10 knots, that allows low noise data collection
    - please record the transect attributes listed in Chapter 4 at the beginning or end of each transect.

Chapter 3

Validation of instrument performance

3.1 External assessment of echosounder performance

3.1.1 Standard sphere calibration

If possible, carry out a standard sphere calibration utilising the techniques described in Foote et al. (1987) and ICES (2015). Locations where regular calibrations have been carried out previously are given in Table 3.

Table 3: Positions (dd mm.00) of regularly used calibration sites in Subareas 48.1, 48.2 and 48.3.

Subarea	Calibration site	Position	
		Longitude	Latitude
48.1	Admiralty Bay	58°26.58'W	62°08.10'S
48.2	Scotia Bay	44°40.86'W	60°44.88'S
48.3	Stromness Bay	36°40.02'W	54°09.30'S

3.1.2 Seabed reflection calibration

CCAMLR is currently investigating the use of seabed reflection as another way of externally assessing echosounder performance. A protocol for such assessments will be added to this part of the document once it becomes available.

3.2 Internal assessments of echosounder performance on board of vessels

Internal validation procedures to monitor basic system performance are being developed. Vessels running EK80 or ES80 systems are encouraged to perform built-in self-test equipment (BITE – accessed through the diagnostics dialog box) diagnostics and provide the result by filling in Table 4 or providing a screenshot of the test (Figure 2).

Table 4: BITE diagnostics table.

Transducer serial number						
Transducer frequency (kHz)						
Channel 1:	Impedence		Ohm	Phase		°
Channel 2:	Impedence		Ohm	Phase		°
Channel 3:	Impedence		Ohm	Phase		°
Channel 4:	Impedence		Ohm	Phase		°

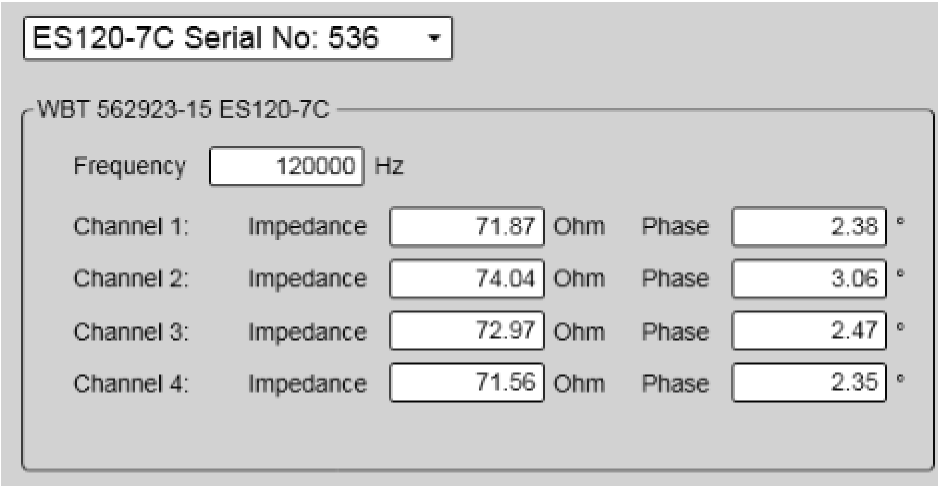


Figure 2: Example of impedance screenshot from a 120 kHz split-beam transducer using the BITE functionality of ES80 software.

Chapter 4

Data reporting and submission

Metadata contain important information that is an essential element of the data logged and should be delivered with the data collected.

Please record the data in Tables 5 and 6 prior to data collection. When data have been collected along nominated transects as listed in Table 1 and shown in Figure 1, please also record the relevant metadata in Table 7.

Please contact your national technical coordinator or Scientific Committee Representative regarding the submission of data to the Secretariat.

Table 5: Cruise metadata required to accompany acoustic data submissions to the Secretariat.

Parameter	Definition
Vessel name	The name of the vessel
Vessel IMO	The IMO number of the vessel
Cruise start date	The date the vessel left port
Cruise end date	The date the vessel returned to port

Table 6: Instrument and calibration attributes recommended to accompany acoustic data submissions to the Secretariat (adapted from SC-CAMLR-41, Annex 5, Table 2).

Parameter	Definition
Operating frequency (kHz)	Frequency of the transceiver/transducer combination in kHz. Some systems, such as broadband and multibeam, will have a range of frequencies. If so, specify the minimum, maximum and centre frequency
Transducer location	Location of installed transducer. Refer to ICES SISP 4-TG-AcMeta Appendix B.2 for a list of standard transducer locations
Transducer manufacturer	Transducer manufacturer
Transducer model	Transducer model
Transducer depth (m)	Mean depth in metres of transducer face beneath the water surface
Transducer orientation	Direction perpendicular to the face of the transducer. A simple description for a ship mounted sounder would be ‘downward-looking’, a mooring could be ‘upward-looking’. If required, ICES SISP 4-TG-AcMeta Appendix C provides a comprehensive description of transducer orientation conventions
Transducer equivalent beam angle (dB)	Manufacturer-specified transducer equivalent beam angle in dB, expressed as $10\log10(\Psi)$, where Ψ has units of steradians
Transducer beam angle major (degrees)	Major beam opening in degrees, also referred to as ‘athwartship angle’. See ICES SISP 4-TG-AcMeta Appendix D for description of beam geometry conventions
Transducer beam angle minor (degrees)	Minor beam opening in degrees, also referred to as ‘alongship angle’. See ICES SISP 4-TG-AcMeta Appendix D for description of beam geometry conventions
Transceiver manufacturer	Transceiver manufacturer
Transceiver model	Transceiver model
Transceiver serial	Transceiver serial number

(continued)

Table 6 (continued)

Parameter	Definition
Transceiver firmware version	Transceiver firmware version
Calibration date	Date and time of calibration
Calibration method	Describe the method used to acquire calibration data (see ICES SISP 4-TG-AcMeta Appendix B.4, Standard lists)
Calibration processing method	Describe method of processing that was used to generate calibration offsets
Calibration accuracy estimate	Estimate of calibration accuracy. Include a description and units so that it is clear what this estimate means (e.g. estimate might be expressed in dB or as a percentage)
Calibration location	Name of the site where the calibration was carried out. See also Table 3
Acquisition software name	Name of software that controls the echosounder and its data logging
Acquisition software version	Version of software that controls the echosounder and its data logging

Table 7: Transect attributes recommended to accompany acoustic data submissions to the Secretariat (adapted from ICES SISP 4-TG-AcMeta standard and WG-ASAM-2021/15, Table 1).

Parameter	Definition
Subarea	The subarea in which the transect was conducted. For example, 48.1, 48.2 or 48.3
Transect number	The number of the transect as defined in Table 1
Start datetime (UTC)	Start date and time in UTC of the transect formatted following ISO 8601. For example, 18:00 UTC on 24 October 2008 would be represented as 2008-10-24T18:00:00
End datetime (UTC)	End date and time in UTC of the transect formatted following ISO 8601. For example, 18:00 UTC on 24 October 2008 would be represented as 2008-10-24T18:00:00
Start latitude	The latitude of the start of the transect expressed in decimal degrees
Start longitude	The longitude of the start of the transect expressed in decimal degrees
Start heading	The heading at the start of the transect expressed in degrees
Start course	The course at the start of the transect expressed in degrees
Start depth (m)	The bottom depth in meters at the start of the transect
Start speed (kn)	The speed of the vessel in knots at the start of the transect
Start wind direction	The wind direction at the start of the transect expressed in degrees
Start wind speed (kn)	The wind speed in knots at the start of the transect
Start sea state	The state of the sea at the start of the transect using World Meteorological Organization (WMO) Sea State Codes
End latitude	The latitude of the end of the transect expressed in decimal degrees. Positive values are north of the equator, negative values are south of the equator
End longitude	The longitude of the end of the transect expressed in decimal degrees. Positive values are east of the Greenwich Meridian, negative values are west of it
End heading	The heading at the end of the transect expressed in degrees
End course	The course at the end of the transect expressed in degrees
End depth (m)	The bottom depth in meters at the end of the transect
End speed (kn)	The speed of the vessel in knots at the end of the transect
End wind direction	The wind direction at the end of the transect expressed in degrees
End wind speed (kn)	The wind speed in knots at the end of the transect
End sea state	The state of the sea at the end of the transect using WMO Sea State Codes
Transect comments	Free text field for relevant information that might not be captured by the defined attributes

References

Foote, K.G., H.P. Knudsen, G. Vestnes, D.N. MacLennan and E.J. Simmonds. 1987. Calibration of acoustic instruments for fish density estimation: a practical guide. *ICES Coop. Res. Rep.*, 144: 69 pp.

ICES. 2015. Calibration of acoustic instruments. *ICES Coop. Res. Rep.*, 326: 136 pp, doi: https://doi.org/10.17895/ices.pub.5494.

Korneliussen, R.J., N. Diner, E. Ona, L. Berger and P.G. Fernandes. 2008. Proposals for the collection of multifrequency acoustic data. *ICES J. Mar. Sci.*, 65: 982–994.

Krill biomass estimate workflow – WG-ASAM-2023

Please see ‘ASAM_2023_KrillBiomassStats_CombV3.Rmd’, which is the accompanying RMarkdown document.

1. Read in metadata table “ASAM_metadata_2022_v1_tidy.csv”

2. Consolidate survey names

Recode survey areas to the nearest available new strata.
Strata were allocated a strata_code to the 4 AMLR areas (E, W, S and J based on geographic location).
3 new areas were added in 2022 – DP, GS and PB.

Stratum_name	Number_surveys	strata_code
Elephant Island	31	E
West	31	W
South	26	S
Joinville	14	J
Bransfield	2	S
South Shetland Islands North	1	W
South Shetland Island (SSI)	1	W
Bransfield Strait (BS)	6	S
Elephant Island (EL)	1	E
DP	1	DP
PB	1	PB
GS	1	GS

3. Remove Duplicate and Bad data

As analysis requires Density (g m^{-2}), CV, and Area, for weighted density calculations:

1. Remove rows which do not have complete records for ‘Density’ and/or ‘CV’ or where values other than CV were reported (i.e. confidence intervals).
2. Remove anything with a comment in the ‘ASAM_NOTES’ because this was either:
    a. the same AMLR data but run with the Greene algorithm so DUPLICATED
    b. incomplete/the area was not covered properly so difficult to weight appropriately.
3. Remove rows where area was not recorded.

NOTE: When running the RMarkdown script removed files are stored in a ‘remdat’ data table.

4. R friendly format

1. Ensure all numeric values are stored as class numeric.
2. Create a year-month timestamp for plotting.
3. Create a ‘season’ year variable where survey values collected in ‘Oct-Dec’ are annotated as the year of collection +1.

5. Calculate the Std. deviation (S.*D. density*) and variance of density (*Var. density*) for each survey (i)

$$S.D.\ density_i = Density_i * \frac{CV_i}{100}$$

$$Var.\ density_i = (S.D.\ density_i)^2$$

6. Calculate 95% Confidence Intervals of each survey for plotting, assuming a lognormal distribution

qlnorm(p=0.025, meanlog=log(Density$_i$), sdlog=sqrt(log(1+(CV$_i$/100)^2)))

qlnorm(p=0.975, meanlog=log(Density$_i$), sdlog=sqrt(log(1+(CV$_i$/100)^2)))

7. Update Subarea 48.1 strata values from WG-ASAM-2023/01

1. Subset to metadata to Subarea 48.1.
   Subarea strata codes "E" = Elephant, "J" = Joinville, "W" = SSIP, "S" = Bransfield Strait, "GS" = Gerlache Strait, "PB" = Powell Basin, "DP" = Drake Passage.
2. Update areas from WG-ASAM-2023/01 'AMLR_Area'.

8. Calculate annual biomass for each new stratum and season

1. Subset surveys by 'Strata' e.g. 'J', and sampling 'Season' e.g. '2019'.

2. Assign each survey an area weighting ($areawt_i$) based on the $area_i$ of each survey, divided by the sum of all survey areas within the Strata Season subset:

$$areawt_i = \frac{area_i}{\sum_{i=1}^{n} area_i}$$

where *n* is the total number of surveys within the strata and season subset.

3.1 Calculate weighted mean density ($wtDensity$, g m^{-2}) for each Strata and Season using the *weighted.mean* function in R where:

x = vector of $Density_i$

w = vector of $areawt_i$

3.2 Calculate the weighted mean variance ($wtVar.density$) of density for each Strata and Season, using the *weighted.mean* function in R where:

x = vector of $Var.density_i$

w = vector of $areawt_i$

3.3 Calculate the weighted mean *CV* ($wtCV$) for each Strata and Season, using the *weighted.mean* function in R where:

x = vector of CV_i

w = vector of $areawt_i$

NOTE: where the total number of surveys in a single stratum and survey season = 1, the weighting will equal 1 and the weighted mean density, variance and CV will be unchanged from the density and CV given in the original survey.

4. Define new area for strata ($StrataArea$)

5. Calculate krill biomass (tonnes) for each Strata and Season as:

$$Biomass = wtDensity * StrataArea$$

6. Calculate variance of biomass for each Strata and Season as:

$$Var = wtVar.density * StrataArea^2$$

7. Calculate the *CV* of Biomass (tonnes), where:

$$CV = \frac{\sqrt{Var}}{Biomass} \times 100$$

9. Average across all available years 'yall'

Biomass estimates for each stratum are the mean of all available years.

10. Use R qlnorm to calculate the one-sided lower 95% confidence bound of density (*LB95*).

qlnorm(p=0.025, meanlog=log($wtDensity$), sdlog=sqrt(log(1+(sqrt($wtVar.density$)/$wtDensity$)^2)))

11. Calculate the one-sided lower 95% biomass for use in strata with only one survey.

$$LB95\_Biomass = LB95 * StrataArea$$

Report of the Working Group on Statistics, Assessment and Modelling 2023 (WG-SAM-2023)

(Kochi, India, 26 to 30 June 2023)

Contents

Report of the Working Group on Statistics, Assessments and Modelling 2023 (WG-SAM-2023)
(Kochi, India, 26 to 30 June 2023)

Introduction

1.1 The 2023 meeting of the Working Group on Statistics, Assessments and Modelling (WG-SAM) was held at the Holiday Inn Hotel in Kochi, India, from 26 to 30 June 2023. The meeting was hosted by the Centre for Marine Living Resources and Ecology (CMLRE), an attached office of the Ministry of Earth Sciences, Government of India.

Opening of the meeting

1.2 The meeting Co-conveners, Dr C. Péron (France) and Dr T. Okuda (Japan) welcomed participants back to in-person meetings (Appendix A). The meeting was opened with a traditional ceremony and lighting of the lamp, to symbolise success in finding the correct pathway for the future and a Sanskrit song of good intentions. Dr GVM Gupta, CCAMLR Commissioner for India and Director of the CMLRE, welcomed all participants and noted that India was very happy to be hosting the meeting, which has been in planning for three years. He wished the participants success in their work and a comfortable stay in Kochi. Dr S. Saravanane, the Scientific Committee Representative for India to CCAMLR, also welcomed the group on behalf of the CMLRE, Ministry of Earth Sciences, Government of India.

Adoption of the agenda

1.3 With minor changes to the agenda topics within Agenda Item 6, the agenda was adopted (Appendix B) and a schedule was developed for the week.

1.4 Documents submitted to the meeting are listed in Appendix C and the Working Group thanked all authors of papers for their valuable contributions to the work presented to the meeting.

1.5 In this report, paragraphs that provide advice to the Scientific Committee and its other working groups have been indicated in grey. A summary of these paragraphs is provided under 'Advice to the Scientific Committee'.

1.6 The report was prepared by J. Devine and A. Dunn (New Zealand), T. Earl (UK), C. Jones (USA), S. Kawaguchi and C. Masere (Australia), F. Massiot-Granier (France), S. Parker (Secretariat), C. Péron (France), J. Quiroz Espinosa (Chile), L. Readdy (UK), S. Somhlaba (South Africa) and S. Thanassekos (Secretariat).

1.7 A glossary of acronyms and abbreviations used in CCAMLR reports is available online at https://www.ccamlr.org/node/78120.

Review of the terms of reference and workplan

2.1 The Working Group reviewed the terms of reference agreed by the Scientific Committee in 2022 and set out in SC CIRC 23/52.

2.2 The Working Group reviewed the workplan set out in SC-CAMLR-41, Table 6, and agreed that some of the tasks could be progressed through discussions at this meeting. The Working Group further agreed to discuss additional modifications to the workplan under 'Future Work' (paragraph 10.1).

Development of methods to estimate biomass for krill

Gear selectivity

3.1 WG-SAM-2023/19, a continuation of the work described in WG-SAM-2022/27 (WG-SAM-2022, paragraphs 3.17 and 3.18), considered methodological aspects of trawl selectivity assessment for krill focusing on the gear selectivity function by Krag et al. (2014) which was used to estimate the selectivity parameter values for the krill stock assessment model (Grym). The authors maintain their position on the need for additional data to assess the gear selectivity for krill fishing and presented the results of the analysis of krill biometrics. The results of this study confirmed the presence of sexual dimorphism in the body proportions of krill and demonstrated the difference in biometrics between different sex and maturity stages, especially the measure of their body height that may affect the estimation of gear selectivity, one of the input parameters for the Grym. The authors stated that the results obtained are additional evidence that the data used to construct the selectivity function (Krag et al., 2014) does not adequately describe the krill fishing process. The authors of WG-SAM-2023/19 concluded that caution should be exercised when using biometrics for deriving gear selectivity functions, and stated that the gear selectivity function derived by Krag et al. (2014) is currently the best available information, but the function is not sufficient to be used to parameterise the Grym, and has not been peer reviewed by the Scientific Committee for its practical use. The authors noted that the topic related to methodological aspects of gear selectivity functions for krill should be considered by working groups as part of a revision of krill resource management.

3.2 The Working Group recalled the work by Krag and colleagues on gear selectivity and reiterated that it had been extensively reviewed by both WG-EMM (WG-EMM-2012, paragraph 2.34; WG-EMM-2016, paragraphs 2.15 to 2.17) and WG-SAM-2022, and that it has been agreed that the gear selectivity function described by Krag et al. (2014) was currently the best available information to parameterise the Grym (WG-SAM-2022, paragraph 3.18).

3.3 The Working Group further noted the difficulty in evaluating the gear selectivity described in WG-SAM-2023/19 without any statistical information, such as confidence bounds, and encouraged the authors to present their analysis in detail. The Working Group also noted that it is important for the authors to demonstrate how a selectivity function derived using different biometry between different sex may influence the output of the Grym.

Data collection needs and standards

Effective sampling to estimate length-frequency distribution

3.4 Dr Earl summarised an initial analysis on effective sampling size for krill length-frequency distributions that is currently being undertaken (Table 1, Task 1) in order to obtain any feedback from the Working Group on the intended analysis. In the analysis, krill observer data from Area 48 were aggregated by vessel and subarea, with gaps of less than 10 days between samples. This resulted in ~100 blocks of data, and by bootstrapping, Dr Earl estimated variability in the mean length depending on the effective sampling size as a first approach.

3.5 The Working Group suggested using metrics that could be more representative of the whole length distribution, such as inter-quartile range, root mean square error or an approach similar to that used for the tag-overlap statistic.

Development of integrated stock assessment for krill

4.1 WG-SAM-2023/25 presented preliminary results from a pilot model using Casal2 to conduct an assessment of Antarctic krill (*Euphausia superba*) in Subarea 48.1. Model inputs included fishery catches, acoustic survey data (either nautical area scattering coefficient (NASC)-derived biomass estimates or raw NASC data, which produced similar population estimates), length-frequency distributions from the fishery and from research surveys. The proposed use of Casal2 would result in the same integrated modelling framework being used for krill as for toothfish. The authors noted that the Scientific Committee could design future data-collection plans for the krill fishery that facilitate the application of integrated assessment models by combining frequent surveys that simply report NASC data with occasional surveys during which length-frequency data are collected using research nets.

4.2 The Working Group agreed that this pilot model was a useful exploration of the use of Casal2 for the assessment of krill, and encouraged the authors to continue progressing this approach for the potential future stock assessment of krill.

4.3 While the Working Group expressed interest in the approach, its ability to inform data collection plans, its practical use of NASC data instead of biomass estimates, and its usefulness in providing an additional approach to assessing krill stock status, it recalled that the development of an integrated stock assessment for krill was considered desirable within three to five years (Table 1, Task 2) and that the ongoing revision of the krill fishery management approach was, inter alia, relying on the use of the Grym (SC-CAMLR-41, paragraph 3.31). The Working Group discussed the presented implementation of Casal2 to assess krill stocks and suggested the authors consider the following future work:

(i) the impact of using an age-based or a length-based implementation could be assessed, noting that a preservation of the source data would be preferred (i.e. the conversion between length composition and age composition should be considered, with conversions from length to age to length avoided)

(ii) if an age-based model is to be used, that age classes known to be difficult to age might be included as a ‘plus’ group

(iii) the effect of different interannual recruitment variability assumptions should be tested

(iv) a Casal2 implementation using the same assumptions, data inputs, and parameters as those used in the Grym should be performed to help validate the model

(v) consideration of the krill stock hypothesis in Area 48 (i.e. linkages to adjacent subareas) could be given in further developments

(vi) the presentation of model configuration and outputs should be made consistent with other Casal2 implementations (paragraphs 6.33 to 6.35).

Develop methods to estimate biomass for finfish

5.1 The Working Group discussed work that Members were encouraged to conduct on conversion factors for Patagonian (*Dissostichus eleginoides*) and Antarctic toothfish (*D. mawsoni*) in the Convention Area. It recalled discussions on conversion factors during the dedicated workshop in 2022 (SC-CAMLR-41, Annex 9) and by WG-FSA-2022, paragraphs 8.15 to 8.20, and the importance of calculating accurate green weight by considering factors such as sample sizes and biological information (e.g. sex, gonad and liver weights) collected on appropriate spatial and temporal scales.

5.2 Dr Massiot-Granier brought to the attention of the Working Group that French vessels conduct sampling for conversion factors that are year-round, widely spatially distributed and frequent. These data could be used for conducting power analyses for estimating appropriate sample sizes for conversion factors in other areas of the CAMLR Convention Area.

5.3 The Working Group requested the Secretariat to work with French scientists to progress work on conversion factors that could clarify recommendations to other Members who need to improve data collection methods for their vessel operations. The Secretariat will further develop a paper for WG-FSA-2024 on an implementation strategy based on the recommendations made by Members.

5.4 WG-SAM-2023/18 presented a review of tag-overlap statistic calculation methodology given in footnote 3 of Conservation Measure (CM) 41-01, Annex 41-01/C. The paper highlighted a possible upward bias that might arise in calculating tag-overlap statistics if a randomly sampled length frequency by observers is not scaled by length frequencies of caught fish, which include retained and tagged fish. The sample from which length frequencies are derived must be representative of the entire catch.

5.5 The Working Group welcomed the review of the methodology and it further noted that observers might require non-random sampling of fish from time to time (e.g. sampling fish for otolith) and it emphasised the need to separate the lengths of non-randomly sampled fished from those randomly sampled for length frequencies in order to avoid introducing any bias. Historic non-random sampled length frequency could be hard to detect since there is no provision in the 'Biologicals' form to record them.

5.6 The Working Group recommended, consistent with advice (SC-CAMLR-41, paragraph 3.121) the Secretariat to:

(i) use the calculation which scales the length distribution of the retained fish based on the number of fish caught for the calculation of tag-overlap statistics (WG-SAM-2023/18)

(ii) utilise tag-overlap statistics calculated using this method for Fishery Reports and the CCAMLR Compliance Evaluation Procedure (CCEP)

(iii) consider developing a publicly available R package for working with CCAMLR data extracts, including the calculation of the tag-overlap statistic

(iv) consider the usefulness of modifying CM 41-01, Annex C, footnote 3, to further clarify the tag overlap statistic calculation method

(v) consider the addition of a column in 'Biologicals' in order to specify if fish have been randomly sampled or not.

Develop stock assessments to implement decision rules for finfish

6.1 WG-SAM-2023/12 provided a summary of progress against the 2018 Independent Stock Assessment Review for Toothfish (ISART) recommendations for the stock assessment of Antarctic toothfish in the Ross Sea region, including references to papers and discussions in CCAMLR reports.

6.2 The Working Group noted that most of the recommendations from the ISART have been addressed and resulted in a number of improvements to the Ross Sea toothfish assessment model. Work had been completed on all but a few of the recommendations.

6.3 The Working Group noted that WG-SAM-2023/12 provided a useful template document for other integrated assessments to track the progress made on CCAMLR integrated stock assessments since ISART.

6.4 The Working Group developed a summary for all of the integrated toothfish assessments involved in the upcoming review by the Center for Independent Experts (CIE) of the progress made against the ISART recommendations (Appendix D).

6.5 The Working Group recognised that addressing the ISART recommendation 18 on tagging mortality would be challenging and require field experiments.

6.6 The Secretariat provided an update on the status of the upcoming CCAMLR independent stock assessment review for toothfish. A panel of experts will be selected as reviewers by the CIE, and the review will take place in August as outlined in SC CIRC 23/52.

Develop new methods for stock assessments

6.7 WG-SAM-2023/14 presented a generalised additive mixed modelling (GAMM) framework to estimate the probability of a macrourid sampled in the Ross Sea region (RSR) is either *Macrourus caml* or Whitson's grenadier (*M. whitsoni*). This GAMM was used to underpin recent vector autoregressive spatio–temporal (VAST) modelling analyses presented to WG-SAM-2022 and WG-FSA-2022. Preliminary results indicated that the selected GAMM had a good fit to the data, with 55.3% of the deviance explained and with model residuals randomly distributed in a narrow range around zero. Preliminary results also suggested that *M. caml* occurs in higher proportions than *M. whitsoni* in each management area of the RSR.

6.8 The Working Group recommended that the data inputs of the GAMM and VAST models be expanded to include more data from the fishery and investigations of model sensitivity to such expansion be conducted. To support the expansion of data inputs in the GAMM and VAST models, the Working Group also recommended future work to confirm the accuracy of species identification by scientific observers operating across the three gear types employed in the RSR (autoline, Spanish line and trotline), and in particular, confirmation that species codes are being used as intended (e.g. that the code WGR is being used specifically for *M. whitsoni*).

6.9 The Working Group agreed that training material should be developed to ensure that scientific observer biological records are identified to the species level, as opposed to the generic GRV code, and be developed by the Secretariat.

6.10 The Working Group recommended the results of the modelling be used to support the development of a revised framework for determining macrourid by-catch limits in the RSR by taking into account the species of macrourid present, their relative abundances, spatial distributions, productivities and catches by the RSR toothfish fishery.

6.11 The Working Group noted that the effect of excluding data with a difference of more than 300 m between start and end haul depths could be explored and be part of recommendations for this type of analysis in the future if it improves the model.

6.12 The Working Group noted that the effects of environmental covariates on species proportion in this study are likely to be relevant to the distributions of these species in populations in other areas. The Working Group noted that a similar study related to species identification based on otolith morphometrics that in part underpins the dataset for the GAMM model is under development in Division 58.5.2 based on these papers. This work may serve as a useful dataset to explore whether correlations between grenadier species' distribution and environmental variables differ between regions.

6.13 The Working Group noted that this approach has limited potential for use with historical data since *Macrourus* species were not identified by observers historically and would require other methods such as the use of otolith morphology to identify to species level, noting that otoliths were not routinely collected from macrourids at the time.

6.14 WG-SAM-2023/13 presented methods for updating biomass estimates and exploitation rates consistent with the CCAMLR decision rules for Antarctic starry skate (*Amblyraja georgiana*) in the Ross Sea. It included a risk assessment methodology, summarised the data available for this update, and proposed sensitivity simulations to input parameters to account for life-history uncertainties. Specifically, it provided a range of possibilities for biomass and exploitation rate estimates, but model uncertainties still exist, particularly around post-release mortality and age determination. An updated version of this risk assessment for the starry skate will be presented to WG-FSA-2023. Further updates would benefit from the data collected from: (i) the planned year of skate tagging commencing in the 2027/28 season, (ii) continued recording of skate injury condition at recapture or release when tagging occurs, and (iii) research to improve post-release mortality estimates.

6.15 The Working Group noted that the analyses could be limited to a core area where skates are in high abundance. It also noted that the results of the risk analysis are likely to depend on age estimation (as they relate to growth and maturity). Age readings using spines are ongoing and results will be presented at WG-FSA-2023.

6.16 The Working Group highlighted that studies are ongoing on Kerguelen sandpaper skates (*Bathyraja irrasa*) involving pop-up satellite archival tags (PSATs) to explore post-tagging survival and blood sampling to assess stress levels. Results of this work may be helpful for the starry skate assessment and will also be shared with CCAMLR working groups when they are completed.

6.17 WG-SAM-2023/15 provided a comparison of methods to estimate von Bertalanffy growth parameters for *D. eleginoides* in Subarea 48.3. Growth models were compared between three sex categories (combined sex; females; males) and the same time periods used in previous studies. Comparison of the estimation methods suggested that the Bayesian growth model allowing for additional uncertainty for older ages had the best fit to the data and least bias when examining model residuals. It explored the sensitivity of this growth model to the inclusion of young fish (≤6 years) using trawl survey data. Results showed that including the youngest age classes of fish (ages 2 to 3) from survey data had a large influence on the model estimates, suggesting that the von Bertalanffy model could be inappropriate to capture growth at early ages.

6.18 The authors proposed to use the Bayesian growth model for future estimation of von Bertalanffy growth parameters to be used in assessments for *D. eleginoides* in Subarea 48.3, and to include survey data in the age dataset, with the exception of the age 2–3 fish, given their large influence on model estimates.

6.19 The Working Group noted that data from Subarea 48.4 were not included in this study due to differences in the specific growth of fish in that area. It also noted that young fish in Subarea 48.3 predominantly occur in one area around Shag Rocks, and therefore spatial patterns could not explain the different growth pattern observed in the age 2–3 fish.

6.20 The Working Group noted that priors could be revisited (e.g. the τ parameter of heteroscedasticity). Correlation between parameters could be explored by plotting full posterior distributions, recognising that it is not likely to have a strong impact on the estimation considering the quantity of data used.

6.21 WG-SAM-2023/09 explored different tag-loss models for *D. mawsoni* in the Ross Sea region, including: (i) assessing the effect of increasing the maximum time at liberty included in the analysis to those tags recaptured beyond six years at liberty, (ii) determining if ongoing tag loss was a function of time at liberty, (iii) determining the effect of initial tag loss on ongoing tag-loss rates, and (iv) allowing tag-loss rates to differ by size-class of tagged fish or season of tag release. Models with an initial tag loss and a constant ongoing annual tag loss were the most parsimonious based on likelihood ratio tests. Estimated rates of initial and ongoing tag loss from the 3 555 double-tagged fish since 2005 and subsequently recaptured suggested that about 5.7% (95% confidence interval (CI) 0.042–0.072) of individual tags were lost immediately, followed by an ongoing loss rate of 0.033 tags per year. The loss rates were similar to previous estimates, with the initial tag-loss rate slightly higher than 3.5% and the ongoing tag-loss rate slightly lower than 0.039 y^{-1}. A key assumption of the tag-loss rate estimation is that probability of a lost tag on an individual fish was independent of the loss of the other tag and that the two tags had identical tag-loss rates.

6.22 The Working Group recommended using all years at liberty when estimating tag-loss parameters for all stocks, that these tag-loss rate estimates be updated periodically and that the updated estimates (WG-SAM-2023/09) be used in future stock assessments of the Ross Sea region. It further recommended alternate model formulations be investigated to evaluate the effect of the correlation between initial and ongoing tag-loss rates and simulation studies be carried out to investigate the potential effect of non-independence of tag loss with time.

6.23 The Working Group noted that tag placement could be a factor contributing to tag-loss rates, and taking pictures of the tag placement at recapture would help assess this effect. It also noted that T-bar tags in larger fish may not be anchored as they are designed to be, as noted at the 2023 COLTO–CCAMLR Tagging Workshop (WS-TAG-2023) (paragraphs 11.1 to 11.5).

6.24 The Working Group noted that practices might differ by vessel which may affect tag-loss rates and recommended further analyses exploring this.

6.25 The Working Group noted that the approximated double-tag-loss rate that could be calculated from the results of this paper is likely to be negligibly different from the value of 0.0084 currently in use in trend analysis (WG-SAM-2011/18). This value was previously used in the Ross Sea region stock assessment, and the double-tag-loss rate function is now available in Casal2.

6.26 WG-SAM-2023/11 presented methods to calculate the numbers at age of tagged fish and of recaptured fish which could be provided to the assessment model of the Ross Sea region *D. mawsoni* instead of numbers at length as has been done in the past. Results showed that the numbers at age of tagged fish calculated using this age-based approach were close to the numbers at age of tagged fish calculated within the assessment model when using the existing length-based approach, and that the numbers at age of recaptured fish calculated using the age-based approach were consistent with the otolith-derived age data for those same recaptured fish where otolith readings were available.

6.27 The Working Group recommend that the use of the age-based approach for tagged fish and for recaptured fish be explored in future toothfish stock assessments for the Ross Sea region and evaluated as an alternative to the use of the length-based approach.

6.28 The Working Group noted that results of this new method could be compared with the age frequencies estimated from otolith reading of recaptured fish.

6.29 The Working Group noted that the methodology might be difficult to apply to year-round fisheries since it relies on adding the time at liberty to an overall age. This issue does not influence the Ross Sea fishery data, which sample fish during a short summer period.

Draft integrated stock assessments in Casal2

6.30 The Working Group thanked Mr. N. Walker (New Zealand) and Mr Dunn for organising four Casal2 workshops held online during the intersessional period and noted the usefulness of these workshops which assisted Members to develop Casal2 assessment models for WG-FSA-2023.

6.31 The Working Group requested that the Secretariat create a private GitHub repository for the Casal2 training materials and example R code to aid Members to develop their stock assessment models.

6.32 The Working Group noted the need for development of a standard set of diagnostic tools and formats for presentation of model diagnostics in Casal2. It recalled its advice from WG-SAM-2015, paragraphs 2.33 to 2.43, that described a standard set of outputs and diagnostics for CASAL models and agreed that these should be applied and updated for Casal2. It was noted that Casal2 had advantages over CASAL in that summary plots and diagnostics are more easily generated, which allows the development of more informative summaries.

6.33 The Working Group recommended that integrated stock assessments, irrespective of the assessment, using CASAL and Casal2 include (where relevant) the following:

(i) table of annual cycle with time steps used in the assessment model (Table 2)

(ii) table of tagging release and recaptures by year

(iii) table of process error weighting

(iv) plot of the observations by year and their relative weights (e.g. WG-SAM-2023/10, Figure 1)

(v) table of the maximum of the posterior density (MPD) likelihood components

(vi) plots of fits to age and length-frequency and abundance data and mean age

(vii) likelihood profiles

(viii) Markov chain Monte Carlo (MCMC) model convergence diagnostics

(ix) model-derived estimates with MCMC credible intervals for example for selectivity functions, spawning, stock status, year-class strength (YCS), stock biomass projections and risk profiles.

6.34 The Working Group encouraged the development and use of other plots and diagnostics, including:

(i) graphical representation of the MPD likelihood components

(ii) time-at-liberty likelihood profile

(iii) r-hat statistics for MCMC convergence

(iv) projections with constant F that gives a long-term expected stock biomass of 50% B_0 with a 90% probability of being above 20% B_0

(v) Kobe plot with the 20% and 50% reference points and a target F reference point (from (iv) above)

(vi) stacked bar charts of the catch

(vii) retrospective analyses.

6.35 The Working Group recommended that Members develop and share code related to paragraphs 6.33 and 6.34 via a CCAMLR GitHub repository.

6.36 WG-SAM-2023/08 showed that using parameter transformations improved model optimisation and MCMC performance and was useful for parameters when there was evidence of poor convergence. The paper also noted that the use of more up-to-date algorithms in Casal2 or the use of catch in numbers rather than catch in biomass had a negligible impact on model estimates. Comparison of the catch in numbers with the catch in biomass models suggested that the assumptions used for the conversion factors, length-weight and age-length relationships were appropriate and did not create a bias. The Working Group thanked the authors for the work, agreed that it was valuable in providing some guidance to new assessments for setting up models.

6.37 The Working Group recommended that Members developing integrated assessments consider parameter transformations where improvements in diagnostics of MCMC convergence are required. Specifically, the use of the simplex method for parameterising recruitment deviates or YCSs and the inverse transformation for the right-hand limbs of selectivity relationships be considered as useful defaults. A $\log(B_0)$ transformation may also be considered when assessments are fitted to time series of surveys or catch-per-unit-effort (CPUE) indices.

6.38 WG-SAM-2023/10 investigated the double-tag-loss rate function and the effect of including tag-recapture observations with greater time at liberty in the Ross Sea region *D. mawsoni* assessment using Casal2.

6.39 The Working Group noted that the double-tag-loss rate function (WG-SAM-2023/10) was preferred over the single-tag-loss rate function for double-tagged fish. The Working Group recommended the use of the double-tag-loss rate function for double-tagged fish in future assessments using Casal2.

6.40 The Working Group noted tag releases for 2001–2004 in the Ross Sea region were in the years prior to CCAMLR standardising the tagging protocols and different tag types had been used. The Working Group noted that the amount of information from these years was no longer a significant component of the tagging data and recommended that tag-release data for 2001–2004 for the Ross Sea region should be omitted from future assessments.

6.41 WG-SAM-2023/10 showed that model diagnostics indicated a trend in the likelihood profiles with increasing time at liberty, and four hypotheses were identified that might explain the patterns. Analyses presented suggested that tag dispersion was the most plausible explanation, but models that included an effect for tag dispersal did not fully explain the pattern in the first three years of time at liberty.

6.42 The Working Group agreed that the framing and investigation of the hypotheses was a useful approach to investigating issues within stock assessments. The Working Group suggested that additional ecological hypotheses, such as higher than expected natural mortality, ontogenetic changes in residence time, or age-based changes in movement patterns, could be explored as well as incorporating hypotheses concerning fishing behaviours or localised changes to fishing grounds, which may explain the residual pattern in tag-recapture data.

6.43 The Working Group encouraged further investigation of the patterns in likelihood profiles identified in WG-SAM-2023/10, and that this be presented to future meetings of the Working Group.

6.44 WG-SAM-2023/20 presented the translation of the 2021 integrated stock assessment of *D. eleginoides* around Heard Island and McDonald Islands from CASAL to Casal2. Differences in model outputs and diagnostics were negligible.

6.45 The Working Group agreed that the Casal2 assessment model has been validated against the CASAL assessment model and that the Casal2 model can be progressed to WG-FSA-2023.

6.46 In light of progress by Members on using Casal2, the Working Group discussed how stock assessments for which both CASAL and Casal2 might be ready to use would be presented at WG-FSA-2023. The Working Group recalled paragraph 3.31 of WG-SAM-2022 and recommended that equivalent CASAL and Casal2 models would only need to be presented for the base case.

Trend analysis rule development

6.47 WG-SAM-2023/16 presented a provisional trend analysis for research blocks in data-limited toothfish fisheries and requested feedback from the Working Group. The document included summaries of fish releases and recaptures within and between research blocks, annual biomass estimates and updated trends, the decision tree of the trend analysis, preliminary catch limits and retrospective analyses. The 2023 update to the general bathymetric chart of the Oceans (GEBCO) dataset was used to re-estimate fishable areas and associated CPUE-by-seabed area biomass estimates and preliminary catch limits.

6.48 The Working Group noted the value of the trend analysis and thanked the Secretariat for the report.

Management strategy evaluations for target species

7.1 WG-SAM-2023/17 presented a proposed agent-based modelling framework to support management strategy evaluations (MSEs) for the CCAMLR trend analysis and potential alternative data-limited approaches for managing toothfish fisheries under research plans. The paper described the use of agent-based models (ABMs) to simulate toothfish populations, coded in R, which could be used by Members to develop collaboratively. The paper introduced some of the core concepts of the ABM approach, and simple implementations of key processes (growth, natural mortality, recruitment, fishery removals and tagging) were described.

7.2 The Working Group welcomed the work by the Secretariat and recalled that the development of an ABM was one of approaches recommended by WG-FSA-2022 (WG-FSA-2022/53; WG-FSA-2022, paragraphs 4.66 and 4.67). The Working Group agreed that further development of the ABM framework would constitute a reasonable starting point towards building one of the operating models of the planned MSE for the trend analysis rules.

7.3 The Working Group recommended that further work would be useful, and that it should include:

(i) a paper to a future meeting of WG-FSA that describes ABMs for those unfamiliar with the general method

(ii) undertake parameter perturbation analyses to validate the ABM model code

(iii) further development of the ABM and comparison of a set of simple ABM implementations with a cohort simulation model (e.g. using Casal2) using equivalent parameters

(iv) develop an initial draft MSE for the current trend analysis rules using the ABM and cohort simulation models as operating models

(v) introduce additional complexity into the ABM that would extend its assumptions beyond those that could be simulated in a cohort model (for example, site fidelity of fish in ontogenetic and spawning migrations) to evaluate the effect of these assumptions on the MSE

(vi) develop candidate parameter values (including parameter correlations and functional forms) for use in the operating models. These could draw on analyses from *D. eleginoides* and *D. mawsoni* stocks that are data rich and include analyses to inform these candidate parameter values, such as growth parameters, mortality, selectivities, migration rates, spatially explicit residence time, or other parameters that are required for the operating models

(vii) develop scenarios for the operating models with different assumptions of stock structure hypotheses for *D. eleginoides* and *D. mawsoni* toothfish, including:

(a) an assumption of a closed population within each research block

(b) assumptions of broader stock hypotheses, including the stock hypotheses of *D. eleginoides* in Divisions 58.4.1 and 58.4.2 (WG-SAM-2022/09) and for *D. mawsoni* for Area 48 (WG-SAM-2018/33 Rev. 1) and Subarea 88.2 (WG-SAM-2014/26)

(viii) the development of methods for the evaluation and presentation of the MSE for the trend analysis rules by the Scientific Committee.

7.4 The Working Group recommended the Secretariat set up an e-group combined with a private CCAMLR GitHub repository to share code and allow Members to collaborate on code development.

7.5 The Working Group requested that any developments be presented to WG-SAM.

Review of new research proposals

New proposals under Conservation Measure 21-02

8.1 WG-SAM-2023/07 presented a fisheries operation plan by a Uruguayan vessel for the exploratory toothfish fishery in Subarea 48.6. The Working Group noted that the paper did not follow the requirements for research notifications under CM 21-02, and was written in Spanish, so an evaluation of a research plan was not possible.

New proposals under Conservation Measure 24-01

8.2 WG-SAM-2023/05 set out a proposal by Chile to undertake research for *Dissostichus* spp. under CM 24-01 in Subarea 48.2 during the 2023/24–2025/26 seasons. There are four specific objectives: (i) explore the connectivity based on the modelling of spatial distribution, relative abundance, and length and age structure, (ii) review the fisheries potential impacts on dependent and related species, (iii) improve the hauling and tagging process to help with standardisation procedure, and (iv) improve the knowledge of near-bottom and seabed marine ecosystems using scientific electronic monitoring.

8.3 The Working Group recalled previous research activities on *Dissostichus* spp. undertaken by Ukraine (WG-FSA-2019/51), and the UK (WG-FSA-2021/22) on connectivity, catch rates, and *Dissostichus* species composition in this region of Subarea 48.2, as the research area in WG-SAM-2023/05 overlaps with areas from these previous studies. It was further noted that previous discussions at WG-SAM and WG-FSA would assist in improving the planning of this research proposal.

8.4 In relation to survey design, the Working Group noted that the proposal identified five areas where the research will be focused. Within each of these areas, 10 sets were proposed to be deployed across three depth strata. The Working Group recommended that there should be a minimum number of sets by depth stratum needed, potentially three or four sets in each stratum and area (9–12 by area). Subsequent surveys could then adjust deployments within strata based on catch from previous surveys.

8.5 In terms of the spatial distribution of *Dissostichus* spp. in this region and how it might impact the survey design, the Working Group noted that the distribution of the two species was mapped in WG-FSA-21/22. The Working Group noted that small numbers of *D. eleginoides* had only been encountered in the northern portion of each of the areas defined in WG-SAM-2023/05. The Working Group recommended that the location of the sets be redesigned not only by depth strata but also by target species distribution.

8.6 The Working Group recommended that this research be effort limited, and that sets by area should be multiples of 3 (9 to 12 sets in each area), with set length (or number of hooks per set) defined. Although this research is designed to be effort limited, the Working Group recommended the calculation of a precautionary catch limit using CPUE obtained from previous research activities, and a CPUE-by-seabed area calculation.

8.7 The Working Group noted that where there was no prior information on toothfish abundance or distribution, the location of research areas where sets should be placed be based on toothfish habitats based on bathymetry. Where a pre-defined station was found to be unsuitable for setting gear, the station should be repositioned in a nearby area and the rules for the radius of movement or use of alternate station should be clearly defined in the proposal.

8.8 The Working Group noted that macrourids were likely to be the main by-catch taxa in this region. The Working Group recommended that there should be some additional analyses undertaken on by-catch rates from previous research activities by Ukraine and the UK.

8.9 Dr Quiroz Espinosa notified the Working Group that WG-SAM-2023/05 would be revised to incorporate the recommendations of WG-SAM-2023 and presented at WG-FSA-2023.

8.10 WG-SAM-2023/06 Rev. 1 presented a research proposal under CM 24-01 by Ukraine to continue the acoustic trawl survey of mackerel icefish (*Champsocephalus gunnari*) in Subarea 48.2 for 2023/24 and 2024/25. The Working Group noted the results of similar research activities undertaken in the 2022/23 season (WG-SAM-2023/22) and that the principal objective of this research is to determine the distribution and abundance of *C. gunnari* around the western South Orkney Islands shelf using information from acoustic and targeted trawls.

8.11 The Working Group noted that other objectives of this proposal included better understanding of the stock structure of *C. gunnari* in Subarea 48.2 and comparing it to the adjacent Subarea 48.1 stock, the estimation of catchability of fishing gear, data collection on the spatial and depth distributions of by-catch species, comparison of the main biological parameters of *C. gunnari* with historical data, plankton and oceanographic research, and supporting objectives of the South Orkney Islands southern shelf marine protected area (MPA).

8.12 The Working Group recalled the deliberations of WG-ASAM-2023 on the preliminary results of the research undertaken by Ukraine in 2022/23 (WG-ASAM-2023, paragraphs 7.1 to 7.4), particularly that acoustic data were gathered with an ES80 echosounder using a single frequency 120 kHz transducer.

8.13 The Working Group noted that the species distribution in catches was varied and that it may not be possible to distinguish between the acoustic signals of pelagic krill and icefish without multi-frequency methods. It further noted that the transducer had not been calibrated on the vessel for four years.

8.14 Dr S. Kasatkina (Russia) highlighted that the target strength data from the *Atlantida* for icefish and myctophids may be useful for identifying targets within the acoustic data for the research undertaken by Ukraine. However, the quantitative assessment of icefish requires the use of a multi-frequency method for collecting and processing acoustic data. The practical implementation for an acoustic survey of icefish requires equipping the vessel with an additional hull-mounted transducer with a frequency of 38 kHz, calibrating the ship's echosounder at each operating frequency, and engaging a specialist with experience in analysing data from a multi-frequency acoustic survey. Dr Kasatkina emphasised that such an approach would make it possible to achieve the principal objective of characterising the distribution and abundance of *C. gunnari* around the western South Orkney Islands shelf.

8.15 The Working Group recalled that although calibration is preferable, some analysis with data from vessels that had not been recently calibrated was carried out with data collected by commercial vessels in the krill fishery.

8.16 Dr I. Slypko (Ukraine) informed the Working Group that the vessel plans to additionally install a 38 kHz transducer (provided by Australia) and to calibrate the echosounders prior to the next survey.

8.17 The Working Group noted that the new proposal includes two new transects north of Coronation Island based on acoustic scattering layers that likely represent dense aggregations of Antarctic krill and finfish, as well as the removal of one transect in the southern part of the survey area.

Review of ongoing research plan results and proposals

Research results and proposals from Area 48

9.1 WG-SAM-2023/22 presented initial results from a combined acoustic and trawl survey by the Ukrainian fishing vessel *More Sodruzhestva* targeting *C. gunnari* in Subarea 48.2. The results indicated that the survey was completed in accordance with the program, although only a small amount of *C. gunnari* (46.5 kg) was caught, raising the possibility that there may not be sufficient icefish to identify in the acoustic data. Video recordings showed that fish species could be identified in the majority of cases, and showed behaviour of the fish within the swept area of the trawl, which may be useful to better understand the interaction between fish and the trawl gear. Oceanographic results suggested a cold eddy within the survey area providing an area of high productivity. Further results will be presented to WG-FSA-2023.

9.2 Some participants noted that the observations of the composition of icefish species were similar to that previously observed around the South Orkney Islands.

9.3 The Working Group noted that with the single-frequency transducer used in this research it may not be possible to distinguish krill and icefish distributions in the water column (paragraph 8.13). It also noted the comments of WG-ASAM-2023, paragraphs 7.1 to 7.4, concerning the acoustic data collection and processing, and the use of a multi-frequency method of data collection and processing.

9.4 The Working Group noted that the efficiency of the trawl was likely to be much less than 100%, when defined as the proportion of fish within the fishing zone that are retained in the net. As a result, any estimate of biomass from such a trawl survey is likely to be highly precautionary and provides useful scientific information if the efficiency is similar between surveys and within stations in the survey.

9.5 The Working Group noted that combined trawl and acoustic surveys have already been used to provide information on fish biomass in the Convention Area, for example the surveys provided by Russian scientists using the *Atlantida* and UK scientists using the *Dorada* respectively (WG-FSA-2002, paragraphs 5.95 to 5.101).

9.6 WG-SAM-2023/24 presented an updated analysis of the dynamic sea-ice concentration (SIC), sea-ice temperature and winds in research blocks 4 and 5 of Subarea 48.6. Results indicated a decreasing trend in annual sea-surface temperature spikes through time later shifting to an increase in 2022, suggesting the cooling phase of a 5–6-year periodical cycle may have concluded. Although SIC is estimated to be decreasing from 2022, the repeated accessibility averaged from 2016 to 2023 is lower than was previously estimated based on SICs from 2002 to 2017.

9.7 The Working Group noted the useful information on the distribution of the sea ice, and the probability of repeated access, and requested that any future analysis be extended to include:

(i) previous occasions when fishing has occurred in the research blocks relative to the estimated SIC

(ii) indicate the likely impact of the ice cover on future survey design.

9.8 WG-SAM-2023/01 Rev. 1 provided an update to the efforts involved in the research plan pertaining to Subarea 48.6 in 2021/22–2023/24 under CM 21-02, paragraph 6(iii). This is the third year of an ongoing three-year plan. The authors noted that South Africa will be unable to participate in fishing activities in 2023/24 due to vessel availability, but would still be contributing to other milestones as planned. As a result of the reduction in the number of vessels from three to two, catch allocations were revised to ensure that the same amount of research would be achieved.

9.9 WG-SAM-2023/21 presented a tentative outline for supplementing the existing research plan in Subarea 48.6 by including Korea in the research. The potential research topics proposed were:

(i) releasing additional tags for better understanding toothfish abundance and distribution

(ii) the use of PSATs to better estimate the mortality rates associated with tagging

(iii) a dietary analysis to provide information on trophic relationships

(iv) identifying the abundance and distribution of by-catch species such as icefish and grenadier species.

9.10 The Working Group noted that the existing research in Subarea 48.6 would be completed in 2023/24, and that the results of this research may be useful when planning further research in the area. Korea was encouraged to work with the proponents of the existing research plan to explore possibilities for future collaborative research, and present a research plan to future meetings of WG-SAM.

9.11 Dr Masere noted that work using PSATs is currently being undertaken in Division 58.5.2. The Working Group welcomed Dr Masere's offer to share results as they become available.

Research results and proposals from Area 58

9.12 WG-SAM-2023/03 presented a multi-Member research plan by Australia, France, Japan, the Republic of Korea and Spain to conduct exploratory fishing for *Dissostichus* spp. under CM 21-02, paragraph 6(iii), for 2022/23 to 2025/26 in East Antarctica (Divisions 58.4.1 and 58.4.2). The plan is an update of WG-SAM-2022/04 with some modifications to the spatial design of fishing haul locations in Division 58.4.1 and a change of vessel. Additionally, the design has reverted to an effort-limited approach in all research blocks in Division 58.4.1 owing to a lack of available data from the last five fishing seasons.

9.13 The Working Group thanked the authors for the comprehensive research plan, and recalled discussions during the meeting of the Scientific Committee in 2022, WG-FSA-2022 and WG-SAM-2022 on the plan.

9.14 Dr Kasatkina stated that her position remains the same as last year with regard to the research plan under CM 21-02, paragraph 6(iii) (SC-CAMLR-41, paragraphs 3.129 and 3.130).

9.15 Dr Kasatkina noted that the research plan for the *Dissostichus* spp. exploratory fishery for 2022/23 to 2025/26 in East Antarctica (Divisions 58.4.1 and 58.4.2) is provided under CM 21-02, paragraph 6(iii), and should fully comply with the requirements of CM 24-01 (Annex 24-01/A, Format 2), including standardisation of fishing gears. There are no provisions in the Rules of Procedure of the Scientific Committee and the Commission for partial implementation of CCAMLR conservation measures. She noted that the International Council for the Exploration of the Sea (ICES) working groups widely used standardisation of fishing gears and methods to implement multi-vessel survey and programs within the ICES area.

9.16 Dr Kasatkina noted that the 'new' fishery may be notified in East Antarctic (Divisions 58.4.1 and 58.4.2) according to CM 21-01, paragraph 1.

9.17 The Working Group noted that fishing has occurred in this area previously and the definition of what is considered a new fishery is the decision for the Commission.

9.18 The Working Group recalled that CM 24-01 Format 2, item 3.a, bullet 3 'Calibration/standardisation of sampling gear' could be misinterpreted (WG-FSA-2022, paragraph 3.134), however, the planned survey design allows for calibration across vessels and gears and therefore would fulfill this criterion. This type of survey design is similar to that carried out by ICES members where multiple vessels and gears are used and inter-calibration made possible by including some spatial overlap of vessel fishing locations within an area. The data from these multi-vessel research surveys are then combined using methods such as those developed by Thorson and Ward (2014), Berg et al. (2014) and Berg (2020) to provide a single index for inclusion into a stock assessment for management advice.

9.19 Most participants considered that there was no scientific rationale against this research proposal as nothing was presented and recalled from WG-FSA-2022, paragraph 5.35, that Dr Kasatkina agreed to present a paper to the Scientific Committee in 2023 to facilitate further discussions on scientific aspects of the regulatory framework.

Research results and proposals from Area 88

9.20 WG-SAM-2023/02 comprised a notification to continue research for *Dissostichus* spp. for the second year of a three-year research plan under CM 24-01, paragraph 3, and was not required to be reviewed by WG-SAM (CCAMLR-38, paragraph 5.64).

9.21 WG-SAM-2023/23 presented a progress report on research conducted in 2023 under CM 24-01 on *D. mawsoni* in Subarea 88.3 by the Republic of Korea and Ukraine. The report noted CPUE variability between vessels and research blocks for both target and by-catch species (*D. mawsoni* and mainly *Macrourus* spp.).

9.22 The Working Group thanked the authors for this paper and noted the use of the generic family level code for *Macrourus* spp., with results showing that species identified at this family level mainly consisted of *M. caml* and that it was important to identify specimens to species when collecting biological data. It also noted the very informative species spatial distribution maps which may allow determination of the factors influencing the differences in their distributions. The Working Group advised that to facilitate further work on species-specific life histories and spatial distributions, that species-specific codes be used.

9.23 The Working Group welcomed the collection of *Macrourus* otoliths. Australia mentioned its work on developing an ageing reference set of grenadier otoliths which may provide a useful guide for this work.

9.24 The Working Group also noted that research block 883_5 was not fished owing to logistical reasons and encouraged the proponents to ensure that this block be surveyed next year.

9.25 The Working Group noted that the research plan in Subarea 88.3 intends to coordinate with the Domain 1 MPA proposal. Integrated spatial management in the Antarctic Peninsula area, including toothfish fisheries, will be progressed through the harmonisation symposium discussions currently occurring in an e-group and within the Scientific Committee.

9.26 WG-SAM-2023/04 presented a notification to continue research for *Dissostichus* spp. for the third year of a three-year research plan under CM 24-01, paragraph 3 in Subarea 88.3 by Korea and Ukraine, and was not required to be reviewed by WG-SAM (CCAMLR-38, paragraph 5.64).

Future work

10.1 The Working Group reviewed the current workplan (SC-CAMLR-41, Table 6) and adjusted the timing and collaborators associated with the current tasks (Table 1). It also added several new tasks generated from discussions during the meeting such as the impact of including non-randomly selected fish in the observer biological data forms (paragraph 5.6v), and analysis of factors that may influence tag release mortality (paragraph 11.3).

10.2 The Working Group discussed the potential for hybrid working group meetings in the future and noted that the Secretariat will be preparing a discussion paper on this subject for the Scientific Committee.

10.3 The Working Group noted that there was an increasing need within CCAMLR Members to improve and expand quantitative analytical capacity, especially in relation to developing stock assessments in CASAL and Casal2. The Working Group noted that although some mechanisms exist to support capacity development, such as the CCAMLR Scientific Scholarship Scheme, they do not cover mentor time or travel and that additional mechanisms could be developed. The Working Group encouraged Members to develop proposals for mechanism to address this important need for discussion by the Scientific Committee and the Standing Committee on Administration and Finance (SCAF).

Other business

11.1 The Working Group noted that two workshops had been held in 2023 that were relevant to its work: A workshop on the CCAMLR tagging program (WS-TAG-2023) and a workshop on age determination methods (WS-ADM-2023). Brief summaries were provided on relevant aspects of the workshops.

11.2 Dr Jones (Co-convener of WS-TAG-2023) summarised the outcomes of the joint COLTO–CCAMLR Workshop which aimed to develop best practices for tagging toothfish and skates, as well as mechanisms to maximise survival rates of released fish. The Workshop developed a tagging protocol, posters to help communicate the tagging protocol to those responsible for tagging, and the components of a tagging training manual. The report of the Workshop will be submitted to WG-FSA-2023 for review.

11.3 The Working Group noted that the Secretariat had compiled information about how vessels are configured for tagging, including aspects such as the height above sea level that fish are released, the distance fish are transported on deck and types of lifting aides used. The Working Group considered that this type of information could be useful to better understand tagging mortality and how it may vary among vessels. The Working Group agreed to include this analysis as a task in its workplan (Table 1).

11.4 The Working Group noted that information on vessel configuration relevant for tagging was not currently available for all toothfish vessels and recommended that the Scientific Committee consider requesting this important information be included in fishery notifications.

11.5 The Working Group noted that PSATs were also briefly discussed during the workshop. The Working Group agreed that it would be useful to have a focus topic/workshop on the use of PSATs and the analysis of PSATs data. The Working Group noted that Australia has recently collected video and other relevant information during a PSAT tagging experiment in Division 58.5.2.

11.6 Dr Devine (Co-convener of WS-ADM-2023) summarised the outcomes of the age determination methods workshop. Recommendations to WG-SAM included (see also paragraph 10.1):

(i) determine potential bias to stock assessments resulting from poor otolith readability scores

(ii) develop target levels of precision for age determination among readers or compared to reference sets (e.g. mean weighted coefficient of variation (CV)) to monitor and maintain consistency in age interpretation

(iii) determine the minimum level of double reading necessary to ensure consistency in age readings

(iv) determine minimum sample size of otoliths to read for the determination of age composition for stock assessments

(v) support the development of an otolith image reference collection, which would require an in-person age determination workshop to train and develop consistent age interpretation procedures.

11.7 The Working Group agreed with the workshop recommendation to hold an in-person workshop in early 2024 to progress this work, and that the workshop could potentially be hosted at the University of Colorado (Dr C. Brooks). Dr Devine agreed to develop terms of reference for discussion at WG-FSA-2023.

11.8 The Working Group noted that the database structure needed to store and utilise reference set data was a more immediate priority than that needed to store age data from multiple laboratories given that reference set comparisons were required to develop collaborative ageing programs, and that currently no stock assessments were using cross-laboratory age data.

Advice to the Scientific Committee

12.1 The Working Group's advice to the Scientific Committee is summarised below; these advice paragraphs should be considered along with the body of the report leading to the advice:

(i) vessel tagging configuration to be included in fishery notifications (paragraph 11.4)

(ii) tag-overlap statistic (paragraph 5.6).

Adoption of the report and close of the meeting

13.1 The report of the meeting was adopted.

13.2 At the close of the meeting, Dr Okuda and Dr Péron thanked the participants for their collaboration and coordination in completing the meeting. They thanked the rapporteurs and the Secretariat for their work and support in developing the report. They especially thanked the hosts and support team for their coordination with hotel shuttles, a site tour of the CMLRE facility, and the wonderful food and social gathering.

13.3 On behalf of the meeting participants, Dr Jones and Dr Somhlaba thanked the Co-conveners for their clear leadership, well organised and efficient planning and conducting of the meeting, and for the significant preparation and hard work.

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Table 1: Intersessional work plan for WG-SAM. Timeframe periods are: short = 1–2 years, medium = 3–5 years and long = 5+ years. Items tasked to WG-SAM from the Scientific Committee Strategic Plan (SC-CAMLR-41, Table 6). Numbers following level of urgency indicates the stated value in the box which replaced 'X', i.e. the year. CEMP – CCAMLR Ecosystem Monitoring Program, MSE – management strategy evaluation, SISO – Scheme of International Scientific Observation.

Theme	Priority research topic	Timeframe			Contributors	Secretariat participation
		Global	2024	2025		
1. Target species	(a) Develop methods to estimate biomass for krill					
	(iii) Data collection – SISO and vessels and CEMP					
	Task 1: Effective sampling to estimate length-frequency distribution	short	X		Dr Robson, Dr Kawaguchi	
	(b) Develop stock assessments to implement decision rules for krill					
	Task 2: Development of integrated stock assessment for krill	medium	X	X	Mr Mardones, Dr Watters	
	(c) Develop methods to estimate biomass for finfish					
	(i) Survey design					
	Task 3: Gear standardisation – tagging program	short	X	X	Dr Péron, Dr Masere, Dr Kasatkina	Yes
	(ii) Data collection – SISO and vessels					
	Task 4: Metrics of vessel tagging performance	short	X	X	Dr Péron, Dr Masere, Mr Dunn, Dr Hoyle	Yes
	Task 5: Recording selection of non-random biological data	medium	X	X	Mr Gasco, Dr Massiot-Granier	Yes
	Conversion factors					
	Task 6: Develop protocol for conversion factors	short	X		Mr Gasco, Dr Massiot-Granier, Mr Walker	Yes
	(iii) Improve biomass estimation methods					
	Task 7: Optimise tag-based study (spatial overlap)	medium	X	X	Dr Masere, Dr Péron, Dr Devine	
	Task 8: Vessel configuration factors affecting tagging mortality	medium	X	X	Dr Devine	Yes
	(iv) Data for stock assessment					
	(1) Age Reading					

(continued)

Table 1 (continued)

Theme	Priority research topic	Timeframe			Contributors	Secretariat participation
		Global	2024	2025		
	Task 9: Determine bias of poor otolith readability	short	X		Dr Devine, Dr Quiroz, Mr Sarralde	
	Task 10: Develop target precision levels for ageing	short	X		Dr Devine, Dr Quiroz, Mr Sarralde	
	Task 11: Determine minimum double reading level for ageing	short	X		Dr Devine, Dr Quiroz, Mr Sarralde	
	Task 12: Determine minimum otolith sample size for age composition	short	X		Dr Devine, Dr Quiroz, Mr Sarralde	
	Task 13: Build an otolith image reference collection – In-person ageing workshop	short	X		Dr Devine, Dr Quiroz, Mr Sarralde	Yes
	(d) Develop stock assessments to implement decision rules for finfish					
	(i) Research to develop new assessments					
	(1) Research plan evaluations:					
	Task 14: Research plan assessment	short			WG-SAM	
	48.2 Icefish		X	X		
	48.6 Antarctic toothfish		X			
	58.4.1–58.4.2 Antarctic toothfish		X	X		
	88.1 shelf survey Antarctic toothfish		X	X		
	88.3 Antarctic toothfish		X			
	(e) Management strategy evaluations for target species (Second Performance Review, Recommendation 8)					
	(i) Evaluation of the CCAMLR decision rules and potential alternative harvest control rules for assessed fisheries:					
	Task 15: Develop and agree on an operating model	medium	X	X	Dr Ziegler, Mr Dunn, Dr Massiot-Granier, Dr Earl, Mr Somhlaba	Yes
	Task 16: MSE	medium	X	X		Yes

(continued)

Table 1 (continued)

Theme		Priority research topic	Timeframe			Contributors	Secretariat participation
			Global	2024	2025		
		(ii) Development and testing of data-limited fishery decision rules					
		Task 17: Develop and agree on an operating model	medium	X	X	Dr Ziegler, Mr Dunn, Dr Massiot-Granier, Dr Earl, Mr Somhlaba	Yes
		Task 18: MSE (WG-FSA-2022/53, WG-FSA-2022, paragraph 4.67)	medium	X	X		Yes
		(iii) Finfish management strategies that are robust to climate change					
2. Ecosystem impacts	(a)	Ecosystem monitoring (Second Performance Review, Recommendation 5) Structured ecosystem monitoring programs (CEMP, fishery)					
		Task 19: effective sample size for fish by-catch monitoring in the krill fishery	medium	X	X	Dr Jones	
3. Adminis-trative topics	(e)	Communication of progress, internal and external: Task 20: Diagnostic graphs on stock status	short	X	X	Stock assessors	

Table 2: Template for a table of annual cycle for determining time steps in Casal2 models. AF – age frequency; LF – length frequency; CPUE – catch per unit effort.

Month	Catch (%)		Biological processes						Observations					Assigned time step
	Actual	Assumed	Ageing	Recruitment	Maturation	Growth (%)	Natural mortality	Spawning	Tag release	Tag recapture	Surveys	AFs/LFs	CPUE	
Year start														
Nov														
Dec														
Jan														
Feb														
Mar														
Apr														
May														
Jun														
Jul														
Aug														
Sep														
Oct														
Year end														
Total	100	100												

Appendix A

List of Participants

Working Group on Statistics, Assessments and Modelling
(Kochi, India, 26 to 30 June 2023)

Co-conveners	Dr Clara Péron Muséum national d'Histoire naturelle
	Dr Takehiro Okuda Fisheries Resources Institute, Japan Fisheries Research and Education Agency
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CCAMLR Secretariat	Dr Steve Parker Science Manager
	Dr Stephane Thanassekos Fisheries and Ecosystems Analyst

Appendix B

Agenda

Working Group on Statistics, Assessments and Modelling
(Kochi, India, 26 to 30 June 2023)

1. Introduction

   1.1 Opening of the meeting
   1.2 Adoption of the Agenda

2. Review of the terms of reference and workplan

3. Development of methods to estimate biomass for krill

   3.1 Data collection needs and standards
      3.1.1 Effective sampling to estimate length frequency distribution

4. Develop stock assessments to implement decision rules for krill

   4.1 Development of integrated stock assessment for krill

5. Develop methods to estimate biomass for finfish

   5.1 Research plan design
      5.1.1 Gear standardisation effects on toothfish tagging program
      5.1.2 Development of toolbox for research plan design

   5.2 Data collection needs
      5.2.1 Develop protocol for toothfish conversion factor sampling
      5.2.2 Tag recapture reconciliation issues

6. Develop stock assessments to implement decision rules for finfish

   6.1 Develop new methods for stock assessments
   6.2 Draft integrated stock assessments in Casal2
   6.3 Trend analysis rule development
   6.4 Diagnostic summaries of stock status

7. Management strategy evaluations for target species

   7.1 Evaluation of the CCAMLR decision rules and potential alternative harvest control rules for assessed fisheries
      7.1.1 Development of an operating model
      7.1.2 Management strategy evaluation (MSE)
         7.1.2.1 Develop operating model for data-limited toothfish fisheries

8. Review of new research proposals

   8.1 New proposals under CM 21-02
   8.2 New proposals under CM 24-01

9. Review of ongoing research plan results and proposals

   9.1 Research results and proposals from Area 48
   9.2 Research results and proposals from Area 58
   9.3 Research results and proposals from Area 88

10. Ecosystem monitoring

   10.1 Structured ecosystem monitoring programs
   10.2 Effective sample size for fish bycatch monitoring in the krill fishery

11. Future work

12. Other business

13. Advice to the Scientific Committee

14. Adoption of report and close of meeting.

Appendix C

List of Documents

Working Group on Statistics, Assessments and Modelling
(Kochi, India, 26 to 30 June 2023)

WG-SAM-2023/01 Rev. 1	Continuation of the Research on Antarctic toothfish (*Dissostichus mawsoni*) in Statistical Subarea 48.6 in 2023/24 from a multiyear plan (2021/22–2023/24): Research Plan under CM 21-02, paragraph 6(iii) Delegations of Japan, South Africa and Spain
WG-SAM-2023/02	Notification for the Ross Sea shelf survey in 2024: second year of an approved three-year research plan. Research plan under CM 24-01, paragraph 3 – Continuing Research Delegation of New Zealand
WG-SAM-2023/03	Continuing research in the *Dissostichus mawsoni* exploratory fishery in East Antarctica (Divisions 58.4.1 and 58.4.2) from 2022/23 to 2025/26; Research plan under CM21-02, paragraph 6(iii) Delegations of Australia, France, Japan, Republic of Korea and Spain
WG-SAM-2023/04	Continuing research plan for *Dissostichus* spp. under CM 24-01, paragraph 3, in Subarea 88.3 by Korea and Ukraine from 202122 to 202324 (Notification ID 120784) Delegations of Korea and Ukraine
WG-SAM-2023/05	New Fishery Research Proposal Plan for *Dissostichus* spp. under CM 24-01, paragraph 3, Subarea 48.2 during season 2023/24 – 2025/26 Delegation of Chile
WG-SAM-2023/06 Rev. 1	New fishery research proposal under CM 24-01, paragraph 3, to continue the acoustic-trawl survey *Champsocephalus gunnari* in Statistical Subarea 48.2 for 2024 and 2025 Delegation of Ukraine
WG-SAM-2023/07	Notificación de intención de participar en la pesquería exploratoria de *Dissostichus* spp. en la subárea 48.6 de la CCRVMA durante la temporada 2023/24
WG-SAM-2023/08	Parameter transformations and alternative algorithms in Casal2 models A. Dunn and A. Grüss

WG-SAM-2023/09	An update of tag loss rates for Antarctic toothfish (*Dissostichus mawsoni*) in the Ross Sea J.A. Devine
WG-SAM-2023/10	Evaluation of the impacts of using a double tag loss rate function and changing the time at liberty in the assessment of Ross Sea region Antarctic toothfish (*Dissostichus mawsoni*) A. Dunn and A. Grüss
WG-SAM-2023/11	Development of methods to use age-based tag-release and tag-recapture data in the assessment model of Ross Sea region Antarctic toothfish (*Dissostichus mawsoni*) A. Grüss, S. Mormede, A. Dunn and J.A. Devine
WG-SAM-2023/12	Summary of progress on the recommendations of the Independent Stock Assessment Review for Toothfish (2018) for the Ross Sea A. Dunn and J.A. Devine
WG-SAM-2023/13	Risk assessment for the Antarctic starry skate (*Amblyraja georgiana*) in the Ross Sea B. Finucci, J.A. Devine, S.J. Holmes and M.H. Pinkerton
WG-SAM-2023/14	A generalised additive mixed modelling framework to determine the probability that a sampled macrourid is either *Macrourus caml* or *M. whitsoni* in the Ross Sea region: Methods and preliminary results B.R. Moore, A. Grüss and M.H. Pinkerton
WG-SAM-2023/15	Comparison of growth estimation methods for Patagonian toothfish in South Georgia (Subarea 48.3) J.E. Marsh, T. Earl, P. Hollyman and C. Darby
WG-SAM-2023/16	2023 provisional trend analysis: preliminary estimates of toothfish biomass in research blocks Secretariat
WG-SAM-2023/17	A proposed agent-based modelling framework to support management strategy evaluations S. Thanassekos
WG-SAM-2023/18	Tag-overlap statistic calculation method Secretariat
WG-SAM-2023/19	On the issue of gear selectivity in relation to krill in the current CCAMLR topics S. Sergeev and S. Kasatkina

WG-SAM-2023/20	Comparison of outputs from integrated stock assessments using CASAL and Casal2 for the 2021 Patagonian toothfish (*Dissostichus eleginoides*) fishery at Heard Island and McDonald Islands (HIMI) C. Masere and P. Ziegler
WG-SAM-2023/21	Tentative research topics to contribute to the research on *Dissostichus mawsoni* in Subarea 48.6 from 2024/25 to 2026/27; Research plan under CM21-02, paragraph 6(iii) Delegation of the Republic of Korea
WG-SAM-2023/22	Progress report of the acoustic trawl survey *Champsocephalus gunnari* in Statistical Subarea 48.2 in 2023 Delegation of Ukraine
WG-SAM-2023/23	Progress report on the joint research for *Dissostichus* spp. in Subarea 88.3 by the Republic of Korea and Ukraine in 2023 Delegations of the Republic of Korea and Ukraine
WG-SAM-2023/24	2023 updated analysis of the sea-ice concentration in research blocks 4(RB4) and 5(RB5) of Subarea 48.6 with sea-surface temperature and winds and statistical analysis of repeated accessibility T. Namba, R. Sarralde, K Teschke, H. Pehlke, T. Brey, S. Hain, T. Okuda, S. Somhlaba and J. Pompert
WG-SAM-2023/25	Casal2 assessment for Antarctic krill in Subarea 48.1: a pilot model D. Kinzey and G.M. Watters

Other documents

WG-SAM-2022/27	Methodical aspects of measuring the selectivity of gears in krill fishery S. Sergeev and S. Kasatkina

Appendix D

Update on Table 3 of SC-CAMLR-38, Annex 7, showing progress since the 2018 Independent Stock Assessment Review for Toothfish

Table 1: Progress since the 2018 Independent Stock Assessment Review for Toothfish.

	Review Panel (RP) comments 2018	Progress to date
Documentation		
1.	It is recommended that a standardised format be developed by CCAMLR for the presentation of details of assessments to facilitate understanding of the assumptions, data preparation and inputs, parameter estimation and results across the assessments performed by CCAMLR, and that a public summary document with these details be developed and updated at a fixed period (e.g. five years).	WG-FSA-2019/08, WG-SAM-2019/35, WG-SAM-2021/14, WG-FSA-2021/24, WG-FSA-2021/26, WG-SAM-2022/14, WG-SAM-2023/08, WG-SAM-2023/10, WG-SAM-2023 Casal2 Development Team 2023 Fishery summary 2022, Species description 2022, Fishery report 2022, Stock assessment 2022 and Stock annex 2022, CCAMLR Secretariat, 2023 https://fisheryreports.ccamlr.org/
Stock hypotheses		
2.	A number of assessments described the proposed stock hypotheses and described ideas for future work. The RP suggests that appropriate experts be consulted, and a review be planned if these assessments or CCAMLR require evaluation of the hypotheses.	WG-FSA-2019/32, WG-FSA-2019/36, WG-FSA-2019/59, WG-FSA-2019/61, WG-FSA-2019/P01, WG-FSA-2021/21 Parker et al., 2019, 2021 Behrens et al., 2021 Maschette et al., 2023
Surveys		
3.	Where possible, such surveys should be continued and optimised to ensure recruitment variability can be detected.	WG-SAM-2019/03, WG-FSA-2019/03, WG-FSA-2019/20, WG-FSA-2019/08, WG-FSA-2021/12, WG-FSA-2021/19, WG-SAM-2022/01 Rev. 1, WG-FSA-2022/07, WG-FSA-2022/09, WG-SAM-2023/20, WG-SAM-2022/13, WG-FSA-2023/xx (RSSS results)
4.	Subareas 88.1/88.2 – Consideration should be given to restricting the data from the survey to be more representative of recruitment.	WG-FSA-2019/08
5.	Subareas 88.1/88.2 – Consideration should be given to designing the [Ross Sea shelf] survey to take this into consideration or increasing the catch limit, so that the unused catch limit can be released after the survey, or by releasing excess fish, etc.	WG-SAM-2022/01 Rev. 1 SC-CAMLR-41, paragraph 3.138
6.	Division 58.5.2 – a more appropriate approach to fitting the survey might be to fit the index-at-age data using a multivariate likelihood function and the empirical variance-covariance matrix.	

(continued)

Table 1 (continued)

	Review Panel (RP) comments 2018	Progress to date
Ageing		
7.	In some cases, just a single experienced reader has been used. The RP suggests that, where possible, increasing the number of readers to a minimum of two experienced readers, within laboratories, would be beneficial.	WG-FSA-2019/32, WG-FSA-2019/28, WG-FSA-2019/29, WG-FSA-2023/xx (RSSS results) CCAMLR Ageing Workshop
8.	It would be interesting to investigate how smoothing the age–length key (ALK) matrix (by applying a kernel or using some sort of spline function) would affect the stock assessment.	WG-SAM-2022/49
Growth		
9.	The RP suggests that all SAs implement methods to account for these potential biases in fitting Von Bertalanffy relationship growth curves.	WG-FSA-2019/11, WG-FSA-2019/32, WG-SAM-2022/21, WG-SAM-2022/24, WG-FSA-2022/59, WG-SAM-2023/15
10.	Additionally, investigation of the impact of errors in ageing on the VB by the SA scientists have shown that the fit is robust to this error. The RP suggests that this be investigated occasionally to ensure that no biases occur.	WG-FSA-2019/11
11.	Because changing the VB can affect the calculated virgin biomass, and thus the depletion estimates, the RP suggests that the SA scientists explore whether the fitted VB in these cases is sufficiently precautionary.	WG-FSA-2019/32, WG-FSA-2019/11, WG-FSA-2019/08, WG-SAM-2019/32, WG-SAM-2023/08
12.	The RP also suggests that the SA scientists investigate the use of other growth curves that may exhibit better properties in regard to the data. A more flexible curve might produce a more realistic fit.	WG-FSA-2019/11, WG-SAM-2019/32, WG-FSA-2019/08
13.	The RP recommends that sensitivity analyses be used to assess the impact of the different choices of the growth model on stock assessment results and on biological reference points.	WG-FSA-2019/11, WG-FSA-2019/08, WG-SAM-2019/32
14.	Potential changes in growth rates and fishery selectivity will influence tag-recapture rates, particularly due to the dome-shaped selectivity of these fisheries. The RP also recommends that more flexible growth curves be investigated.	WG-FSA-2019/08, WG-FSA-2021/26
15.	The RP recommends that the use of ALKs be investigated to estimate the age composition of tagged fish released as an input to the assessment models for all the toothfish stocks, instead of the current approach.	WG-SAM-2023/11 Casal2 Development Team 2023

(continued)

Table 1 (continued)

	Review Panel (RP) comments 2018	Progress to date
Data weighting		
16.	The RP recommends that data weighting methods for tagging data should be further investigated. For example, consideration should be given to using data weighting methods based on the average time at liberty.	WG-FSA-2019/08
Tag loss		
17.	The RP suggests that it is timely to update this analysis for Subareas 48.3 and 48.4 and Subarea 88.1 and small-scale research units (SSRUs) 882A–B stocks based on more recent information that may include fish with a longer time at liberty. Changes in tag-loss rates should be investigated. Information on the uncertainty involved in the estimation should be provided.	WG-SAM-2022/17, WG-SAM-2023/09, WG-SAM-2023/10
Initial tagging mortality		
18.	The RP encourages future research on the estimation of initial tagging mortality rates, and factors that may cause this to vary.	WG-FSA-2023/xx (Tagging Workshop)
Tag detection		
19.	The RP encourages future research on the estimation of tag detection rates, and factors that may cause this to vary.	WG-FSA-2023/xx (Tagging Workshop)
20.	The RP recommends that implementation of good tagging protocols (release and recapture) be encouraged for all vessels involved in these fisheries.	WG-FSA-2019/15, SC-CAMLR-38/01, WG-FSA-2023/xx (Tagging Workshop)
Time at liberty truncation		
21.	Tagging data was limited to recapture years-at-liberty less than four for Division 58.5.2 (although data exist for up to six years at liberty)* and Subarea 48.3 and Subarea 48.4 assessments, but six years at liberty for Subarea 88.1 and SSRUs 882A–B assessments. The RP recommends further investigation of this issue.	WG-FSA-2019/32, WG-SAM-2023/10
Selectivity		
22.	The spatial distribution of the fleets has changed over time, particularly in the early years of the fisheries and in Subarea 88.1 and SSRUs 882A–B and temporal changes in selectivity should be considered.	WG-FSA-2019/08, WG-SAM-2023/11

(continued)

Table 1 (continued)

	Review Panel (RP) comments 2018	Progress to date
Natural mortality		
23.	The RP recommends that consideration should be given to estimating age-specific natural mortality rates using a functional form with few parameters and sex-specific natural mortality rates. Simulation analysis should be conducted to determine in what circumstances natural mortality rates can be reliably estimated.	WG-FSA-2019/32, WG-SAM-2019/04, WG-FSA-2019/08
Recruitment standard deviation		
24.	The RP recommends that consideration should be given to adjusting the penalty for years in which there is incomplete information about year-class strength.	WG-SAM-2023/08
Sex structure		
25.	The RP suggests that a more thorough evaluation is needed on the necessity of sex. If it is concluded that a sex-structured model is appropriate, all the data collection programs need to be modified to collect the appropriate sex information.	WG-FSA-2021/26
Diagnostics		
26.	A standard set of diagnostic plots across the assessments covering important and sensitive parameters is encouraged to be included in each stock assessment.	WG-FSA-2019/32, WG-FSA-2019/10, WG-FSA-2019/28, WG-FSA-2019/29 WG-FSA-2019/08, WG-FSA-2021/21, WG-SAM-2022/14, WG-SAM-2023/08 Casal2 Development Team 2023

*Erratum: Tagging data used for Division 58.5.2 stock assessment was limited to recapture years-at-liberty less than six and not four.

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Annex 6

Report of the Working Group on Ecosystem Monitoring and Management 2023 (WG-EMM-2023)
(Kochi, India, 3 to 14 July 2023)

Contents

Report of the Working Group on Ecosystem Monitoring and Management 2023 (WG-EMM-2023)

(Kochi, India, 3 to 14 July 2023)

Introduction

1.1 The 2023 meeting of the Working Group on Ecosystem Monitoring and Management (WG-EMM) was held at the Holiday Inn Hotel in Kochi, India, from 3 to 14 July 2023. The meeting was hosted by the Centre for Marine Living Resources and Ecology (CMLRE), an attached office of the Ministry of Earth Sciences, Government of India.

Opening of the meeting

1.2 The meeting convener, Dr C. Cárdenas (Chile) welcomed participants (Appendix A) back to in-person meetings. The meeting was opened with a traditional ceremony and lighting of the lamp, to symbolise success in finding the correct pathway for the future and a Sanskrit song of good intentions. Commander PK Srivastava, Scientist G of the Ministry of Earth Sciences, began the inauguration to provide the context for the meeting. Dr GVM Gupta, CCAMLR Commissioner for India and Director of the CMLRE, and Dr V. Kumar, Advisor, Ministry of Earth Sciences, welcomed all participants and outlined the many ways in which India has contributed and intends to contribute to the science of CCAMLR in coming years. They wished the participants success in their work and a comfortable stay in Kochi despite the monsoons. Mr N. Saravanane, the Scientific Committee Representative for India to CCAMLR, provided a vote of thanks to the speakers and also welcomed the group on behalf of the CMLRE.

Adoption of the agenda

1.3 The agenda was adopted.

1.4 Documents submitted to the meeting are listed in Appendix B and the Working Group thanked all authors of papers for their valuable contributions to the work presented to the meeting.

1.5 In this report, paragraphs that provide advice to the Scientific Committee and its other working groups have been indicated in grey. A summary of these paragraphs is provided in ‘Advice to the Scientific Committee and its working groups’.

1.6 The report was prepared by C. Adams (New Zealand), P. Brtnik (Germany), M. Collins (UK), J. Devine (New Zealand), L. Emmerson (Australia), G. Griffith (Norway), S. Hill (UK), J. Hinke (USA), O. Hogg (UK), S. Kawaguchi (Australia), T. Knutsen (Norway), B. Krafft (Norway), B. Meyer (Germany), H. Murase and T. Okuda (Japan), C. Oosthuizen (South Africa), E. Pardo (New Zealand), S. Parker (Secretariat), G. Robson (UK), M. Santos (Argentina), F. Schaafsma (Kingdom of the Netherlands), K. Teschke (Germany), S. Thanassekos (Secretariat) and C. Waluda (UK).

1.7 A glossary of acronyms and abbreviations used in CCAMLR reports is available online at https://www.ccamlr.org/node/78120.

Review Terms of Reference and workplan

2.1 The Working Group reviewed the terms of reference agreed by the Scientific Committee in 2022 and set out in SC CIRC 23/52.

2.2 The Working Group reviewed the workplan set out in Table 7 of SC-CAMLR-41 and agreed that the Working Group would discuss additional modifications to the workplan under 'Future Work' (See paragraphs 10.1 to 10.3).

Krill fishery

Fishing activities (updates and data)

3.1 WG-EMM-2023/13 presented a review of sea ice data in relation to fishing vessel activities in Subareas 48.1 and 48.2. The paper highlighted inter-annual and seasonal dynamics in sea ice conditions recorded between 1997 and 2022 and proposed that variability in ice conditions and associated vessel accessibility should be considered when developing management schemes for the krill (*Euphausia superba*) fishery, and in particular when developing approaches to the fishery management schemes by subdividing the allowable catch into summer and winter (Zhao and Ying, 2022; Watters and Hinke, 2022). The authors noted that fishing grounds may not be accessible to fishing for most of the winter season, specifically for up to four out of six winter months in the Bransfield Strait and up to six out of eight winter months around the South Orkney Islands. The authors noted that the proposal to subdivide the allowable catch into winter and summer is based on the assumption of the impact of fishing on the ecosystem, especially during the summer period, and suggests a drastic limitation of the available catch in the summer and an increase in the catch in the winter. The authors emphasized that such an approach to fishery management requires further discussion and justification.

3.2 The Working Group noted that it was helpful to discuss changes in fishing behaviour and the impact of sea ice dynamics on the accessibility to fishing grounds. It also noted, however, that sea ice is just one factor influencing fishing vessel activities and that consideration should also be given to the effect of Voluntary Restricted Zones (VRZs) (Hill et al., 2022), the experience of captains, logistical costs, strategic reasons (e.g., quality of krill oil) and the use of supply vessels.

3.3 The Working Group noted that sea ice does not prevent the krill fishery in Subarea 48.1 from regularly reaching the subarea trigger level and reiterated the importance of the precautionary approach considering the effect of reduced sea ice (especially along the Antarctic Peninsula) on the opening of previously inaccessible fishing grounds, and the importance of the summer season as a time when predators are more constrained to breeding colonies.

3.4 WG-EMM-2023/56 provided a summary of the activities on the krill fishing vessel *Antarctic Endeavour* in Subareas 48.1 and 48.2 between January and July 2022. The document provided a compilation of data on catch, effort, CPUE, krill length frequency distributions, by-catch, and bird and mammal interactions with the fishery. Additionally, the report detailed yield obtained in krill fishmeal production. Comparisons were drawn with the three preceding years of operations of this vessel within the same subareas. The authors encouraged similar periodic reporting from other CCAMLR vessels participating in the krill fishery.

3.5 The Working Group welcomed the data provided and agreed on the usefulness of this type of reporting as an account of krill fishing in Subareas 48.1 and 48.2. The Working Group noted that the fishing complied with the Voluntary Restricted Zones (VRZs) in Subarea 48.1 but expressed concern that fishing occurred close to the South Orkney Islands during the breeding season of land-based krill-dependent predators. The Working Group recognised the importance of this type of reporting as a means of recording how patterns of fishing change over time and encouraged other krill fishing Members to provide this kind of reporting in the future.

Scientific observation

3.6 WG-EMM-2023/28 reported on a training course of 19 Chilean Scientific Observers held during June 2023 as part of the CCAMLR International Scientific Observation (SISO) scheme. The report highlighted the topics covered during this training and the readiness of these trained observers to work both on Chilean vessels and on vessels of other CCAMLR Members.

3.7 The Working Group noted the importance of the work of SISO observers and highlighted the need for coordination between Members to ensure standardisation in methods, and training and exchange between scientists and observers to maximize data quality. The Working Group also noted that it would be useful for the Secretariat to receive feedback on the SISO training materials, specifically if anything was deemed to be missing or unclear. The Working Group further noted linkages with WG-IMAF and the possibility for coordination to feed into intersessional work focused on the development of protocols and seabird and mammal identification guides.

Fishing vessel surveys

3.8 WG-EMM-2023/01 presented the report of the 2023 annual Norwegian krill survey off the South Orkney Islands (Subarea 48.2). The survey was undertaken by the support vessel *Antarctic Provider*, which was equipped with four custom shipping containers housing laboratories, monitoring equipment and acoustic data processing capability to generate krill biomass estimates using the swarms method. The generated data included acoustic recordings, taxonomic sorting of trawl catches and marine mammal and seabird sighting data collected during daylight hours along the transects. A pilot study using drones was also undertaken, providing information on the distribution and body morphometrics of whales. A land party was deployed on Powell Island to tag penguins for satellite tracking of foraging movements and to study potential overlap with fishing activities. This study forms part of an integrated monitoring effort extending across the Scotia Sea (along with the UK and USA annual surveys in Subareas 48.3 and 48.1 respectively).

3.9 The Working Group welcomed the integrated approach used by Norway, which will generate important data for the spatial overlap analysis. In addition, the Working Group noted technological developments in net towing cables which can integrate towing and power supply allowing a single cable to be used for towing the research trawl.

3.10 WG-EMM-2023/P02 presented a summary of the distribution and biomass estimates of Antarctic krill off the South Orkney Islands during a ten-year annual time series (late January to early February, 2011 to 2020). Surveys were undertaken using a random stratified parallel transect design with combined acoustic and biological trawl samples. The paper demonstrated consistently high krill densities in the Scotia Sea region with krill concentrated along the shelf break and associated submarine canyons. Average krill biomass within the 60 000 km^2 survey area ranged from 1.4 to 7.8 million tonnes. According to the statistical method used, there were no clear trends in estimated krill biomass over the ten years. The paper noted that compared with the CCAMLR 9.3% reference exploitation rate (gamma), the management of the krill fishery in the South Orkneys region is precautionary. The results show that industry-based surveys are cost-efficient approaches to high-quality monitoring of krill.

3.11 The Working Group welcomed the data provided as a valuable ecosystem monitoring timeseries which will support future management in Subarea 48.2. The Working Group noted that the time series of biomass estimates could indicate changes in krill availability over the course of the past decade (Fig. 1) and requested that reports suggesting an absence of a trend should be accompanied by analyses of statistical power. The Working Group also noted that the simple ratio of catch to regional biomass may not be the best way to assess whether catch is precautionary and that matching the spatial scales of biomass estimates with the footprint of the fishery provided an alternative (e.g., Watters et al., 2020). The Working Group also noted that the recently updated estimate of gamma for neighbouring Subarea 48.1 (SC-CAMLR-41, paragraph 3.33) is 3.38%, which is lower than the 9.3% used as a precautionary reference point in WG-EMM-2023/P02.

Krill fishery management

4.1 WG-EMM-2023/05 presented a comparison of length frequency sampling between krill researchers and scientific observers on board a commercial krill fishing vessel over several seasons. Observers are required to sample 200 individuals every 3 or 5 days, depending on the month and other requirements according to CM 51-06, whereas researchers sampled every day at the same time and analysed krill from one or two subsamples. Observers tended to use a monocular microscope that had lower magnification, and there were differences in how the two groups defined maturity stages. There were significant differences in the length frequency distributions for most of the compared samples. The paper concluded that current CCAMLR observer protocols tended to under-sample small krill, the juvenile component of the catch, and the different staging protocols resulted in different life-stage compositions. The bias created by this will have an effect on estimating the spawning component of the catch and determining the amount of sub-adult stages that will develop into mature krill the following season.

4.2 The Working group noted that the paper clearly demonstrated the differences in measurements between krill researchers and scientific observers, but that the variability in size measurements depending on the season of sampling was to be expected. The Working Group agreed that there was a need to improve accuracy when measuring and determining the sex of krill, particularly for the juveniles. The Working Group further noted the need for an accurate length frequency distribution for the acoustic target strength and acoustic estimates of biomass.

4.3 The Working Group recommended that the CCAMLR observer protocols should be modified to include a random selection of individuals to measure, and that the change to the protocol should be linked to the data form for traceability. The Working Group also recommended that measurements should be taken daily at a similar time of day, the entire subsample should be measured instead of focusing on a specific number of krill, and observers should have appropriate equipment (e.g., a stereomicroscope). The Working Group recommended that regular krill staging training workshops for observers should be held.

4.4 The Working Group noted that the impact on observer workload needed to be considered when making recommendations on sampling frequency. The requirements of the data collection have changed from historic needs, and current requirements should also be considered if tasking the observers with additional measurements.

4.5 Using the appendix of WG-EMM-2023/05 as a starting point, the Working Group developed draft sampling protocols to be followed by SISO observers on board vessels using the continuous fishing system as well as on traditional trawlers. The protocol included details on subsampling from the catch, measuring krill and determining stage and sex. The protocol was developed with the understanding that feedback from WS-KFO-2023 was required on its practicality and on its inclusion within the SISO Scientific Observer's Manual - Krill Fisheries. The draft protocol is provided in Appendix D.

4.6 Paper WG-EMM-2023/44 presented updated Grym parameters for the assessment for Divisions 58.4.1 and 58.4.2-east, where most of the data used were from a survey conducted in 2022 by Australia. The output of a "ramped" model of maturity was compared with the logistic model, and the output of the "ramped" model was proposed to be used for the Grym parameterisation. Feedback was requested from the Working Group about additional updates or information that might have been missed.

4.7 The Working Group noted that the use of maturity ogive model was consistent with both what has historically been done for Area 48 and the work plan. The Working Group recalled that methods had been previously discussed at WG-FSA (WG-FSA-2021, paragraphs 5.10 to 5.11). The Working Group noted some of the parameters were updated using data collected from a survey in the area and were deemed the best available data for these Subareas. The Working Group discussed that differences in size and maturity are likely due to the habitat and environment of Divisions 58.4.1 and 58.4.2-east being different from Subarea 48.1.

4.8 The Working Group supported the work on the assessment for Divisions 58.4.1 and 58.4.2-east with the proposed parameterisation described in Table 1 of WG-EMM-2023/44 and noted that it should be considered by WG-FSA-2023.

4.9 WG-EMM-2023/03 presented a summary of the current and ongoing development of the revised approach to the management of the Antarctic krill fishery. In this collaboratively developed document, the authors described the status of the revised approach that was adopted by CCAMLR in 2019 and is currently in development, which integrates three components, namely regular updates of biomass estimates, a population projection model to estimate precautionary harvest rates, and a krill-predator spatial overlap analysis to adjust the spatial and seasonal allocation of catch limits. The document was developed to address the recommendation by WG-FSA-2022 (paragraph 9.14) to expand the krill management documentation available as part of the fishery reports. Noting that this document was intended to be a living document to be updated annually, to help Commissioners and the public understand the process, the authors recommended the Working Group recommend forwarding it for consideration at SC-CAMLR-42.

4.10 The Working Group welcomed this useful document and noted it provided transparency on the ongoing development of the krill fishery management approach. It noted that the document identified important future work under the section "Additional elements under consideration" and that this document, intended to be a living document, should be updated as needed. The Working Group noted that the document was derived from Scientific Committee report paragraphs (and supporting Working Group report paragraphs), and that other important elements had been progressed since the SC-CAMLR-41, such as the development of a Krill Stock Hypothesis by SKEG, further considerations of climate change impacts, and the relationship between fishery dynamics and krill developmental stages and sex. The Working Group noted that it would be useful to define an annual review process, through communication between the Secretariat and Members (including those not usually involved in fishery reports review), at the time of the annual fishery reports update.

4.11 The Working Group recommended the Scientific Committee adopt this document at its next meeting as additional documentation of the krill fishery management approach documents available on the CCAMLR website.

WG-ASAM advice and considerations of the krill fishery management strategy (biomass survey designs, methods to use fishing fleets as monitoring platforms, data collection)

4.12 Dr S. Parker (Secretariat), on behalf of the WG-ASAM co-conveners, summarised the discussions regarding the management of the krill fishery as provided in WG-ASAM-2023. He noted that WG-ASAM discussed the CCAMLR acoustic data repository, data collection by fishing vessels on nominated transects, the development of automatic analysis methods in collaboration with Norway and the Secretariat, updates of biomass estimates in Subarea 48.1 (WG-ASAM-2023, Table 1), and the development of a workflow to calculate biomass estimates for each management stratum (WG-ASAM-2023, Appendix E).

4.13 The Working Group welcomed the outcomes of the WG-ASAM meeting and looked forward to further technical developments which will contribute to the management of the krill fishery.

WG-SAM advice and considerations of the krill fishery management strategy (development of integrated stock assessment for krill)

4.14 Dr. Okuda (co-convenor of WG-SAM) summarised the discussions on gear selectivity, effective sample size for length frequency distributions, and a draft integrated stock assessment for krill using Casal2 (WG-SAM-2023). He noted that WG-SAM recognized that the gear selectivity function reported in Krag et al. (2014) constitutes the best available science and it is just one of the parameters used in the Grym, and suggested sensitivity analyses be conducted to understand the effect of different selectivity relationships.

4.15 The Working Group welcomed the outcomes of the WG-SAM meeting and looked forward to further developments which will contribute to the management of the krill fishery.

4.16 WG-EMM-2023/02 presented the modelling work for krill movement between and within key regions of the Southern Ocean including Area 48. Lagrangian drifters were used to simulate transport pathways during the early life stages of krill. The drifters simulated simplistic behaviour of the early life stages including the initial descent/ascent cycle, diel vertical migration (DVM), and advection with simulated sea ice velocity, instead of ocean velocity, under certain conditions. This study aimed to explore differences in the pathways to Marguerite Bay on the Western Antarctic Peninsula, a suspected larval winter nursery ground, in response to changes in the vertical movement rates in the initial descent/ascent cycle based on embryo size, the timing and depth of DVM, and when and if advection with sea ice occurred. The results showed how embryo size can significantly change potential source regions for krill along the Western Antarctic Peninsula as larger embryos allow for survival over shallower bathymetry.

4.17 The Working Group encouraged future work including laboratory and field experiments on egg sinking rates.

4.18 The Working Group noted the absence of sensitivity analysis in this work especially related to the sinking rate of embryos, but highlighted the contribution of this research to the krill stock hypothesis. It also noted that interannual changes in circulation patterns among years including a deep current, are important for the large-scale transport of krill, and recalled similar discussions of toothfish transport models (WG-FSA-12/48, WG-FSA-18/40, Behrens et. al., 2021, Mori et. al., 2021) which highlighted that interannual differences can subsequently influence recruitment patterns. It further noted that this kind of modelling work is important for the discussions on the D1MPA.

Develop methods to estimate biomass for krill

4.19 WG-EMM-2023/55 presented results from two deployments of the wind and solar powered Sailbuoy (www.sailbuoy.no) autonomous vehicle, equipped with a 200 kHz Simrad EK80 echosounder. The 2021 mission covered transects off the South Orkney Islands with limited success due to collisions with sea ice and limited navigational precision. The 2023 mission successfully focused on a krill feeding hotspot, and provided an otherwise unavailable backscatter time series covering a 10 by 40 km area. The authors found the Sailbuoy to be most suitable in "station keeping mode", acting as a self-deploying and recovering acoustic mooring that can provide echosounder data in near-real time, which could be complemented by krill length frequency data collected by vessels.

4.20 The Working Group welcomed this use of new technologies which provided a cost-effective method to collect acoustic data. It noted that similar efforts were underway in Subarea 48.3 (WG-EMM-2022/18) and suggested future deployments use a 120 kHz echosounder to better detect krill.

Data collection needs (SISO (recognising the Report of the Krill Fishery Observer Workshop), vessels)

4.21 WG-EMM-2023/23 presented an analysis of SISO observer sampling rates in the krill fishery for each vessel that fished for krill from 2018 to 2022, including krill biological sampling, fish by-catch sampling, and warp observations. Current sampling rate requirements were given to aid in the interpretation of results, noting that WS-KFO-2023 may provide useful perspectives on this interpretation. Results indicated that the majority of biological sampling rates were above the required minimum rates, by-catch sampling rates were generally high despite the absence of a required minimum rate, and warp observation rates did not always reach the required rate (1 sample per day).

4.22 The Working Group welcomed this analysis and supported its recommendations, including that future analyses could keep both sampling rate computation methods (per-day and per-haul) and also present sample sizes. It recommended the paper be forwarded to WG-IMAF-2023 for consideration of warp observation rates and their potential usefulness to the extrapolation of bird mortalities. The Working Group noted the higher biological observation rates for traditional trawlers than for vessels using the continuous fishing system, as well as the potential need for higher observation rates in particular geographical areas or when krill catches are large, and recommended forwarding the paper to WS-KFO-2023 for consideration of these issues.

Biomass estimation methods (Grym parameters for krill stock model)

4.23 WG-EMM-2023/11 (also presented as WG-SAM-2023/19 and a continuation of the work described in WG-SAM-2022/27; see WG-SAM-2022, paragraphs 3.17 to 3.18), considered methodological aspects of trawl selectivity assessment for krill, focusing on the gear selectivity function published by Krag et al. (2014) which was used to estimate the selectivity parameter values for the Grym. The authors maintained their position that the data used to construct the selectivity function (Krag et al., 2014) does not adequately describe the krill fishing process and that additional data was needed to assess the gear selectivity for krill fishing. The results of the analysis of krill biometrics were presented and confirmed the presence of sexual dimorphism in the body proportions of krill and, according to the authors, demonstrated the statistically significant difference in biometrics between different sexes and maturity stages of krill that may especially affect the estimation of gear selectivity function, and affect the krill demographic structure in catches. The authors stated that while the gear selectivity function derived by Krag et al. (2014) is currently the best available information, it is not sufficient to be used to parameterise the Grym and has not been peer reviewed by the Scientific Committee for its practical use. The authors noted that the topic related to methodological aspects of gear selectivity function for krill should be considered by Working Groups as part of the revision of the krill fishery management.

4.24 The Working Group noted that this paper had been considered by WG-SAM (WG-SAM-2023, paragraphs 3.2 and 3.3, see also paragraph 4.14) and agreed that the Krag et al. (2014) selectivity function constituted best available science. Noting the subsequent contribution by Herrmann et al. (2018), the Working Group encouraged the authors to conduct sensitivity analyses using different gear selectivity parametrizations in the Grym to assess the effects on its outputs.

4.25 WG-EMM-2023/35 presented an evaluation of the Grym's sensitivity to seasonal trends in mortality using within-year patterns in natural and fishing mortality to simulate changes in predator pressure and contemporary trends of the fishing fleet. Results indicated that the inclusion of intra-annual variations in these mortality rates increased precautionary yield, that fishing mortality had a greater effect than natural mortality, and that current harvest levels in Subarea 48.1 were more precautionary than in Subarea 48.2 (the latter being fished in the peak summer months). The authors advised taking contemporary spatio-temporal fishing trends into account in future stock assessments, as well as considering models that include additional ecosystem components.

4.26 The Working Group welcomed this analysis and noted that such sensitivity analyses were beneficial to understanding model behaviour (see also paragraph 4.24). It noted that additional scenarios could be tested to account for low predator pressure outside of summer, instead of setting natural mortality to zero.

4.27 The Working Group agreed that good modelling practices could include:

(i) Sensitivity analyses to assess the robustness of models, their assumptions, and any resulting advice,

(ii) Medium-term projections (e.g., 20-35 years) to describe plausible futures rather than short-term, specific predictions,

(iii) "Bookending" simulations, where parameter values are set close to, or at their extremes to test model boundaries and develop precautionary advice.

Account for spatial structure of krill

4.28 WG-EMM-2023/06 presented the report of the workshop of the SCAR Krill Expert Group (SKEG), held online from 20 to 24 March 2023, focused on the development of a Krill Stock Hypothesis (KSH) in Area 48 (see also Meyer et al., 2023). Noting that the number of participants (83 participants from 13 countries, including early career researchers) provided a sufficient sample size for polling questions to support the development of a KSH, the authors indicated that the workshop developed a preliminary KSH (and identified key data requirements to support its further refinement, including more data on krill length distributions, information on egg and larvae distribution, recruitment locations, and year-class strength. Several recommendations were made to WG-EMM including reviewing and recommending the Krill Stock Hypothesis (KSH) as a useful management tool (e.g., to help refine spatial management units), identifying critical aspects of the KSH that needed testing, and identifying data collection needs and protocols.

4.29 The Working Group welcomed this report and thanked SKEG for its effective response to the Scientific Committee's request to develop a working stock hypothesis for krill in Area 48 (SC-CAMLR-41, paragraph 3.28). It noted that the ambitious action plan would require funding coordination and international collaboration to take advantage of the range of sampling platforms (trawlers, research vessels and autonomous platforms) proposed. The Working Group established a workplan, including timelines and identified priorities, taking into consideration the elements presented in WG-EMM-2023/50 (paragraph 4.31).

4.30 WG-EMM-2023/50 presented a proposed scientific strategy to improve the understanding of krill population connectivity in Area 48 and adjacent waters. The strategy included (i) the collection of multiple sources of data (krill samples, acoustic data, and environmental data), (ii) krill genetic characteristics to evaluate gene flow and migration rates among areas, and (iii), the development of oceanographic models to better understand observed spatial and temporal distributions and simulate transports across areas. The authors indicated that the goal was to better understand the causative mechanisms influencing krill distribution patterns, which will provide information to support the spatial overlap analysis and help design biological sampling protocols.

4.31 The Working Group welcomed this paper, noted the novel use of genetic analyses (e.g., Shao et al., 2023) to assess transport and retention, and encouraged CCAMLR scientists to share krill samples from across the Convention Area to conduct such analyses. While noting that the paper provided, inter alia, an effective framework to improve the understanding of spatial population structure and krill flux, the Working Group considered that its recommendations could be considered along with those of WG-EMM-2023/06 (paragraph 4.29) to draft a combined workplan.

4.32 Recalling the discussion in WG-SAM-2022 (paragraph 3.13), the Working Group noted that progressing field and laboratory work to better understand krill stock dynamics in Area 48 and adjacent waters, and the resulting patterns that are observed in survey and fishery data, was a priority in the context of the revision of the krill fishery management approach. Noting the fruitful and effective collaboration between SKEG and CCAMLR scientists (paragraph 4.29), the Working Group developed an ambitious workplan aimed at addressing the wide range of underlying issues. Combining the extensive international expertise and multiple sampling platforms, specific tasks will be addressed using a variety of scientific approaches. With the understanding that the proposed workplan was to be further refined and that both scientific funding and fishing industry incentives needed to be brought forward, the Working Group agreed to the Krill Stock Hypothesis Information Collection Plan (Table 1).

4.33 The Working Group recalled that the revision of the krill fishery management approach for Subarea 48.1 is being progressed by following the krill work plan agreed by the Scientific Committee in 2019 (SC-CAMLR-38, paragraphs 3.29 to 3.34), and that the Scientific Committee agreed that scientific information is available to allow progress of the work (SC-CAMLR-41, paragraphs 3.43 to 3.51). The Working Group noted that the revisions of krill catch limits can be progressed by taking account of the uncertainties in a staged manner while the KSH is being updated in the longer term.

Develop stock assessments to implement decision rules for krill in Subarea 48.1

4.34 WG-EMM-2023/48 presented an application of the open-source Management Strategy Evaluation (MSE) tool, OpenMSE (https://cran.r-project.org/package=openMSE) which is currently used to test and measure performance of various management strategies on selected fisheries (teleosts) and inform management bodies. The authors approximated the Grym under the OpenMSE framework by running eight scenarios with identical input parameters to compare outputs. Using appropriate parameterizations and modifications, OpenMSE was able to approximate the Subarea 48.1 krill implementation of the Grym. OpenMSE provides substantial flexibility, can be built on a dynamic approach to access large datasets, is transparent and open source. The OpenMSE tool will provide a valuable resource to model and test potential management procedures in the future.

4.35 The Working Group welcomed this work and recognized the importance and need for exploring a dynamic management tool where management implementation, data generation, and updating can be done continuously. It recognised OpenMSE as a potentially useful tool and the Working Group encouraged the authors to further explore its development. Possibilities for complementing input variables for the calculation of total fishing mortality were suggested, for example including additional work on mortality associated with escapement from fishing gear (Krafft et al., 2016; Herrmann et al., 2018; Krag et al., 2021). The Working Group referred the authors to the SKEG as a possible source for improved or additional data inputs. The Working Group noted that similar work was being carried out by Chilean colleagues, and that there were opportunities for collaboration. The Working Group also noted the work may benefit from being reviewed by WG-SAM.

4.36 WG-SAM-2023/25 presented a pilot model using Casal2 to perform a 20-year forward projection to assess the effect of fishery catches on the Antarctic krill population in Subarea 48.1. Data supplied to the model included a time-series of fishery catches, acoustic biomass surveys, and length frequency distributions. Biomass estimates derived from fishing and research vessel acoustic surveys were combined. The model reported that at the end of the 20-year projection with 620 000 metric tons caught per year, spawning biomass was about 64% of the estimated unexploited biomass. The results demonstrated that Casal2 provided a method to convert NASC estimates to biomass estimates without collecting length-frequency data during every acoustic survey and subsequently applying a target-strength model. Based on this assessment the authors proposed that the Scientific Committee design a data-collection plan for the krill fishery that facilitates the application of integrated assessment models by combining frequent acoustic surveys that simply report NASC with occasional surveys during which length frequency data are collected using research nets.

4.37 The Working Group welcomed this work and encouraged the authors to continue further development to complement or evaluate the outputs of the Grym. The Working Group noted the comments by WG-SAM-2023 (paragraphs 4.1 to 4.3), that Casal2 development within CCAMLR had been previously supported by Mr A. Dunn (New Zealand) and that similar support could be possible.

4.38 WG-EMM-2023/39 demonstrated the Length-Based Spawning Potential Ratio (LBSPR) method to estimate the reproductive potential of Antarctic krill. The study used size composition data of Antarctic krill collected over the last 20 years by SISO observers during fishing activities in Subarea 48.1. Knowledge about the species' reproductive potential is crucial to informing spatial and temporal catch limits to reduce the risk of overfishing recruits. The study demonstrated that it was possible to identify differences in reproductive potential and therefore in reproductive resilience over different temporal and spatial scales. The authors concluded that this approach could contribute to the development of a more informed and sustainable krill fishery management plan.

4.39 The Working Group welcomed this numerical approach and encouraged the authors to continue this important work. The Working Group also noted that this is another illustration that

CCAMLR scholarship recipients can bring a fresh view into scientific discussions, facilitate progress in a short time, and develop tools that are constructive for fishery management discussions.

4.40 WG-EMM-2023/12 presented results of the two survey legs performed by the Russian research vessel *Atlantida* during February and March 2020 in the Bransfield Strait (Subarea 48.1). Each leg had a 6-day duration, with a one-month intermediate interval, covering the same locations with five acoustic transects and 16 CTDs and Isaacs-Kidd trawl stations. Systematic registration of marine mammal and seabird sightings were made during daylight hours. Spatial and temporal variability of geostrophic circulation of water masses, distribution of density and length of krill, direction and intensity of krill transport were analyzed in relation to predator distribution and their calculated consumption of krill. Data on seabird and mammal dependence on krill as individual krill requirement (g/day) were used as described in Warwick-Evans et al. (2021). During the periods of observations almost no krill fishing vessels were operating in the study area. The paper suggested that a significant difference in krill biomass (792 569 t) was found between the two survey legs and that the krill length distribution shifted from predominantly large krill to predominantly small recruiting krill over the 1-month period. The krill biomass changes were not comparably higher than catches ranging from the annual krill catch in Subarea 48.1 (155 000 t trigger level) and the maximum annual krill catch achieved in the krill fishery in Area 48 (450 782 t in 2020/21 fishing season) as well as the potential predator consumption estimated for the study area. The authors concluded that these changes cannot be due to natural biological processes such as growth, spawning, predation, or fishery, but rather that they are a consequence of krill transport, redistribution and replenishment processes caused by ocean currents. They suggested further considerations of the significance of krill for penguin and pinniped colonies in shallow coastal waters that may be ecologically more important. The authors emphasized that the results of the multidisciplinary two-leg survey carried out by RV *Atlantida* (2020) in the Bransfield Strait are the best available data on krill flux characteristics in relation to spatial and temporal variability in krill biomass distribution, and the distribution and consumption of dependent predators. The authors noted that the survey design was presented to the Working Group and data collection and processing were carried out in full compliance with CCAMLR recommendations, with particular attention to the implementation of an acoustic survey based on the three-frequency krill identification method, as well as following the known recommendations for standardizing at-sea monitoring surveys and observation for marine birds and mammals (Kasatkina et al., 2021; Shnar et al., 2021; Trufanova et al., 2021).

4.41 The Working Group welcomed this contribution of a unique and large dataset. It noted that the combination of predator sighting data and simultaneous logging of hydro-acoustic data was a useful combination that provided valuable possibilities to study krill-predator relationships.

4.42 The Working Group did not concur with all conclusions of the paper as local depletion can occur due to the combined effects of predation and harvesting, which likely impact other ecosystem components. The Working Group emphasized the ongoing need to develop a better understanding of predator consumption rates, including for fish and seabirds, which are highly uncertain. The Working Group noted that although the survey design was reported to follow CCAMLR recommendations, it had not yet been reviewed by CCAMLR Working Groups and that the reported sightings of cetaceans were regarded to be low for the area and season.

The Working Group also noted that other methods were available to measure the effect of flux (e.g., Cutter et al., 2022), and that the methods used in this work by comparing biomass estimates from two periods, may not be optimal.

Symposium on holistic approach to management in Subarea 48.1

4.43 The Working Group recalled that following COMM CIRC 23/13–SC CIRC 23/14, the 'Harmonised approach to krill management' e-group was established to progress the development of the format, scheduling and terms of reference (ToR) for a joint science, policy and industry symposium meeting during 2023 (CCAMLR-41, paragraphs 4.17 and 4.18).

4.44 The Working Group discussed the draft ToR from the e-group and considered that:

(i) The areas in question involve overlap with the CCAMLR MPA Planning Domain 1 (D1MPA), which also includes Subareas 48.2 and 88.3, and suggested the Scientific Committee clarify the spatial scope of the discussion.

(ii) The ToR should not discuss revisions of Conservation Measures, which were matters for the Commission, and therefore the Working Group suggested modifying the ToR to reflect this.

(iii) Following the example set by the meeting in Concarneau (2019), an informal format for a workshop would make best use of the time available and help to foster discussions. The output from the workshop could be a Chair's report to the Scientific Committee.

(iv) Arranging one large meeting as suggested by CCAMLR-41, paragraph 4.18 was problematic because it would require a large number of people to participate while the scientific options for scenarios had yet to be developed.

4.45 Based on these considerations, the Working Group considered that ToR 1 and 2 (Appendix E) could be addressed through sequential discussions of the Scientific Committee and the Commission under 'Spatial Management' agenda items. The Working Group suggested that following those discussions, the Commission could consider a follow-up science-focussed workshop prior to the WG-EMM-2024 meeting to address ToR 3 and 4 (Appendix E).

4.46 The Working Group noted that funds for running the 2024 workshop may be necessary and could be sought through contributions from NGOs and the fishing industry.

4.47 The Working Group noted that the ToR were still in draft and in development in the e-group. The Working Group posted its proposals to the e-group as a contribution to the discussion (Appendix E).

Ecosystem monitoring and observation

5.1 WG-EMM-2023/33 reported results of oceanographic research conducted on Ukrainian fishing vessels in the season 2022/23. Results indicated that the temperature of the bottom layer ranged from -0.20° C to +1.47° C, and that there was a tendency for decreasing temperature from the Ross Sea region to the north of the Amundsen Sea.

5.2 The Working Group welcomed the collection of additional data on fishing vessels during fishing operations and noted the importance of strategic data collection. The Working Group advised completing CTD calibrations prior to data collection each year, and the CCAMLR Secretariat offered assistance for liaising with SOOS for submitting the data into international databases.

5.3 WG-EMM-2023/53 summarised research on euphausiid larvae and salps conducted by Argentina on board the Peruvian polar vessel Carrasco during summers in 2019 and 2020 off the West Antarctic Peninsula (Mar de la Flota / Bransfield Strait) and Elephant Island surroundings. Results were compared with the PS112 cruise of 2018 dataset from the same area to determine interannual differences in salp densities. During 2019, *E. superba* and *Thysanoessa macrura* abundances were high, and all euphausiid larvae had very low densities in 2020. Salp densities showed the opposite pattern and were very high in 2018. The changes in abundance of krill and salps were correlated with environmental conditions (*in situ* chlorophyll-a, temperature and salinity, water masses properties), suggesting these were possible drivers of the observed changes.

5.4 The Working Group welcomed this study which compared the densities of krill and salps. The latter are currently understudied. The Working Group noted that salps may have an impact on krill eggs and larvae through predation in the water column but that this may depend on the phytoplankton community present and that further studies would be needed to understand these processes and assess their change.

5.5 WG-EMM-2023/40 presented a case study using bio-loggers and machine learning analysis to determine the functional response of marine predators to changes in their prey field. The study used animal-borne video cameras and accelerometer dive loggers to obtain concurrent visual, acceleration and dive data from foraging chinstrap penguins. The paper indicated a strong correlation between individual prey capture events and events derived from signals in the accelerometer and dive data alone and proposed the outcomes from this approach be considered for CEMP monitoring to link prey capture rates of chinstrap penguins to environmental variability or fishing pressure.

5.6 The Working Group acknowledged the strong statistical relationships between prey capture events and signals from the bio-loggers, and noted that ongoing monitoring would be valuable given inter-bird variability. The Working Group indicated that extending the analysis to assess krill size from the footage would be useful, but noted the difficulties in doing so as well as the existence of other experiments exploring this process.

5.7 WG-EMM-2023/P06 evaluated the temporal trends, range of decreases, and predicted population changes within three generations for multiple colonies of chinstrap penguins across the Antarctic Peninsula and South Orkneys. A total of 133 colonies were analysed using the Mapping Application for Penguin Populations and Projected Dynamics (MAPPPD) data for the period 1960 to 2020, and reported that 62% of the 133 colonies experienced decreases between the first and the last counts, and that 46% of colonies had decreased by over 75%. Potential factors behind chinstrap declines could include changes in krill productivity, competition with other krill predators (e.g., cetaceans) and with the krill fishery (especially in years of low abundance). The authors proposed that the current trends in chinstrap penguin populations would persist in the short- to mid-term, and that this may result in the species being considered as a vulnerable species according to the IUCN A2 criteria.

5.8 The Working Group noted that some populations were decreasing in close proximity to those that were increasing, which was thought to be either due to different foraging locations or potentially to the data analysis approach.

5.9 WG-EMM-2023/41 highlighted the need to assess model diagnostics or model fit to allow robust inferences about changes in chinstrap penguin abundance to be made. More generally, the paper highlighted that (1) future analysis of the MAPPPD data should take into account the uncertainty in these estimates; (2) limited data are available to determine the demographic drivers of chinstrap penguin population change; and (3) adopting reproducible research practices enables validation of research results.

5.10 The Working Group noted limitations in time series and estimates of uncertainty associated with the MAPPPD data and the need to account for these when inferring population change or projected trajectories, and agreed on the importance of analysis code availability for assessing reproducibility of results. It noted that the decline of chinstrap penguins is of concern and that while analytical approaches differed between the two papers, both WG-EMM-2023/P06 and WG-EMM-2023/41 supported the finding of decreasing population trends.

5.11 WG-EMM-2023/P04 presented results of a survey of sperm whales using acoustic mooring data in the Ross Sea region. The study demonstrated that sperm whales are present in the Ross Sea region almost year-round, and found a significant preference for day-time foraging rather than during the night or nautical twilight from the southern mooring, but no clear diel differences from the northern mooring. High sea ice concentrations were generally associated with fewer detections, and less distance to open water (<50 km) was associated with more detections. The authors stated that this research provides baseline information on sperm whale occurrence and establishes a method to track long-term change to help evaluate the conservation values of the Ross Sea region Marine Protected Area (RSRMPA).

5.12 The Working Group noted that there were fewer sperm whales observed from fishing vessels in the Ross Sea region than in Subarea 48.3. The Working Group noted historical data on sperm whale presence over deep waters east of the Ross Sea slope region and suggested that this area may be a useful target area to monitor. The Working Group noted that the high mobility of sperm whales may influence their usefulness in assessing the Ross Sea region MPA. It further noted that long-term acoustic moorings can be a powerful observation tool and recommended continued development of their use.

5.13 WG-EMM-2023/54 (originally presented to the Ecosystem Modelling group of the Scientific Committee of the International Whaling Commission in April 2023) provided an overview of the role of baleen whale science in the revised krill fishery management approach (through the spatial overlap analysis), and highlighted the need for robust estimates of whale abundance, seasonal spatial distribution, krill consumption rates, residency times in feeding grounds, and an understanding of krill swarm preferences. It highlighted the importance of developing methods to minimise/eliminate risk of whale incidental mortality in the krill fishery, and how data needs are complementary to longer-term efforts to model ecosystem function, including the role of climate change, to inform feedback management. The authors proposed further work towards a framework to include cetacean ecology in CCAMLR management framework, and a strategy for supporting future survey efforts.

5.14 The Working Group recognised the importance of increased collaboration between CCAMLR and IWC to include whales in the krill fishery management approach and recalled that Dr N. Kelly (Australia) had been tasked to liaise between these two groups to develop areas of common interest. The Working Group also noted that prey availability, including krill swarm size and the size distribution of krill, are important to prey-predator interactions in addition to krill biomass.

5.15 WG-EMM-2023/P07 compared chinstrap penguin foraging performance and breeding success over two years with contrasting environmental conditions and krill availability at Harmony Point, Nelson Island and South Shetland Islands. Associated with krill availability being lower and deeper in the water column in winter when sea ice cover and summer productivity (chlorophyll-a) were lower, penguins increased their foraging effort (longer distance and duration of trips) and had lower breeding success. The paper proposed continued efforts for coordinating penguin tracking and acoustic monitoring in other colonies to determine whether the results presented explained the local and global decline of chinstrap penguins, and recommended including such studies within the CEMP protocols.

5.16 The Working Group noted that shifts in penguin foraging behaviour can occur rapidly and will vary in relation to phenology. The Working Group suggested that concurrent diet data may allow hypothesis testing in relation to alternate energy pathways. The Working Group noted that the foraging performance parameter “number of wiggles” (i.e., rapid movements detected by the accelerometer), can indicate foraging success and that the reported unexpected relationship with krill abundance may be related to krill size, and that this could be important ancillary data to collect in the future.

5.17 WG-EMM-2023/P08, 2023/P09 and 2023/P10 together presented a synopsis of recent results from Australia’s seabird monitoring program in East Antarctica for Cape petrels breeding in Elizabeth Land, and Adélie penguins breeding in Wilkes Land and the Western Mac Robertson Land. Adjustment factors were developed to allow correction for population surveys conducted at sub-optimal times. Cape petrel population size across the Vestfold Islands in 2019 were similar to levels in the early 1970s. WG-EMM-2023/P09 and WG-EMM-2023/P10 showed diverging population trajectories for the two large regional Adélie penguin populations, with a significant increase across Wilkes Land over several decades, and a rapid decrease over the decade from 2010 in Mac Robertson Land. The decline was likely due to a combination of poor breeding conditions in years with extensive fast ice, with a declining fledgling survival that was linked to smaller cohorts.

5.18 The Working Group welcomed the submission of publications that had been through peer-review, and noted the importance of long-term monitoring for detecting and understanding seabird population change, and for understanding whether CEMP sites reflect population dynamics at a broader scale. The Working Group noted the merit in monitoring response parameters in addition to population size, including breeding success and mark-resight programs to estimate survival.

CEMP monitoring (1-day focus topic)

5.19 WG-EMM-2023/42 provided an overview of the CCAMLR Ecosystem Monitoring Program (CEMP) and identified topics that the Working Group may wish to consider as part of the process to revise CEMP to enhance ecosystem monitoring and to support krill fishery management approaches in Subareas 48.1 to 48.4.

5.20 The Working Group welcomed the paper and noted that ToR would need to be developed intersessionally, including specific tasks, to support any future workshops to expand or enhance CEMP.

5.21 WG-EMM-2023/24 presented a summary of CEMP data submissions received by the Secretariat for the 2022/23 monitoring season, and provided an overview of existing CEMP time series data. The paper highlighted consistent spatial relationships between CEMP sites and the recent distribution of the krill fishery and noted that few CEMP sites were located relatively close to fishing areas, while fishing occurred distant to many CEMP sites. The paper noted that CEMP could be enhanced to directly support both fishery management, ecosystem status and MPA objectives and that the long-term goals of CEMP remain focused on monitoring krill-dependent predators and other ecosystem components.

5.22 The Working Group welcomed the paper and thanked the Secretariat for developing some innovative presentations of the location of CEMP sites relative to krill fishing activities. The Working Group noted that this information was very useful for identifying gaps in coverage and knowledge. The Working Group further noted that disaggregating the data by species, season, timing, and according to krill fishery catch might be useful to explore the effects of krill fishing pressure on krill-dependent predators and that these data could also be presented at different spatial scales.

5.23 The Working Group noted that the collaborative development of tools used to help understand status and trends of harvested, dependent, and related species, such as the trend analysis for toothfish (WG-SAM-2023/16), is an iterative process which could be improved and progressively expanded over time.

5.24 The Working Group noted that the Secretariat is developing a data exploration tool to better convey the metadata associated with CCAMLR data holdings and that this could include CEMP data in the medium term. This tool was presented to WG-ASAM-2023 (paragraph 3.14) and will continue to be developed for use by Members.

5.25 The Working Group noted that a key element for the CEMP review was to consider how CEMP data would be used to ensure meeting the objective of the Convention. The Working Group noted that, beyond the collection and submission of CEMP data, a strategy for the analysis of CEMP data and delivery of scientific advice must be clearly defined. The Working Group noted that developing such a strategy should include consideration of data access, how to progress the analyses, and nuances regarding the interpretation of the data.

5.26 The Working Group also discussed the need to rethink the scope of the CEMP monitoring program. It noted that CEMP is currently focused on summertime monitoring of krill-dependent predators, but that it should include enhanced predator monitoring during summer and winter periods, designate additional monitoring sites and species, identify new or alternate CEMP parameters, and incorporate the monitoring necessary to understand the impacts of climate change and fisheries on the ecosystem, including CCAMLR MPA monitoring.

5.27 The Working Group recalled that other established monitoring programs can provide data to help understand status and trends in the ecosystem. For example, the SISO and agreed protocols for conducting acoustic surveys from fishing vessels may contribute to an expanded CEMP. The Working Group also noted that there are several monitoring programs external to CCAMLR that may contribute to an expanded CEMP, including Penguin Watch, Oceanites, SOOS, and the seabird tracking database hosted by Birdlife International, but that these data would need to be analysed to inform the Scientific Committee.

5.28 The Working Group further noted that Members may hold additional data on other ecosystem components that are valuable for understanding variation in CEMP data (e.g., data on phytoplankton, local meteorological data). The Working Group noted that compiling the metadata of such data could raise awareness among Members and aid in collaborative analysis and interpretation of CEMP data.

5.29 The Working Group recalled that current CEMP sites provide important long-term context for understanding ecosystem status and trends and that these sites were likely to remain key sources of land-based predator monitoring in the future. The Working Group further noted that some CEMP indices that are monitored during the summer period indicate conditions experienced by animals during the winter, thus expanding the spatial and temporal footprint of data collected at CEMP sites. The Working Group noted, however, that temporal and spatial mismatches in fishing and monitoring exist and that reconciling such mismatches remains a key topic for research. The Working Group noted that such mismatches may help identify where and when future monitoring would be needed. In particular, the Working Group agreed the need to expand beyond land-based monitoring to include at-sea monitoring, particularly within areas where the fishery operates.

5.30 The Working Group noted that, while an expansion of the CEMP was desirable, the CEMP review may benefit from initial efforts to identify specific objectives for the use of CEMP data with respect to management of the krill fishery. Identifying such objectives first would facilitate future consideration of the specific details of an expansion, such as designating additional CEMP species, monitoring methods, or identifying environmental variables for assessing impacts on the ecosystem arising from climate change or fishery-ecosystem interactions.

5.31 The Working Group agreed that the current CEMP database contains a large, but underutilized, dataset. The Working Group agreed that progress towards identifying relevant and useful outputs for informing management decisions would require considerable analyses of existing CEMP data. The Working Group noted that this rich data set provides a basis for developing diagnostic tools and candidate summary outputs, both quantitative and qualitative, with the potential to inform ecosystem health checks, MPA monitoring, the spatial overlap analysis, and to identify trends related to the impacts of climate change.

5.32 The Working Group agreed that a priority task is to initiate collaborative analyses to better understand the status and trends in existing CEMP data, to identify gaps that may inform future data requirements, and explore alternatives to the Combined Standardized Index (CSI) for representing aggregate indices of status and trends in the ecosystem.

5.33 The Secretariat introduced a recent Status of the Ecosystem report used by the Alaska Fisheries Science Center (USA) to summarize the status of the ecosystem and its bearing on fisheries management in the Bering Sea (https://apps-afsc.fisheries.noaa.gov/REFM/docs/2022/EBS-ESR-Brief.pdf). The Working Group noted that this report provided a useful demonstration for how summaries from different types of monitoring data, including physical and biological data, could be structured to communicate a status report, or health check, to Commissioners and stakeholders.

5.34 The Working Group thanked the Secretariat for introducing the example status report. The Working Group noted that the frequency with which catch limits and their spatial distributions are updated may help inform the development of such reports for use in CCAMLR.

5.35 The Working Group recalled that advice arising from the CEMP could take the form of strategic (i.e., long-term) advice or tactical (i.e., short-term) advice. The Working Group noted that using regular summaries of CEMP data to produce ecosystem status reports represented longer-term strategic health checks that could contribute to assessments of whether current management practices remained precautionary.

5.36 WG-EMM-2023/26 presented an overview of CCAMLR-related ecosystem monitoring and scientific activities undertaken by the British Antarctic Survey (BAS) during the 2022/23 season. Data summaries for physical environmental conditions, monitoring from four CEMP sites on seabirds, pinnipeds, and marine debris, and at-sea surveys for krill and groundfish were highlighted.

5.37 The Working Group welcomed the paper, noting it was the second consecutive year that such a summary had been provided by BAS. The Working Group encouraged other Members to provide similar summaries from their CEMP monitoring data and especially in collaboration with other Members.

5.38 The Working Group noted that in years of low krill abundance, alternative prey resources may sustain predators in Subarea 48.3. The Working Group noted that consideration should be given to such alternative food webs in a revised CEMP.

5.39 WG-EMM-2023/29 presented results from a monitoring programme for three penguin populations in Ardley Island, southwest of King George Island from 2019-2023. The paper highlighted the recent decline of Adélie penguin populations in contrast to a stable gentoo population, as well as tracking data to identify the core summer foraging areas of Adélie penguins and the broader spatial footprint of Adélie penguins during the winter. The authors noted that long-term monitoring of both predator and prey is important to understand drivers of year-round population change.

5.40 The Working Group welcomed this paper and the establishment in 2022 of a CEMP monitoring program by Uruguay at Ardley Island. The Working Group noted the importance of year-round data collection for understanding drivers of population and ecosystem change and encouraged the authors to continue to progress this important work.

5.41 WG-EMM-2023/43 described progress towards using remotely operated time-lapse cameras as a tool for cost-effective, large-scale monitoring of flying seabirds. Cameras can help describe breeding phenology, breeding success, and adult attendance curves that can be used to estimate local abundance and its inter-annual changes. The authors suggested that the use of cameras in conjunction with ground-based monitoring could significantly enhance the CEMP if applied to flying seabirds.

5.42 The Working Group welcomed the paper and noted that the use of cameras to monitor several CEMP parameters for penguin species had been successfully implemented by several Members. The Working Group noted that camera selection, placement, and monitoring objectives were key considerations for implementing camera-based monitoring of flying seabirds, whose behaviours, sensitivity to researchers, and spatial distributions differ from penguins.

5.43 The Working Group noted the benefit of methods that provide information on breeding population size, in addition to the more detailed information derived from fixed cameras that focus on subsets of the population. For example, The Working Group noted that small Unoccupied Aerial Systems (UAS, or drones) or ground-based counts could complement camera-based work where practical.

5.44 The Working Group encouraged further field-based validation of the monitoring approach for flying seabirds as outlined in WG-EMM 2023/43 and progress towards developing standard methods and data submission forms.

5.45 The Working Group noted that automated image analysis may expedite delivery of data to the CEMP and to the Scientific Committee. Developing a catalogue with images and annotations to help develop, train, and test automated image analysis techniques may provide for useful collaborations among Members involved in camera-based monitoring.

5.46 WG-EMM-2023/45 reported on land-based monitoring of Antarctic breeding seabirds by the Australian Antarctic Program and the principles used to redesign the program to address multiple monitoring objectives. This report described the rationale for a hierarchical approach to monitoring seabirds that combines annual, local-scale monitoring with periodic (4 to 7 years), broad scale monitoring to deliver large scale seabird monitoring data to achieve CCAMLR’s objective. The program was designed to deliver regular health checks and further develop datasets needed for a spatial overlap analysis to distribute the krill catch limit in east Antarctica.

5.47 The Working Group welcomed the paper and noted its relevance to developing a health check concept for the CEMP. The Working Group noted that a health check, or ecosystem status report, like that envisioned in WG-EMM-2023/45, could become a fourth leg of the krill management strategy.

Planning for the CEMP review

5.48 The Working Group recalled that the CEMP was established in 1985 (SC-CAMLR-IV, paragraph 7.2) to:

(i) Detect and record significant changes in critical components of the marine ecosystem within the Convention Area, to serve as a basis for the conservation of Antarctic marine living resources.

(ii) Distinguish between changes due to harvesting of commercial species and changes due to environmental variability, both physical and biological.

5.49 The Working Group recalled that the CEMP was originally designed to collect data on multiple parameters using standardized methods, including environmental conditions, data on harvested species, and data on dependent predators (Agnew, 1997).

5.50 The Working Group recalled the CEMP review that was conducted in 2003, which was convened to assess the strengths and weaknesses of the existing program and the limitations these might impose for meeting the original objectives, and potential additions and improvements to the existing program (SC-CAMLR-XXIII, Appendix D).

5.51 The Working Group noted that, despite the initial plans for the CEMP and several recommendations from the 2003 review, a full implementation of an ecosystem monitoring program remains largely incomplete. Given the need to support growing interest in the krill fishery and other ecosystem monitoring requirements within CCAMLR, the Working Group reaffirmed that another review to update and expand the CEMP was timely and necessary.

5.52 The Working Group noted the original aims of the CEMP (paragraph 5.48). Recalling the outcomes of the 2003 Review, the Working Group agreed that an additional aim was needed.

5.53 The Working Group recommended that the Scientific Committee consider adding a third aim to formalize an objective that CEMP data be analysed, and the results be clearly communicated to inform management decisions regarding catch limits and their spatial distribution. The Working Group noted that target audiences for the results of analyses from CEMP data were broader than the CCAMLR community.

5.54 The Working Group recalled the substantial progress made on the krill work plan and the agreement reached on the new fishery management approach based on management strata within Subarea 48.1. However, despite this progress no consensus was reached for its implementation (SC-CAMLR-41, paragraph 3.67). To progress the development of its implementation, the Scientific Committee in 2022 highlighted the critical role that CEMP is required to play to support new management. The Scientific Committee recommended that future monitoring include: (i) krill biomass recruitment and demography, (ii) fish by-catch, (iii) status of dependent predator species including cetaceans, and (iv) the development and assessment of potential impact of the increased fishery on the ecosystem in general (SC-CAMLR-41, paragraph 3.49), and that an increase in catch limits requires a commensurate increase in data collection and monitoring on krill and other components of the Antarctic ecosystem that may be impacted (SC-CAMLR-41, paragraph 3.54).

5.55 With respect to the scope of the CEMP, the Working Group agreed that a CEMP review should consider how to expand beyond the current land-based predator monitoring focus of the CEMP. The Working Group noted that expanding the scope of the CEMP should parallel the objectives and needs of the corresponding management framework for which the data are collected.

5.56 The Working Group noted the importance of considering baleen whale distributions and abundance, as well as other at-sea observations in areas where the fishery operates. The Working Group also noted that identifying a broader range of indicator taxa from across trophic levels or foraging guilds may be useful. For example, changes in primary production and mesopelagic fish populations were identified as important knowledge gaps in the understanding of ecosystem status.

5.57 The Working Group noted that an expanded CEMP requires not only data to detect a change in the status of an indicator variable, but also data to understand why that change has occurred. The Working Group noted that such supporting information could be derived from expanded monitoring by Members or, where appropriate, liaison with other programs that collect and share the necessary data on relevant environmental (e.g., meteorological data, remotely sensed data, or model output) and biological (primary production) conditions.

5.58 The Working Group noted that progressing a review of CEMP would likely require intersessional work and dedicated workshops that would allow expertise from beyond the community of WG-EMM to participate. The Working Group noted that a general structure for progressing the work might be based on a categorical approach derived from the original aims of CEMP to consider 'environmental data', 'harvested species', and 'dependent and related species'.

5.59 The Working Group discussed the requirements from Commission to consider future monitoring requirements of krill biomass and other ecosystem components (including fish by-catch and krill dependent predator species to detect potential impacts of the increased fishery on the ecosystem) to support the revised krill management approach (CCAMLR-41, paragraph 4.17).

5.60 The Working Group identified a need for clarity about how the remit of WG-EMM and the CEMP contribute to the broader endeavour of ecosystem monitoring. The current and proposed uses of ecosystem monitoring data within CCAMLR include ecosystem health checks, spatial overlap analysis and MPA monitoring. CEMP currently delivers data on land-based predators, monitored at specified sites using standard methods. Members who submit CEMP data generally monitor multiple variables at CEMP sites and some of these variables are not submitted to the CCAMLR Secretariat. This existing additional monitoring can include tracking data and environmental variables which may be useful for interpreting predator data. CCAMLR oversees various monitoring programmes, some of which are currently included in CEMP and some of which (e.g., SISO) are not. There are several other organisations, many of which are not directly connected to CCAMLR, which collectively monitor a wide range of variables in the Southern Ocean. The scope of WG-EMM can encompass the monitoring of any ecosystem variable to achieve CCAMLR objectives (WG-EMM ToRs).

5.61 WG-EMM also has specific tasks related to ecosystem monitoring, including the current priority of supporting the revised krill fishery management approach for subarea 48.1. In this case the focus is on harvested, dependent and by-catch species. An enhanced CEMP designed to address this issue might include standardized monitoring of the target species (krill), its land-based and pelagic predators, and potentially relevant environmental variables at appropriate scales.

5.62 The Working Group identified three broad objectives for ongoing discussion of CEMP:

(i) Supporting the implementation of the revised krill fishery management approach for Subarea 48.1,

(ii) Enhancing circumpolar ecosystem monitoring in the context of climate change and fishing,

(iii) Supporting MPA design and monitoring.

5.63 Supporting the revised krill fishery management approach was identified as the immediate priority.

5.64 The Working Group recommended that:

(i) Implementation of a revised krill fishery management approach in Subarea 48.1 should be accompanied by enhanced ecosystem monitoring at appropriate scales in those management strata that are fished,

(ii) such monitoring could include data collected on vessels and at breeding sites, using remote observations and automated monitoring systems for biological and physical variables,

(iii) partnership with other programmes that collect predator data in these areas might be an appropriate way of expanding CCAMLR's access to monitoring data,

(iv) sustainable funding mechanisms (potentially including incentives for submitting monitoring data) should be identified, as enhanced data collection and analysis require additional effort and resources,

(v) consideration should be given to the acquisition of environmental data at appropriate spatial and temporal scales to identify potential drivers of monitored parameters,

(vi) analysis should be conducted on existing CEMP data to advise the Scientific Committee on status and trends of the ecosystem and to progress implementation of the krill fishery management strategy (paragraphs 5.20, 5.21 and 5.53).

5.65 The Working Group proposed four temporary teams to progress these recommendations through intersessional work and a dedicated session at WG-EMM-2024:

(i) Analysis of existing monitoring data (Dr Hill with support from the Secretariat),

(ii) monitoring of current and potential sentinel species (Drs Emmerson, Waluda, Collins),

(iii) krill fishery and at sea monitoring (SKEG),

(iv) environmental/non-biological parameters of relevance to wider ecosystem monitoring (Dr Knutsen).

5.66 The Working Group encouraged participants who wish to join these teams to identify themselves in the existing CEMP e-group. The Working Group agreed that participation in these teams could be extended to external experts at the discretion of the team leaders.

Other monitoring data (marine debris)

5.67 WG-EMM-2023/14 reported a summary of the CCAMLR marine debris monitoring program (MDMP) that was established in 1986 to monitor marine debris in the Convention Area. The MDMP reported data collected by CCAMLR Members from beach surveys, seabird colony surveys, observations of marine mammal entanglements, hydrocarbon soiling events, opportunistic sightings, gear lost by fishing vessels, and marine debris (including fishing gear from other sources) observed at-sea and recorded by the SISO observers. Most of the debris reported was plastic or fishing gear. While spatial patterns in gear loss generally reflect spatial patterns in fishing effort, some areas show higher rates of loss, likely due to a combination of sea ice dynamics, currents, and seafloor characteristics.

5.68 The Working Group welcomed the report and recommended that the Scientific Committee consider endorsing:

(i) the proposed changes to the opportunistic e-form,

(ii) the development of the proposed e-form table (Annex 1 in WG-EMM-2023/14) to include in the C2 form to enable the quantitative monthly reporting of fishing gear lost onboard the vessel beyond the current reporting of the frequency of lost fishing gear (i.e., occasionally, weekly, and daily),

(iii) the development of the proposed e-form table (Annex 2 in WG-EMM-2023/14) for reporting debris found at-sea in the observer logbook.

5.69 The Working Group welcomed Dr. C. Waluda (United Kingdom) to lead the Intersessional Correspondence e-group with Secretariat assistance to progress the marine debris workplan.

5.70 The Working Group noted that further work to standardize reporting of marine debris by effort would be needed to provide time trends in marine debris and allow any extrapolation to other times or areas. The Working Group noted that beach surveys are time consuming, and that it is difficult to determine if all the debris in an area was collected during the survey. The Working Group recommended future work to examine this issue.

5.71 The Working Group noted that the proposed additions to the observer e-logbook form for reporting debris found at-sea will facilitate quantitative summaries of the different types and components of found debris.

5.72 The Working Group noted that "Sago Extreme" fish de-hooking and collection devices were deployed by a toothfish longline vessel in Subarea 58.7. The Working Group noted that 15 of the devices were reported as lost. The Working Group expressed concern about the marine debris aspects of the loss of the devices and noted that details about their operation had been discussed, but not extensively by WG-FSA-2021 (paragraphs 7.6 and 7.7).

5.73 The Working Group noted that when trotline gear is lost, part of that loss could include "cachaloteras" (cetacean exclusion devices). The Working Group requested that the loss of these devices should be summarised in a future marine debris report.

5.74 The Working Group noted that the Chilean Antarctic Institute and the British Antarctic Survey conducted collaborative research on Coppermine Peninsula at Robert Island. Marine debris collected during the survey was transported to Punta Arenas and data will be submitted to the Secretariat. The Working Group noted that Argentina and Australia also conducted marine debris surveys at some CEMP sites and plan to submit data to the Secretariat.

5.75 WG-EMM-2023/26 reported on marine debris surveys undertaken by the UK in 2022/23. Below average levels of beach debris were recorded at Bird Island, Signy Island and Goudier Island, with plastic being the most abundant material at all sites. Debris levels found in seabird colonies at Bird Island was close to the long-term mean. At King Edward Point, four Antarctic fur seals were observed entangled in debris, and two entangled fur seals and five foul-hooked/entangled albatrosses were observed at Bird Island.

5.76 The Working Group welcomed the results of the surveys and highlighted the value of this long-term data monitoring program. The Working Group discussed the possible reasons for lower-than-average debris compared to previous years, and noted that marine debris can persist for long periods, and that the number of fishing vessels has decreased at the same time as vessel practices to avoid loss of fishing gear have improved. The Working Group also noted that the loss of fishing gear can be increased by interactions with sea ice and that changes in sea ice patterns could affect the amount of lost gear.

5.77 The Working Group noted that large plastic items at the surface become small plastic items in the water column and persist through time and could have ecological effects. The Working Group noted that understanding marine debris patterns could be improved through the use of particle tracking models in the Convention Area.

Krill-based ecosystem interactions

Krill biology, ecology and population dynamics

6.1 WG-EMM-2023/22 presented preliminary results of a study on the distribution and abundance of krill, and krill predators in Subarea 48.3 during winter. Although krill fishing takes place from May to September in concentrated areas in Subarea 48.3, there was a lack of information on krill and their predators during this time. During the survey, krill data were collected using nets (RMT1) and acoustics, and bird and cetacean observations were performed. Krill size was highly variable between hauls, which influenced interpretation of acoustic data. Findings indicated that the vertical distribution of krill changes throughout the season, with higher krill estimates occurring in night-time acoustic transects, particularly in July. Krill is suspected to reside near the sea floor (below 250 m) during the day, which is not detected by acoustics. Several species of whales were present in high abundances and these were observed feeding actively. Little overlap was observed between the krill fishery and gentoo penguin foraging areas. Details on acoustic results were presented to WG-ASAM (WG-ASAM-2023/06). The survey will be repeated in 2023.

6.2 The Working Group discussed the observed decrease in krill biomass which is suspected to be a result of variable current flows and not of the krill fishery. The Working Group suggested that length frequency distributions from krill fishing vessels might provide information on krill demography for a comparison with net data collected during the survey. The Working Group proposed that more data on temperature and currents would be useful to investigate the effects of krill transport in the area, and suggested that analyses of the inter-annual variability in krill biomass as well as temporal and spatial variability in the condition of the krill collected would be valuable. The Working Group, furthermore, considered that feeding estimates by cetaceans used in ecosystem studies might need to be reconsidered, given that winter feeding is usually not taken into account.

6.3 The presence of late stage furcilia larvae was noted by the Working Group. The suggestion was made that these larvae might originate from areas as far as the Weddell Sea or the Antarctic Peninsula. The Working Group noted observations of large numbers of furcilia in winter during the 'Discovery period' (Marr 1962) as well as from the early phase of the Japanese krill fishery, but whether this is an annual event or episodic remains to be revealed through future monitoring. It also noted that these small-sized krill might be preferred by some predators. The Working Group discussed the distribution of fur seals which were rarely seen during the May survey, raising the question where the fur seals are during this time as high numbers occurred in July, particularly in the eastern core box (WG-EMM-2023/22).

6.4 The Working Group highlighted to the Scientific Committee the increasing amount of information being generated through winter krill monitoring by the UK in Subarea 48.3 and the long-term krill biomass survey by Norway in Subarea 48.2 since 2011 (WG-EMM-2023/01), representing significant progress in the development of data to underpin the spatial overlap analysis in subareas 48.2 and 48.3. The Working Group also re-affirmed the effectiveness of the krill work plan for facilitating data accumulation vital for progressing the development of the revised krill fishery management approach in Area 48.

6.5 In order to correlate krill biomass with environmental variables and concomitantly understand drivers of krill distribution, habitat models were developed and evaluated in paper WG-EMM-2023/34 using data from two synoptic surveys conducted in the Scotia Sea during 2000 and 2019. A previously published model (Silk et al., 2016), developed using 2000 survey data, fitted poorly to the 2019 data. Performance was somewhat improved when model parameters were re-estimated using the 2019 data, but a completely new model with a new suite of explanatory variables was necessary to achieve reasonable performance. Bathymetry and phytoplankton abundance were consistent predictors of krill distribution in the Scotia Sea, but there was a lack of consistency in other predictors. The apparent relevance of distance to sea-ice edge, salinity, temperature, geostrophic velocity and sea level anomaly depended on the specific data set and modelling approach used. Models generally failed to predict high density spots. The study concluded that models from one survey performed poorly at predicting distribution in another survey, and that krill distribution does not have consistent relationships with most environmental variables (apart from bathymetry) due to its dynamic nature.

6.6 The Working Group welcomed the paper and noted the importance of the analysis. The Working Group discussed the predictable presence of krill in areas used by fishing vessels, but noted that fisheries do not always necessarily operate in the area with the highest biomass and mainly use bathymetry and previous experience as predictors of krill presence. The Working Group further discussed behavioural components of krill that may be of influence, such as DVM, swarm aggregation and retention, and potentially, differences in these components in various life stages. The suggestion was made that the use of other modelling methods might increase comparability between years. Further investigations could include finer time scale variables and a further look into, for example, food availability and eddies. Knowledge on the factors that drive aggregation and swarming behaviour of krill, and on temporal and spatial variation of phytoplankton would be desirable to improve models.

Krill predator biology, ecology and population dynamics

6.7 WG-EMM-2023/30 evaluated the potential conservation threats to South Shetland Island Antarctic fur seals (*Arctocephalus gazella*) amidst precipitous population collapse in the last 15 years. The paper outlines an array of environmental and ecological threats to the successful recovery of South Shetland Island Antarctic fur seals, including natural processes, as well as the spatial and temporal overlap between the pups of the South Shetland Island Antarctic fur seal sub-population and the krill fishery.

6.8 The Working Group highlighted the importance of including updated juvenile fur seal tracking data during winter in future spatial analysis work to better represent their distribution. Such analyses include the spatial overlap analysis, and the D1MPA proposal (which currently incorporates data on breeding and post reproductive dispersion period of adults, SC-CAMLR-38/BG/03).

6.9 The Working Group highlighted the potential utility of collecting DNA samples from Antarctic fur seals by-caught in the krill fishery to help identify population structure.

6.10 The Working Group encouraged the authors to submit the paper to WG-IMAF-2023 and to the ATCM Climate Change Working Group, and highlighted the role of the CCAMLR Scientific Committee in identifying the potential causes for the observed Antarctic fur seal decline and in addressing them.

6.11 WG-EMM-2023/49 summarised the results of four dedicated sighting surveys during the Japanese Abundance and Stock structure Surveys in the Antarctic (JASS-A program) in four austral summer seasons (2019/20 – 2022/23). The main research objectives of JASS-A are i) the study of the abundance and abundance trends of large whale species, and ii) the study of the distribution, movement and stock structure of large whale species. The dominant whale species sighted were Antarctic minke, humpback, fin, and blue whales in all surveys. Antarctic minke whales were mainly distributed in the southern part of the research areas, and were observed in higher densities in coastal ice-free waters (145° W – 120° W). Whale abundance data will be used to estimate krill consumption by whales, analysed in conjunction with the data collected by the previous Japanese whale research programs and IWC IDCR/SOWER (International Whaling Commission International Decade of Cetacean Research/Southern Ocean Whale and Ecosystem Research, 1978/79 – 2009/10) surveys in the same region.

6.12 The Working Group noted the large number of Antarctic minke whales in schools relative to the other whale species observed during the survey.

6.13 The Working Group highlighted the utility of collecting acoustic data as part of future large-scale surveys and thanked the authors for this ongoing work and their offer of future collaboration.

Spatial management

7.1 WG-EMM-2023/47 provided scientific evidence to support a draft Conservation Measure for a "Weddell Sea marine protected area Phase 2" (i.e., in the section of Planning Domain 3 to the East of the prime meridian). The evidence was based on data which are available via an online atlas and converted to a binary spatial representation of taxa or features on a grid of 100 km^2 hexagonal units, using distribution modelling. A wide range of taxa and features was considered including areas of historic productivity indicated by whaling records, and generalised representations of predator habitat including "Important Bird Areas" and "Areas of Ecological Significance". Other features included pelagic bioregions and the boundary between biogeochemical cells. An additional analysis identified areas with the lowest rate of projected warming from an ensemble of climate models as a metric of climate resilience. The evidence does not include a fishing layer as there has been little fishing in the area. However, consideration was given to the effects of ice cover on accessibility to potential fishing grounds.

7.2 WG-EMM-2023/36 summarised the objectives of and scientific progress towards the proposed "Weddell Sea Marine Protected Area – Phase 2" and provided a draft Conservation Measure for the implementation of this MPA. The proposal, as defined by the draft Conservation Measure, does not include any specific restrictions on fishing and related activities. Rather, it provides a framework for policy makers to apply appropriate restrictions. The proposal was developed as the result of consultation with interested CCAMLR Members and Observers through a series of three workshops, and by bilateral and multilateral meetings. This consultation was facilitated by the data atlas and distribution modelling described in WG-EMM-2023/47, and an interactive software tool to aid spatial planning. The proposal lists nine MPA objectives, eight of which include protection targets. The overall aim was to identify the minimum spatial footprint of a set of protected areas that cover 50% and 10% of relevant hexagons for "important" and "representative" objectives respectively. A key priority was to protect large-scale processes which support primary productivity. The process led to the selection of five areas for protection, including three "General Protection Zones" (GPZs), a coastal "Special Connectivity Zone" (SCZ) and a "Climate Research Zone" (CRZ) (Figure 2 in WG-EMM-23/36). The SCZ is important for longitudinal population connectivity and the CRZ represents an area of expected temperature stability. The authors assert that the proposal conforms to the requirements of the General framework for the establishment of CCAMLR Marine Protected Areas (CM 91-04) and is formulated based on the best scientific evidence available.

7.3 The authors of WG-EMM-2023/36 clarified that their objective in presenting the draft Conservation Measure was to facilitate discussion of the supporting scientific evidence. They also clarified that the key threat that the proposed MPA is intended to address is climate change. The authors noted that the data layers will be made available including identification of original sources, consistent with FAIR principals. The interactive software tool (which is a front end for the R package prioritizr) will also be made available. An updated draft RMP proposal with SMART objectives, consistent with CCAMLR-SM-III/12, will be developed for SC-CAMLR-42.

7.4 The Working Group thanked the authors for an extensive analysis and commended them on their collaborative approach and commitment to sharing data and tools.

7.5 The Working Group recognized that WG-EMM-2023/36 was useful to facilitate discussions given that it contains the translation of the data layers into a MPA proposal. The Working Group discussed the scientific background for the MPA proposal and agreed that the actual draft Conservation Measure contained in WG-EMM-2023/36 is not a matter for discussion by the Working Group.

7.6 The Working Group agreed that distribution modelling is appropriate for this area where data are relatively scarce. It noted that additional data are available, especially for benthic communities, as the analyses have been delayed and would be completed in the future. The Working Group noted that while some potentially important taxa might have been omitted from the analysis, the protection targets for all the included groups were attained.

7.7 The Working Group noted that the analysis used generalised protection targets and that an alternative approach would be to define specific targets for individual taxa, particularly predators. For many of the taxa and processes, the level of protection achieved by the proposed MPA exceeded the target levels for individual taxa and features. The Working Group supported the potential to protect longitudinal connectivity using the SCZ and noted that the proposal does not include equivalent protection for latitudinal connectivity.

7.8 The Working Group noted that a standardised set of zone types and definitions for use in all proposed and current MPAs would be useful.

7.9 The Working Group recognised that understanding of environmental variability may change as new data and models become available and that there may be a future need for dynamic boundaries to allow adjustments. It suggested that the RMP should be designed to support such dynamic adjustments.

7.10 The Working Group noted that there are existing toothfish research blocks in some of the proposed GPZs and that further development of these fisheries may lead to repositioning of these research blocks. It also noted that continued research fishing might help with monitoring the effectiveness of an MPA.

7.11 Dr. Kasatkina (Russia) reiterated her position on the MPA process (articulated in CCAMLR-SM-III/07,08,09,10). Dr. Kasatkina noted that the proposals to designate MPA on Weddell Sea did not provide any evidence of threats from the fishery and climate change to marine living resources and biodiversity of the Weddell Sea region which require the protection and the urgency of providing this protection. Dr. Kasatkina also noted that potential threats from a fishery regulated by effective Conservation Measures on the basis of the precautionary and ecosystem approaches are very low, and protection against climate change cannot be achieved by an MPA. She stressed the need for clarity on the criteria for assessing the achievement of the MPA objectives.

7.12 Dr Kasatkina noted that MPA proposals (WG-EMM-2023/47 and WG-EMM-2023/36) did not justify the boundaries and specific objectives of the MPA and that the baseline data are mainly represented by fragmentary and historical data. Dr. Kasatkina highlighted the need for clarity on the quality and sufficiency of baseline data to meet the MPA objectives and developing measurable indicators for monitoring and criteria for achieving the MPA objectives.

7.13 Dr. Kasatkina suggested accompanying Tables 2 – 6 of WG-EMM-2023/36 by characteristics and trends for representative species and clarifying the protection targets taking into account evidence of potential threats. She also recalled the importance of the hypothesis on the life history and stock status of toothfish (*Dissostichus mawsoni*) in Area 48 for managing its resources (WS-DmPH, 2018) and noted that there are no references to such a hypothesis in WG-EMM-2023/47 and WG-EMM-2023/36, due to a lack of baseline data.

7.14 Additionally, Dr. Kasatkina recalled the Russian position that the MPA Research and Monitoring Plan accompanied by characteristics and trends estimated at start of the MPA for indicators of monitoring and criteria for achieving specific objectives should be an integral part of MPA proposals.

7.15 At the time of adoption, Dr G. Griffith (Norway) suggested the following response to paragraphs 7.11 to 7.14:

> 'It is realized that there are some possible misunderstandings of the scientific justification for the areas proposed to be within the WSMPA Phase 2, and how the SMART Criteria can be applied to the proposal. The WG subgroup discussions on "Developing SMART criteria, with baselines and decision rules, to evaluate CCAMLR MPAs" (CCAMLR-SM-III/12) was thorough and detailed. WG-EMM-2023/47 and CCAMLR-SM-III/12 have the potential to handle dynamic changes in environmental variability as well as fisheries concerns by incorporating the SMART criteria. These can be discussed bi- or multilaterally between Norway and interested CCAMLR members before Scientific Committee 2023.'

7.16 At the time of adoption, the Working Group recalled paragraph 2 of CM 91-04, which does not require evidence of a negative effect of fishing, or the establishment of a stock hypothesis, in order to establish an MPA.

7.17 The working group provided the following recommendations to the authors to improve the analysis and clarity of presentation prior to submission to the Scientific Committee:

(i) include data on the post-breeding season distribution of Adélie penguins,

(ii) update the assessment of emperor penguin distribution using relevant data from tracking studies near Mawson Station,

(iii) enhance the protection target for the declining Antarctic petrel population and provide specific advice to the Scientific Committee on the protection of declining populations,

(iv) clearly explain how the inclusion or exclusion of the Fisheries Research Blocks affects the calculation of protection targets using the interactive software tool,

(v) explain how the protection targets were derived,

(vi) alter the wording of objective (iv) of WG-EMM-2023/36 to include pelagic mammals,

(vii) provide an explanation of the process which identified the CRZ,

(viii) include binary rasters and the thresholds used to derive the proposed MPA, and digital object identifiers (DOIs) for input data alongside the input data in the atlas,

(ix) document the history of research fishing in the planning area.

7.18 The Working Group also recommended that the additional existing data should be included in the benthic layers, but agreed that this was unlikely to influence the outcome.

Data analysis supporting spatial management approaches in CCAMLR

7.19 WG-EMM-2023/10 reported on using the Spatial Population Model (SPM) to assess the potential impacts of the Ross Sea region MPA for Antarctic toothfish. This analysis showed that under a range of fishing scenarios, both the medium- and long-term impacts of the MPA are to increase yield and increase stock size compared to projections without it.

7.20 The Working Group welcomed progress in the use of spatially resolved population models and noted that this methodology could be applied in other areas / MPAs. The Working Group encouraged further development of the SPM to consider sex-specific differences in Antarctic toothfish. The Working Group suggested the SPM was a useful tool to determine if the population structure and distribution of toothfish has changed in the two areas of importance to mammalian predators in the western General Protection Zones (McMurdo Sound and Terra Nova Bay).

7.21 WG-EMM-2023/46 described the usefulness of phylodiversity as a measure of biodiversity at the Southern Ocean scale to include historical depth in future assessments of climate change impact on biodiversity. The work showed that existing and proposed MPAs will protect a significant proportion of when implemented fully, but also that a significant proportion of phylogenetic diversity would fall outside MPA boundaries.

7.22 The Working Group thanked the authors for their work on the phylogeography of four key Southern Ocean taxonomic groups. The Working Group noted that caution was needed in interpreting open-access biogeographic data, as the taxonomic resolution of these data may not be resolved equally across the study region, creating the possibility of data artifacts in the diversity outputs. The Working Group agreed with the authors that conserving phylodiversity in the Southern Ocean was important.

7.23 WG-EMM-2023/04 described the structure of the 0-group (aged <1 year) fish community of the Scotia Sea using data from a basin-scale survey conducted in early 2019. The study sampled the top 200 m of the water column and caught 347 0-group fish from 19 genera, with one third of all specimens belonging to the genus *Notolepis*. The study recommended that dedicated monitoring is required to understand the seasonal differences in larval community assemblages and the implications of 0-group fish by-catch in the krill fishery.

7.24 The Working Group thanked the authors and welcomed this important contribution to research directed on fish larvae.

7.25 WG-EMM-2023/P01 explored the potential for precise and direct estimation of catch weight (green weight) for Antarctic krill using acoustic sensors installed in the mouth of a trawl net. A linear relationship was found between acoustically estimated catch weight and observed catch weight. Acoustically estimated catch weight significantly predicted actual catch weight, which demonstrated that acoustically based methods for catch weight monitoring have the potential to be used to report total catch weight in a trawl, potentially in real-time, and that similar methods could also be employed in similar types of trawl fisheries. This study also observed the increased acoustic densities of krill toward the centre of the trawl opening suggesting that krill were herded during fishing.

7.26 The Working Group thanked the authors for this important progress in their study exploring a new way of estimating green weight of catch in the krill fishery by using acoustics.

The Working Group noted that acoustic catch weight seemed to be underestimated when actual catch was high and encouraged the authors to explore the likely reasons for this through further study. The Working Group also noted the importance of understanding the accuracy of this method to estimate krill catch when it is scaled up to commercial nets with a larger mesh size. Further study to investigate whether the herding effect can be observed in nets with larger mesh size and mouths, taking into account krill escaping through nets from trawl mouth to codend, would provide important information on the selectivity of the nets. The Working Group further noted the potential application of this method for detecting by-catch of marine mammals and recommended that the authors submit the document to WG-IMAF-2023.

7.27 WG-EMM-2023/31 presented an overview of baseline spatial data prior to the ecoregionalisation of the eastern Sub-Antarctic Region, which focussed on the region between 20° W to 160° E and 30° S to 60° S. This work resulted from The Expert Workshop on Pelagic Spatial Planning for the eastern Sub-Antarctic Region in Cape Town, South Africa in 2019. WG-EMM-2023/17 described hydrologic regionalisation from Crozet to Kerguelen and subtropical southern Indian Ocean and WG-EMM-2023/18 described regionalisation of the physical and biogeochemical environment in the southern Indian Ocean.

7.28 The Working Group thanked the authors for a set of valuable papers. The Working Group encouraged additional analytical steps which could help resolve finer-scale environmental features and quantify uncertainty associated with the analysis, based on similar approaches previously applied in sub-Antarctic benthic ecoregionalisation studies.

7.29 WG-EMM-2023/51 described large scale pelagic acoustic ecoregionalisation in the eastern Sub-Antarctic and WG-EMM-2023/57 used temporal and spatial patterns from multi-frequency acoustic data to describe pelagic structuring in the eastern Sub-Antarctic Region.

7.30 WG-EMM-2023/58 mapped the distribution of trophically important sub-Antarctic zooplankton using data from 30 years of Continuous Plankton Recorder (CPR) surveys. WG-EMM-2023/21 and WG-EMM-2023/38 described zooplankton communities at Crozet and Kerguelen, and Prince Edward Island respectively. WG-EMM-2023/16 described preliminary steps for an atlas of macro-zooplankton in the Sub-Antarctic Indian Ocean and in the South Indian Ocean utilizing historical and new survey data combined with open-access biogeographic data.

7.31 The Working Group commended the authors on their use of a diverse range of data sources, particularly long-term data from CPR analysis and encouraged the use of network metrics and metabarcoding to complement the results presented.

7.32 WG-EMM-2023/20 presented some new results on mesopelagic fish populations from surveys from Crozet to Kerguelen and in the subtropical Indian Ocean. The study integrated both subtropical and Southern Ocean species to investigate the species richness and

geographical distribution of species and assess their alignment with established biogeographic provinces. The study also highlighted the crucial role of mesopelagic fauna in the trophic food web.

7.33 The Working Group thanked the authors for their work on mesopelagic fish and encouraged them to contribute their data to MYCTOBASE. The Working Group discussed the importance of linking work on myctophids and zooplankton, and the importance of mesopelagic fish for climate feedback, carbon flux and the carbon pump. It encouraged further collaboration between Members working on these topics.

7.34 WG-EMM-2023/32 and WG-EMM-2023/37 described the distribution and abundance of seabirds and marine mammals in the Sub-Antarctic and subtropical Indian Ocean from a suite of land-based long-term monitoring studies along with animal-borne biotelemetry/biologging and at-sea observations. These studies aimed to support spatial conservation and management planning, and to identify broader challenges for understanding marine predator distributions in this region.

7.35 The Working Group thanked the authors for this significant body of work which substantially improves understanding of the structure of the eastern Sub-Antarctic region and Indian Ocean and encouraged further collaborations. The Working Group noted that adding Subareas/Divisions to the maps included in the papers would help consider fishing activities in relation to ecoregionalisation and encouraged members to contribute to the Joint Exploration of the Twilight Zone Ocean Network (https://jetzon.org/).

Research and monitoring plans for MPAs

7.36 WG-EMM-2023/07 reported on research conducted by New Zealand in the Ross Sea region relevant to the specific objectives of the RSRMPA. Research highlights included new information on top predator species, the application of alternative method to identify phytoplankton classes from pigments and assessment of the Coupled Model Intercomparison Project (CMIP)5 and CMIP6 Earth System Models for the Ross Sea region.

7.37 The Working Group welcomed the contributions and cooperation of countries operating scientific stations and research vessels in the Ross Sea region and conducting research and monitoring studies in support of the RSRMPA.

7.38 The Working Group noted the implementation of research and monitoring projects in support of the RSRMPA for the period 2022 to 2026 by Republic of Korea.

7.39 The Working Group further noted the importance of research on salps to estimate their contribution to the biological carbon pump and to assess changes in primary production.

7.40 WG-EMM-2023/15 Rev. 1 reported the findings of a multidisciplinary survey of meso-zooplankton conducted on the Korean icebreaker RV *Araon* in the RSRMPA in December 2020. The results showed three meso-zooplankton communities for the Terra Nova Bay polynya, the Ross Sea polynya, and the marginal polynya region, which differ in species composition and abundance. Salinity was identified as the driving environmental factor for different community structure in the three geographical regions.

7.41 The Working Group welcomed this paper and congratulated the authors on this impressive work. The Working Group noted the results on the dynamics of the polynya systems and how oceanic current characteristics shape the meso-zooplankton community.

7.42 The Working Group also welcomed the planned acoustic survey in the Krill Research Zone (KRZ) of the RSRMPA to take place in 2023/24. The Working Group noted that additional data collections, such as observational data on seabirds and whales, samples of substrate in the area identified as a skate nursery (paragraph 7.64), benthic species assemblage and meso-zooplankton samples, could be useful in providing a better overview of ecosystem functioning in the area.

7.43 The Working Group noted studies from Japan and Australia that have recently taken place in East Antarctica (Cox et al., 2022; WG-EMM-2019/42). With the planned KRZ survey combined, this will constitute a set of contemporary krill biomass data spanning the area between 55° E to 160° E.

7.44 The Working Group recommended seeking advice from WG-ASAM after the research cruise regarding the standardisation of acoustic methods and data analysis. The Working Group noted that the EU Copernicus project (https://www.copernicus.eu/en) might provide additional spatio-temporal data sets that could be incorporated into future analyses.

7.45 WG-EMM-2023/P03 presented the report of a Ross Sea research planning meeting held in October 2022 (hybrid meeting) which focused on refining existing questions and to formulate an innovative and sustainable research program aimed at better understanding, conserving, and managing the RSRMPA through the coordination of collaborative, inclusive, and interdisciplinary science (http://www.rossseaesearch.org/).

7.46 The Working Group welcomed this paper and congratulated the authors on the website as an outcome of the workshop; which gives an excellent overview of the workshop itself and the background of the RSRMPA and ongoing activities in this context. The Working Group recognised this website as an exemplary tool to create transparency and openness to engage interested people in the RSRMPA research network.

7.47 WG-EMM-2023/P05 presented CRITTERBASE, a publicly accessible data warehouse that currently hosts quality-controlled and taxonomically standardised data for almost 19,000 samples and more than 3,500 benthic taxa in Arctic, North Sea, and Antarctic regions. CRITTERBASE already supports marine conservation efforts in the Weddell Sea as the data management system for the WSMPA P1 baseline data and is also envisaged to manage data collected as part of a future WSMPA P1 RMP.

7.48 The Working Group welcomed this paper and congratulated the authors on this important contribution. The Working Group noted the large amount of quality-controlled data already in the data warehouse including data to support CCAMLR activities.

7.49 The Working Group noted the ability of CRITTERBASE to store other types of data including video and tracking data and to integrate with other data repositories.

7.50 CCAMLR-SM-III/12 presented the principles and concepts used to develop candidate SMART (Specific, Measurable, Achievable, Relevant, and Time-bound) criteria, with baselines and decision rules, for the RSRMPA. Six candidate examples were presented based on the SMART criteria.

7.51 CCAMLR-SM-III/BG/01 presented forty-six candidate SMART criteria for assessing the effectiveness of the RSRMPA.

7.52 The Working Group welcomed these papers and noted the significant contribution to the development of the SMART criteria approach under the RSRMPA RMP.

7.53 The Working Group supported the SMART criteria approach to assist in characterising the baselines, determining the research and monitoring required and assessing the effectiveness of MPAs, noting that this approach addresses the concerns expressed in e.g., SC-CAMLR-XXXVII/19 and SC-CAMLR-40/18.

7.54 The Working Group noted that the SMART criteria approach may be useful as a general framework for other MPA RMPs. The Working Group further noted that the SMART criteria approach needs to be tailored to the particular MPA and its objectives and may need to be flexibly adapted in its design. The Working Group further noted that developing a flexible framework for identifying SMART indicators that are based on the general and specific objectives of an MPA would be helpful for the application of SMART criteria.

7.55 The Working Group recognised the complexity and comprehensiveness of this approach and noted that the SMART criteria should be streamlined in terms of the number of indicators arising from the specific objectives of the RSRMPA.

7.56 The Working Group agreed that it is appropriate to develop at least one SMART indicator for each of the specific objectives of an MPA. For example, the paragraph 3 of CM 91-05 contains 11 specific objectives suggesting that at least 11 SMART indicators would be appropriate.

7.57 The Working Group noted that the specific objectives of the MPA are often supported by multiple baseline data layers that were used to develop the MPA and that some data layers may support multiple specific objectives. To provide a simplified set of SMART indicators from a potentially large number of baseline data layers, the Working Group agreed that a prioritization of potential SMART indicators would be helpful to implement RMPs and MPA objectives.

7.58 The Working Group noted that a prioritization of potential SMART indicators could be achieved by considering at least three conditions:

(i) The quality, richness, and levels of uncertainty in the baseline data should be considered, noting that the ability to detect changes in the status of a SMART indicator is linked to the uncertainty in the baseline data.

(ii) A prioritization of SMART indicators should consider the current and planned research activities in the MPA region to identify which indicators were likely to be assessed within reasonable time frames.

(iii) The Working Group recalled that an MPA is a spatial management tool. SMART indicators that assess spatially explicit baseline data may provide a more direct link between the indicator and their corresponding decision rules to modify the MPA to ensure the MPA is meeting its specific objectives. The Working Group noted, however, that non-spatial data (e.g., population size) remained important for consideration and should not be automatically discounted in a prioritization process.

7.59 The Working Group noted that the process of balancing trade-offs within this prioritization may not be straightforward and encouraged further work to develop examples illustrating the process.

7.60 The Working Group also identified several questions and suggestions for future work to develop SMART indicators:

(i) Develop a clear and comprehensive definition of SMART indicators.

(ii) How can SMART indicators be used in rapidly changing ecosystems?

(iii) What is the appropriate timeframe for assessing SMART indicators?

(iv) How do SMART indicators apply to different management zones (e.g., climate reference zones, special research zones)?

(v) How do we balance individual SMART indicators versus the collection of SMART indicators when assessing performance of the MPA?

VME data and spatial planning approaches

7.61 WG-EMM-2023/52 presented the first records of *Chionodraco hamatus* nests in Terra Nova Bay during a survey using Baited Remote Underwater Video systems (BRUVs) to investigate the distribution of Antarctic toothfish in support of research and monitoring objectives in the RSRMPA. Fish nests were observed at depths of 356 m, 475 m, and 543 m within the GPZ of the RSRMPA. These findings document the existence of a *Chionodraco hamatus* nesting area in Silverfish Bay. The results highlighted the ecological value of the nearshore coastal areas and a future focus area for research and monitoring in the RSRMPA.

7.62 The Working Group congratulated the authors for the discovery of the icefish nests and highlighted that the study was led by a current CCAMLR scholarship recipient (Dr E. Carlig (Italy)).

7.63 The Working Group noted that the discovery was opportunistic and that it is likely that more nests are still to be discovered in the area and that it can be assumed that the unoccupied but un-silted nests can be considered as active nests. The Working Group noted the importance of further research in the area, and that information from other studies or observer data could assist in identifying possible areas for further surveys.

7.64 WG-EMM-2023/08 presented detailed information on the first records of a deepwater skate *Bathyraja* sp. (*cf. eatonii*) egg case nursery in the Ross Sea within the GPZ of the RSRMPA. Observations were recorded using a deepwater video imaging system as part of a wider programme established for monitoring the RSRMPA. The results meet the criteria for an egg case nursery (Martins et al., 2018). Egg case density, where egg cases were most abundant, was estimated at 0.26 per m^2. The results highlighted the ecological importance of the area and the continued need for non-destructive survey methods to categorize essential skate habitat.

7.65 The Working Group congratulated the authors on the discovery of the egg case nursery of high ecological value. The Working Group recommended sampling of egg cases from these areas to aid species identification. The Working Group noted that observer data such as on toothfish diet and surveying areas where gravid skates have been found could help identify further areas of interest, and that further research is needed to identify possible proxies to serve as indicators of such nursery areas. The Working Group further noted that this discovery highlights the importance of the RSRMPA in this area.

7.66 WG-EMM-2023/25 presented an overview of the outcomes and recommendations of WG-EMM-2022, WG-FSA-2022, SC-CAMLR-41, and CCAMLR-41 regarding a potential protection mechanism for the fish nest area for notothenioid icefish (*Neopagetopsis ionah*), which had been discovered in the southern Weddell Sea (Purser et al. 2022). The authors proposed potential definitions of fish nest and fish nest area, relevant indicators, rationale for a protective buffer zone around fish nest areas, and a potential review process for opening and closing fish nest areas to bottom fishing activities.

7.67 The Working Group welcomed the document and highlighted again, the importance of protecting this fish nest areas in a timely manner.

7.68 The Working Group noted that relying on the presence of eggs in the nest as a criterion for a nest would be too restrictive, given that nests may be observed during the preparation stage.

7.69 The Working Group noted that critical habitats are defined as necessary to the long-term maintenance of a population (Heithaus, 2007), which includes spawning, breeding, feeding, or growth to maturity (Martins et al., 2018).

7.70 The Working Group considered that a fish nest is a visibly altered site/structure used for laying eggs and/or sheltering young, and:

(i) appears as a circular depression in the substrate delineated by gravel and/or sediment, or is contained in a secondary biological structure,

(ii) may be attended by one or more fish.

7.71 Fish nests may be characterized as either:

(i) *active*: benthic areas observed to have defined fish nest structure that may or may not include fish eggs or be attended by fish, and structures are clean of debris and re-sedimentation, or

(ii) *potential:* sites showing defined fish nest structure, but with no signs of active construction or maintenance activities.

7.72 The Working Group agreed that a 10-n mile protective buffer zone is appropriate, but recommended that, in order to be precautionary, reduction or removal of the protective buffer zone should require evidence of abandonment of the fish nest area.

7.73 The Working Group considered broader protection of 'Essential Fish Habitats' throughout the Convention Area, including a sub-category for fish nest areas, and having the provision to add additional sub-categories in the future such as skate nurseries is needed (CCAMLR-41, paragraphs 4.89 and 4.90). The Working Group suggested that the Scientific Committee consider recommending a mechanism such as a Conservation Measure to the Commission.

Climate change and associated research and monitoring

8.1 WG-EMM-2023/09 provided a summary of the New Zealand research voyage to the Ross Sea region in January to February 2023 on RV *Tangaroa* (voyage code TAN2302). The focus was to provide information on the RSRMPA to allow scientific evaluation of its ecological status, spatial adequacy, and effectiveness, covered through 15 specific objectives. The over-arching purpose of this multi-disciplinary research voyage was to increase knowledge about key environmental and biological processes in the Ross Sea region of the Southern Ocean. The research was carried out by New Zealand and Italian scientists on the 38-day voyage.

8.2 The Working Group welcomed the presentation and commended the work done by New Zealand and Italy. It was noted that New Zealand is currently planning two further research voyages on RV *Tangaroa* to the Ross Sea region scheduled for 2025 and 2027, and that applications for the 2025 voyage must be submitted soon. International scientists interested in participating or collaborating on these future voyages are encouraged to contact the authors of this paper for more information. The *Tangaroa* voyages have been collecting long term data that may be of use for the review of the CEMP.

8.3 The Working Group discussed the upcoming SC-CAMLR Climate Change workshop (WS-CC-2023) in September 2023. The Scientific Committee agreed to hold this workshop to improve the integration of scientific information on climate change and ecosystem interactions throughout CCAMLR's work program (SC-CAMLR-41, paragraphs 7.4 to 7.13 and Appendix 1). The Working Group noted that the format of the workshop is hybrid, with options to attend one of two regional hubs in the UK and New Zealand, either in-person or online, followed by daily plenary sessions (see schedule https://meetings.ccamlr.org/ws-cc-2023).

8.4 The Workshop co-conveners (Dr R. Cavanagh (UK) and Mr E. Pardo (New Zealand)) encouraged registration to the workshop, the inclusion of relevant experts within delegations, the identification of keynote speakers, and submission of papers related to the agenda items. They welcomed engagement during the planning process and noted that Scientific Committee observers had been invited to participate.

Other business

9.1 In accordance with requirements under CM 24-01 paragraph 4 (c), WG-EMM-2023/26 provided a brief summary of the groundfish survey in Subarea 48.3 which took place in February 2023. The Working Group noted that a full report will be provided to WG-FSA-2023.

Future work

10.1 The Working Group discussed its future workplan (Table 2) and updated it to reflect current participation and discussions, including contributors, timeline and urgency assignments, including elevating the urgency associated with developing MSEs for both krill and finfish.

10.2 The Working Group noted that some of the krill management work topics fall outside of the goal to implement the CCAMLR decision rules and therefore the structure of the workplan could be revised in the future to account for this. In addition, the Working Group noted that the brief descriptors for the work items may lead to some lack of clarity and that cross references to more descriptive paragraphs would be helpful.

10.3 The Working Group added several work items including:

(i) a new priority research topic to reflect agreed work on the Krill Stock Hypothesis Information Collection Plan to inform about krill life history and population dynamics (paragraph 4.32),

(ii) teams be developed to provide advice on monitoring methods and designs for an enhanced CEMP programme (paragraph 5.65),

(iii) the harmonisation and/or integration of different spatial management initiatives within Subarea 48.1, including the ARK voluntary restricted zones and the D1MPA proposal (SC-CAMLR-41, paragraph 3.65),

(iv) develop methods and metrics for integrated ecosystem reporting (WG-EMM-2022, paragraph 2.18),

(v) develop mechanisms to integrate ecosystem and climate change monitoring into the workstreams of the Scientific Committee and its advice (WS-CC-2023).

Advice to the Scientific Committee and its working groups

11.1 The Working Group's advice to the Scientific Committee is summarised below; these advice paragraphs should be considered along with the body of the report leading to the advice:

(i) SISO protocols (paragraphs 4.3 and 4.4)

(ii) Krill fishery management approach document (paragraph 4.11),

(iii) Good modelling practices (paragraph 4.27),

(iv) Marine debris reporting (paragraph 5.74),

(v) CEMP (paragraphs 5.53, 5.64, 5.65),

(vi) Krill work plan progress (paragraph 6.4),

(vii) Essential fish habitats (paragraph 7.73).

Adoption of the report and close of the meeting

12.1 The report of the meeting was adopted, requiring 5 h and 23 min of discussion.

12.2 The Working group expressed its sadness at the news of the untimely death of our Spanish colleague, Dr Andres Barbosa, who died last January. The Working group noted its appreciation of Dr Barbosa's valuable contribution to the work of CCAMLR and in particular to penguin ecology as well as his role at SCAR.

12.3 Dr Parker, on behalf of the WG-EMM-2023 participants, thanked Dr Cárdenas for his calm and insightful leadership of the meeting resulting in an efficient and fast adoption process.

12.4 Dr Cárdenas thanked the meeting participants for their willingness to work together in a collaborative spirit and support for his role, noting how the return to in-person meetings was both pleasurable and productive. He also thanked the CMLRE team for their hard work, coordination, and introduction to Indian culture, and thanked the Secretariat for their support of the meeting.

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Table 1: Krill Stock Hypothesis Information Collection Plan.
N.B. additional contributors will be identified in the future and the current ones are listed in no particular order.

Priority activities	Data	Samples /Approach	Platform	Sampling by whom	Measurement and/or analysis by whom	Purpose	Urgency		Time frame	Contributors
							For short-term management	To improve process understanding		
Multiple source data collection	Length, maturity, and weight	Krill biological measurement using SISO krill sampling protocol	Fishery	Scientific Observers, CCAMLR Scientists, SKEG community scientists	Scientific Observers, CCAMLR Scientists, SKEG community scientists	Understand spatial seasonal distribution of krill population and pinpoint hot spots	Medium	High	Continuous	Mr J Zhu, Dr Fan, Dr Kim
		Krill biological measurement using random subsampling method consistent with SISO protocol	Research vessels, other vessels	CCAMLR Scientists, SKEG community scientists	CCAMLR Scientists, SKEG community scientists					Dr Krafft, Dr Kutsen, Mr J Zhu, Dr Fam, Dr La
	Length and maturity data from predator diet	Krill from predator stomach contents	Penguins, fur seals	CEMP Parameter A8	CCAMLR Scientists	Understand krill length consumed by predators within the foraging area	Medium	Medium	Continuous	Dr Waluda, Dr Hill, Dr Collins
	Krill larvae	CPR sampling	Tourist vessels	CCAMLR Scientists, SKEG community scientists	CCAMLR Scientists, SKEG community scientists	Understand spatio-temporal distribution of krill larvae	Medium	Medium	Continuous	Dr Schaafsma, Dr Mu
	Genetics	Development of molecular markers for analysing subarea level population	Research vessels, Fishing vessels, other vessels	SKEG community scientists, in collaboration with industry for fishing vessels	CCAMLR Scientists, SKEG community scientists	Understand Connectivity and retention	Medium	High	3-5 Years	Dr Shao Dr Meyer Dr Kawaguchi
		Molecular analysis of microbiome assembly that are geographically structured	Research vessels, Fishing vessels, other vessels	SKEG community scientists, in collaboration with industry for fishing vessels	CCAMLR Scientists, SKEG community scientists			Medium		Dr Kawaguchi Dr Cleary

(continued)

Table 1 (continued)

Priority activities	Data	Samples /Approach	Platform	Sampling by whom	Measurement and/or analysis by whom	Purpose	Urgency		Time frame	Contributors
							For short-term management	To improve process understanding		
	eDNA	Seawater	Research vessels Fishing vessels			Understand habitat use and distribution	Medium	High	3-5 years	Lu Liu Dr Kawaguchi Dr Liszka
	Behaviour	Acoustic data	Research vessels Fishing vessels	Scientists, SKEG community scientists	Scientists, SKEG community scientists	Seasonal horizontal and vertical krill behaviour	Medium	High	5-8 years	Dr Meyer, Dr Krafft, Dr Kasatkina, Dr Wang, Dr La Dr Kawaguchi Dr Smith, Dr Knutsen
	Environment	Sea ice, Chlorophyll (food availability), sea surface temperature	Satellite	CCAMLR Scientists, SKEG community scientists	CCAMLR Scientists, SKEG community scientists	Seasonal food availability	Medium	High	5 years	Dr Meyer, Dr Y. Zhao, Dr Kasatkina
		CTD	Vessels, gliders, animal borne sensors	CCAMLR Scientists, SKEG community scientists	CCAMLR Scientists, SKEG community scientists	Understand habitat environment	Medium	Medium	5 years	
	Currents	Moorings and ship hull mounted ADCP	Moorings, research vessels, Fishing vessels	CCAMLR Scientists, SKEG community scientists	CCAMLR Scientists, SKEG community scientists	Krill behaviour, spatial distribution	High	High	3 years	Dr Krafft Dr Smith

(continued)

Table 1 (continued)

Priority activities	**Data**	**Samples /Approach**	**Platform**	**Sampling by whom**	**Measurement and/or analysis by whom**	**Purpose**	**Urgency**		**Time frame**	**Contributors**
							For short-term management	To improve process understanding		
Modelling & Measurements	Development of oceanographic numerical models	Existing observation data, krill acoustic density, satellite remote sensing, reanalysis database, ocean circulation model, Lagrange particle tracking model, and krill habitat suitability assessment.	Existing data	SKEG community scientists	SKEG community scientists	To better understand population structure and connectivity and retentions between subareas and regions.	High	High	5-10 years	Dr Mori Dr Thorpe
	Krill habitats	Krill habitat suitability assessment								Dr Y Zhao
	Population dynamics	Spatial life cycle model for krill stock, Mechanistic relationship between sea ice and recruitment and other stages, quantification of climate change impacts on population dynamics across life history stages, regional population connectivity (advection and life cycle modelling)		SKEG community scientists, CCAMLR scientists	SKEG community scientists, CCAMLR scientists	Hypothesis testing	High	High	5-10 years	Dr Meyer, Dr Ying, Dr Kawaguchi Dr Hill

(continued)

Table 1 (continued)

Priority activities	Data	Samples /Approach	Platform	Sampling by whom	Measurement and/or analysis by whom	Purpose	Urgency		Time frame	Contributors
							For short-term management	To improve process understanding		
Experimental approach	Experimental results	Measure life history parameters such as egg sinking rates and developmental rates, under controlled environments	Aquarium and field experiments	SKEG community scientists	SKEG community scientists	To better parameterise models to simulate transport pathways during early life stages to help pinpoint spawning hotspots.	Medium	High	5-10 years	Dr Kawaguchi
Field Study	Krill behaviour, Flux	Analysing the drivers of the seasonal horizontal migration of krill (oceanic vs shelf regions)	Research / Fishing vessels, Antarctic stations	SKEG community scientists	SKEG community scientists	To get a mechanistic understanding of krill flux	Medium	High	5-8 years	Dr Meyer Dr Kawaguchi Dr Smith, Dr Kasatkina
Mine existing information (Knowledge, data, and samples)	Existing data, samples and knowledge	Literature review and analysis of historical data		SKEG community scientists	SKEG community scientists	To ensure KSH is consistent with published knowledge and is available in scientific literature	High		1 year	Dr Okuda, Dr Hill, Dr Kawaguchi
	Existing samples that can be extracted for genetic analysis	Different laboratories use agreed methodologies to deliver comparative sequences		SKEG community scientists	SKEG community scientists		Medium	High	3-5 years	

Table 2: Intersessional work plan for WG-EMM updated by WG-EMM-2023. Timeframe periods are short = 1–2 years, medium = 3–5 years and long = 5+ years. Items tasked to WG-EMM from the Scientific Committee Strategic Plan (Annex 4 in SC-CAMLR-41). CEMP – CCAMLR Ecosystem Monitoring Program, SISO – Scheme of International Scientific Observation.

Theme	Priority research topic	Priority research topic task	Timeframe	Contributors	Secretariat participation
1. Target species	(a) Develop methods to estimate biomass for krill	(iii) Data collection – SISO, vessels, and CEMP Urgency: High (2) Develop diagnostic approaches for data quality Urgency: High	Short	Dr Zhu Dr Kawaguchi Dr Collins	Yes
		(iv) Acoustic data storage and processing Urgency: High (3) Develop the use of krill length frequency data in the estimation of target strength, and krill weight for biomass estimates Urgency: High	Medium	Dr Cox, Dr Wang	Yes
		(v) Biomass estimation methods Urgency: High (1) Establish Grym parameters for krill stock assessments in Areas 48 and 58 Urgency: High	Short	Dr Ying Mr Johannessen Dr Kawaguchi Dr Murase Dr Lowther	
		(vi) Account for spatial structure of krill Urgency: Medium	Short		
	(b) Develop stock assessments to implement decision rules for krill	(i) Krill management approach (synthesis of krill recruitment, spatial scale, biomass estimates, predator risk) Urgency: High (1) Subarea 48.1 (2022) Urgency: High (2) Subareas 48.2, etc… (2023/24) Urgency: Medium	Short/medium	Dr Kawaguchi Dr Watters	
		(ii) Develop diagnostic tools Urgency: Medium	Medium		

(continued)

Table 2 (continued)

Theme	Priority research topic	Priority research topic task	Timeframe	Contributors	Secretariat participation
		(iii) Develop ecosystem indicators to inform risk assessment framework Urgency: Low		Dr Warwick-Evans	
		(iv) Methods to account for uncertainty in stock status Urgency: Low (2) Spatial structure within subareas Urgency: High (3) Interannual variability Urgency: Low			
		(v) Develop krill management approach as a multiannual cycle Urgency: High		Dr Hill Dr Watters	
		(vii) Krill management strategies that are robust to climate change Urgency: Medium	Long	Dr Hill	
	(e) Management strategy evaluations for target species (Second Performance Review, Recommendation 8)	(iii) Finfish management strategies that are robust to climate change Urgency: Medium	Medium/Long	Dr. Devine	
		(iv) MSE for krill	Medium	Mr. Mardones Dr. Lowther Mr. Johannessen	
	(f) Krill Stock Hypothesis Information Collection Plan	See Table 1	See Table 1	See Table 1	

(continued)

Table 2 (continued)

Theme	Priority research topic	Priority research topic task	Timeframe	Contributors	Secretariat participation
2. Ecosystem impacts	(a) Ecosystem monitoring (Second Performance Review, Recommendation 5)	(i) Structured ecosystem monitoring programs (CEMP, fishery)	Short/medium	Dr Collins	
		(1) CEMP		Dr Hinke	Yes
				Dr Lowther	
				Dr Hill	
				Dr Waluda	
				Dr Santos	
				Dr Emmerson	
				Dr Makhado	
		(2) Fishery via SISO			
		Urgency: Medium			
		(ii) Ecosystem modelling Urgency: Low	Long	Dr Schaafsma Dr Pinkerton	
		(iii) Invasive species Urgency: Low	Long		
		(iv) Marine debris monitoring	Long	Dr Waluda	Yes
		Urgency: Low		Dr Schaafsma	
				Dr Makhado	
				Dr Emmerson	
				Dr Santos	

(continued)

Table 2 (continued)

Theme	Priority research topic	Priority research topic task	Timeframe	Contributors	Secretariat participation
	(b) Spatial management	(i) Science advice on proposals for a Representative System of MPAs Urgency: High (1) Current proposals Urgency: High (2) Future proposals Urgency: Low	Short/Medium Short	Prof. Koubbi Dr Teschke	
		(ii) the harmonisation and/or integration of different spatial management initiatives within Subarea 48.1, including the ARK voluntary restricted zones and the D1MPA proposal (SC-CAMLR-41, paragraph 3.65) Urgency: High		Dr Santos Mr Santa Cruz	
		(ii) Research and monitoring plans Urgency: High	Medium/Long	Dr Devine et al	
	(c) By-catch risk assessment for krill and finfish fisheries	(i) Monitoring status and trends Urgency: High	Medium		
		(ii) By-catch species catch limits Urgency: High		Dr Devine	
	(d) Habitat protection from fishing impacts	(i) Habitat classification, bioregionalisation and monitoring Urgency: Low			
		(ii) VME identification and management Urgency: Medium		Dr Eléaume Dr Teschke Dr Devine et al.	

(continued)

Table 2 (continued)

Theme	Priority research topic	Priority research topic task	Timeframe	Contributors	Secretariat participation
		(iii) Protection of biodiversity and ecosystems (Second Performance Review, Recommendation 7) Urgency: High (1) Ecosystem impacts from krill and finfish fishing, including analyses whether research and sampling design is able to detect such impacts Urgency: High (2) Physical disturbance of longline fishing on benthic ecosystems Urgency: Low (3) Suitability of reference areas for comparison between fished and unfished areas Urgency: Medium		Dr Hill Dr Hill	
	(e) Monitoring and adaptation to effects of climate change	(i) Develop methods to detect change in ecosystems given variability and uncertainty (Second Performance Review, Recommendation 6) Urgency: Medium	Medium	Dr Schaafsma Dr Dahlgren Dr Hill, Dr Collins, Dr Emmerson, Dr Waluda, Dr Knutsen	Yes
		(ii) Develop integrated ecosystem reporting (WG-EMM-2022, paragraph 2.18)	Medium	Mr Pardo Dr Cavanagh Dr Parker	Yes
		(iii) Develop mechanisms for integration in SC work		Mr Pardo Dr Cavanagh	

(continued)

Table 2 (continued)

Theme	Priority research topic	Priority research topic task	Timeframe	Contributors	Secretariat participation
	Administrative topics	(a) Advise on database facilities required through DSAG Urgency: High			Yes
		(b) Advise on quality control and assurance processes for data provided to and supplied by the Secretariat Urgency: High			Yes
		(c) Refine the scheme of international scientific observation (SISO) across all fisheries Urgency: Medium			Yes
		(d) Further develop data management systems Urgency: Medium (1) Quality assurance Urgency: High (2) DOI Urgency: Medium (3) Data access Urgency: Low			Yes
		(e) Communication of progress, internal and external Urgency: Medium			Yes
		(f) Working group terms of reference Urgency: Low			
		(g) Scientific Committee Symposium in 2027 Urgency: High			

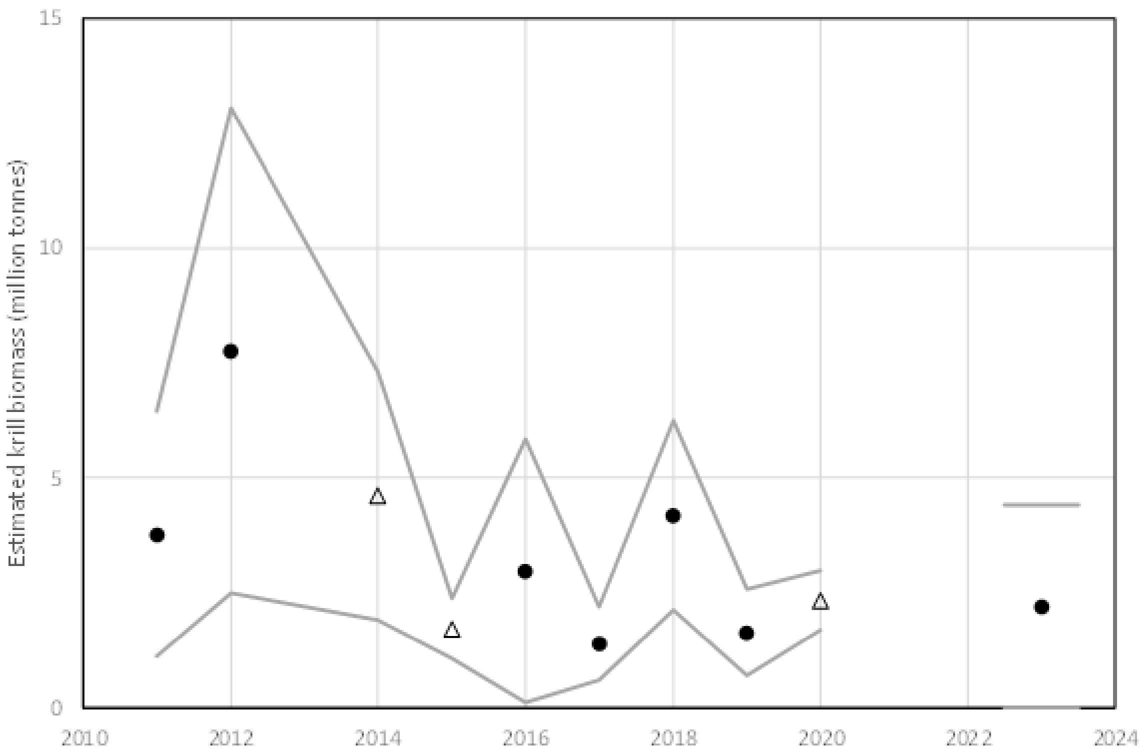

Figure 1. South Orkney Islands krill biomass estimates for 2011–2023. The grey lines mark the 95% confidence interval (±1.96 × standard deviation) around the mean based on the Jolly and Hampton estimator using the transects as the primary sampling unit. Years with swarm detection and integration done at 38 kHz are marked with triangles. The other estimates are based on 120 kHz data. The 2013 estimate is not included due to poor survey coverage. Redrawn from WG-EMM-2023/P01 with additional data from WG-EMM-2023/01.

Appendix A

List of Participants

Working Group on Ecosystem Monitoring and Management
(Kochi, India, 3 to 14 July 2023)

Chair	Dr César Cárdenas Instituto Antártico Chileno (INACH)
Argentina	Dr Emilce Florencia Rombolá Instituto Antártico Argentino
	Dr María Mercedes Santos Instituto Antártico Argentino
Australia	Dr Louise Emmerson Australian Antarctic Division, Department of Climate Change, Energy, the Environment and Water
	Dr So Kawaguchi Australian Antarctic Division, Department of Climate Change, Energy, the Environment and Water
Chile	Mr Francisco Santa Cruz Instituto Antartico Chileno (INACH)
Germany	Ms Patricia Brtnik German Oceanographic Museum
	Professor Bettina Meyer Alfred Wegener Institute for Polar and Marine Research
	Dr Katharina Teschke Alfred Wegener Institute for Polar and Marine Research
India	Dr Siva Kiran Kumar Busala Centre for Marine Living Resource and Ecology (CMLRE)
	Dr Sherine Sonia Cubelio Centre for Marine Living Resources and Ecology
	Dr GVM Gupta Centre for Marine Living Resources and Ecology

	Dr Kusum Komal Karati Centre for Marine Living Resources and Ecology
	Dr Hashim Manjebrayakath Centre for Marine Living Resources and Ecology
	Dr Rajani Kanta Mishra National Centre for Polar and Ocean Research, Ministry of Earth Sciences
	Dr Ravidas Naik National Centre for Polar and Ocean Research
	Mr Saravanane Narayanane Centre for Marine Living Resources and Ecology,
	Dr Sendhil Kumar R Centre for Marine Living Resources and Ecology
	Dr Anoop Kumar Tiwari National Centre for Polar and Ocean Research, Ministry of Earth Sciences
Italy	Dr Erica Carlig National Research Council (CNR) Institute for the study of the anthropic impacts and the sustainability of the marine environment (IAS)
Japan	Mr Tatsuya Isoda Institute of Cetacean Research
	Dr Hiroto Murase Tokyo University of Marine Science and Technology
	Dr Takehiro Okuda Fisheries Resources Institute, Japan Fisheries Research and Education Agency
Korea, Republic of	Dr Sangdeok Chung National Institute of Fisheries Science (NIFS)
	Dr Jeong-Hoon Kim Korea Polar Research Institute (KOPRI)
	Dr Eunjung Kim National Institute of Fisheries Science

	Dr Hyoung Sul La Korea Ocean Polar Research Institute (KOPRI)
	Mr Jeongseok Park National Institute of Fisheries Science
	Mr Sang Gyu Shin National Institute of Fisheries Science (NIFS)
Netherlands, Kingdom of the	Dr Fokje Schaafsma Wageningen Marine Research
New Zealand	Dr Clare Adams Ministry for Primary Industries
	Dr Jennifer Devine National Institute of Water and Atmospheric Research Ltd. (NIWA)
	Mr Enrique Pardo Department of Conservation
Norway	Mr Elling Deehr Johannessen Norwegian Polar Institute
	Dr Gary Griffith Norwegian Polar Institute
	Dr Tor Knutsen Institute of Marine Research
	Dr Bjørn Krafft Institute of Marine Research
Russian Federation	Dr Svetlana Kasatkina AtlantNIRO
South Africa	Ms Zoleka Filander Department of Forestry, Fisheries and the Environment
	Dr Azwianewi Makhado Department of Forestry, Fisheries and the Environment
	Dr Chris Oosthuizen University of Cape Town
	Mr Sobahle Somhlaba Department of Agriculture, Forestry and Fisheries

Ukraine	Mr Illia Slypko Institute of Fisheries and Marine Ecology (IFME) of the State Agency of Fisheries of Ukraine
United Kingdom	Dr Martin Collins British Antarctic Survey
	Dr Simeon Hill British Antarctic Survey
	Dr Oliver Hogg Centre for Environment, Fisheries and Aquaculture Science (Cefas)
	Ms Georgia Robson Centre for Environment, Fisheries and Aquaculture Science (Cefas)
	Dr Claire Waluda British Antarctic Survey
United States of America	Dr Jefferson Hinke National Marine Fisheries Service, Southwest Fisheries Science Center
Secretariat	Dr Steve Parker Science manager
	Dr Stéphane Thanassekos Fisheries and ecosystems analyst

Appendix B

Agenda for the Working Group on Ecosystem Monitoring and Management

(Kochi, India, 3 to 14 July 2023)

1. Introduction

   1.1 Opening of the meeting
   1.2 Adoption of the agenda and organisation of the meeting

2. Review Terms of Reference and workplan

3. Krill Fishery

   3.1 Fishing activities (updates and data)
   3.2 Scientific observation
   3.3 CPUE and spatial dynamics
   3.4 Fishing vessel surveys

4. Krill Fishery Management

   4.1 WG-ASAM advice and considerations of the krill fishery management strategy
   4.2 WG-SAM advice and considerations of the krill fishery management strategy
   4.3 Develop methods to estimate biomass for krill
      4.3.1 Data collection needs (SISO (recognising Observer Workshop), vessels)
      4.3.2. Biomass estimation methods (Grym parameters for krill stock model)
      4.3.3. Account for spatial structure of krill

   4.4 Develop stock assessments to implement decision rules for krill for subarea 48.1
      4.4.1 Synthesis of krill recruitment
      4.4.2 Spatial scale
      4.4.3. Biomass estimates
      4.4.4. Krill spatial overlap analysis

   4.5 Symposium on holistic approach to management in Subarea 48.1

5. Ecosystem monitoring and observation
   5.1 CEMP monitoring (1-day focus topic)
   5.2 Other monitoring data (marine debris)
   5.3 Review of CCAMLR research and monitoring design and implementation

6. Krill-based ecosystem interactions
   6.1 Krill biology, ecology and population dynamics
   6.2 Krill life-history parameters and population models
   6.3 Krill predator biology, ecology and population dynamics

7. Spatial management
   7.1 Data analysis supporting spatial management approaches in CCAMLR
   7.2 Integration of existing measures in spatial management approaches
   7.3 Research and monitoring plans for MPAs
   7.4 VME data and spatial planning approaches

8. Climate change and associated research and monitoring

9. Other business

10. Future work

11. Advice to the Scientific Committee and its working groups

12. Adoption of the report and close of the meeting

Appendix C

List of Documents

Working Group on Ecosystem Monitoring and Management
(Kochi, India, 3 to 14 July 2023)

WG-EMM-2023/01	Report on the annual Norwegian krill survey off the South Orkney Islands, 2023 B.A. Krafft, R. Pedersen, G. Zhang, S. Menze, A. Rasmussen, H. Skaar, J. Dale, M. Biuw, C. Oosthuizen and A. Lowther
WG-EMM-2023/02	The impact of how the early life cycle is physically represented on the modelled transport and retention of Antarctic krill Z.T. Sylvester, M.S. Dinniman, K.S. Bernard, S.E. Thorpe, V. Pham, A.C. Williams and C.M. Brooks
WG-EMM-2023/03	CCAMLR’s revised krill fishery management approach in Subareas 48.1 to 48.4 as progressed from 2019 to 2022 X. Zhao, M. Collins, G.M. Watters, P. Ziegler and the Secretariat
WG-EMM-2023/04	Spatial structuring in 0-group fish diversity in the Scotia Sea region of the Southern Ocean T. Dornan, T. Knutsen, B.A. Krafft, M. Kvalsund, A. Mateos-Rivera, G.A. Tarling, R. Wienerroither and S.L. Hill
WG-EMM-2023/05	Current krill sampling protocols followed by fishery observers undersample small krill and underestimate the proportion of juvenile krill caught D. Bahlburg, L. Hüppe and B. Meyer
WG-EMM-2023/06	Development of a krill stock hypothesis (KSH) for CCAMLR Area 48 – Report of the online workshop of the SCAR Krill Expert Group (SKEG), 20 to 24 March 2023 B. Meyer on behalf of the SKEG board and workshop participants
WG-EMM-2023/07	New Zealand research and monitoring in support of the Ross Sea region marine protected area: 2022–2023 update M. Pinkerton, C.I.M. Adams, E. Behrens, J. Devine, R. Eisert, B. Finucci, A. Grüss, S. Halfter, I. Hawes, B. Moore, J. Mountjoy, E. Pardo, E. Robinson, N. Robinson, C. Stevens and D. Thompson

WG-EMM-2023/08	First observation of a skate egg case nursery in the Ross Sea B. Finucci, C. Chin, H.L. O'Neill, W.T. White and M.H. Pinkerton
WG-EMM-2023/09	Research vessel Tangaroa 2023 Ross Sea Antarctic voyage, 15 January to 23 February 2023 J. Mountjoy and M. Pinkerton
WG-EMM-2023/10	Using the spatial population model (SPM) to assess the potential impacts of the Ross Sea region marine protected area for Antarctic toothfish (*Dissostichus mawsoni*) A. Grüss, M.H. Pinkerton, S. Mormede and J.A. Devine
WG-EMM-2023/11	On the issue of gear selectivity in relation to krill in the current CCAMLR topics S. Sergeev and S. Kasatkina
WG-EMM-2023/12	Comments on the management approach to krill fishery S. Kasatkina
WG-EMM-2023/13	Intra- and interannual variability in seasonal sea ice and krill fishery in Subareas 48.1 and 48.2 V. Shnar and S. Kasatkina
WG-EMM-2023/14	CCAMLR marine debris monitoring program, 2023 Secretariat
WG-EMM-2023/15 Rev. 1	Spatial distribution of the mesozooplankton community in the coastal polynyas of the Ross Sea region marine protected area (RSRMPA) during early summer S.-H. Kim, W. Son, J.-H. Kim and H.S. La
WG-EMM-2023/16	Preliminary steps for an atlas of macrozooplankton in the subantarctic Indian and in the South Indian Ocean P. Koubbi, M. Thellier, V. Djian, C. Merland and B. Leroy
WG-EMM-2023/17	Hydrologic regionalisation from Crozet to Kerguelen and subtropical southern Indian Ocean V. Djian, C. Cotté and P. Koubbi
WG-EMM-2023/18	Regionalisation of the physical and biogeochemical environment in the Southern Indian Ocean C. Merland, C. Azarian, F. d'Ovidio and C. Cotte
WG-EMM-2023/19	Withdrawn

WG-EMM-2023/20	Atlas of mesopelagic fish in the sub-Antarctic Indian and in the South Indian Ocean P. Koubbi, V. Djian, M. Vacchi, C. L. Rintz, B. Leroy, A. Walters, B. Serandour, E. Tavernier and REPCCOAI scientists
WG-EMM-2023/21	Macrozooplankton from Crozet to Kerguelen and subtropical southern Indian Ocean V. Djian, C. Merland, M. Thellier, B. Leroy, C. Cotte, P. Koubbi and REPCCOAI scientists
WG-EMM-2023/22	Determining the distribution of Antarctic krill and krill-dependent predators at South Georgia (Subarea 48.3) during winter C. Liszka, S. Calderan, T. Dornan, S. Fielding, M. Goggins, J. Jackson, R. Leaper, P.A. Olson, N. Ratcliffe, K. Owen, R. Irvine and M.A. Collins
WG-EMM-2023/23	Observer sampling rates in the krill fishery Secretariat
WG-EMM-2023/24	Summary of CCAMLR ecosystem monitoring program (CEMP) data holdings through the 2022/23 monitoring season Secretariat
WG-EMM-2023/25	Fish nest area in the southern Weddell Sea: Discussions and recommendations of CCAMLR-41 and a proposal for further action K. Teschke, R. Konijnenberg, P. Brtnik, L. Ghigliotti and M. Eléaume
WG-EMM-2023/26	British Antarctic Survey: Ecosystem Monitoring in Area 48 (2022/23) C. Waluda, S.E. Thorpe, T. Dornan, P. Hollyman, R. Saunders, A. Bennison, M. Dunn, J. Forcada, R.A. Phillips, N. Ratcliffe, G. Tarling and M.A. Collins
WG-EMM-2023/28	Report of the second training course of Chilean scientific observers on the CCAMLR F. Santa Cruz, L. Rebolledo, L. Krüger and C. Cárdenas
WG-EMM-2023/29	Tracking ecosystem changes in Western Antarctic Peninsula to inform CCAMLR decision-making: insights from the ongoing ecosystem monitoring programme in Ardley Island’s CEMP site. A. Soutullo, A.L. Machado-Gaye and N. Zaldúa

WG-EMM-2023/30	Crash and learn? An evaluation of potential conservation threats to South Shetland Island Antarctic fur seals amidst precipitous population collapse D.J. Krause, R. Brownell, C.A. Bonin, S.M. Woodman, D. Shaftel and G.M. Watters
WG-EMM-2023/31	Baseline spatial data prior to the ecoregionalisation of the eastern sub-Antarctic region A.B. Makhado, J. Huggett, F. Dakwa, N. Mdluli, F. Shabangu, P. Koubbie, C. Cotté, F. d'Ovidio, V. Djian, E. Goberville, L. Izard, A. Kristiansen, B. Leroy, C. Merland, C. Ly Rintz, M. Thellier, D. Thibault, K. Delord, C. Bost, E. Tavernier, C. Azarian, K. Swadling, J. Melvin, J. Kitchener, L. Brokensha, M.-A. Lea and A. Walters
WG-EMM-2023/32	Towards higher predator ecoregionalisation of the pelagic zone in the sub-Antarctic and subtropical Indian Ocean R. Reisinger, A.B. Makhado, K. Delord, C. Bost and M.-A. Lea
WG-EMM-2023/33	Next results of oceanographic research carried out on Ukrainian longline vessels in the CCAMLR area at the season 2022/23 V. Paramonov, L. Pshenichnov, R. Solod, A. Bazhan and P. Zabroda
WG-EMM-2023/34	Using two international synoptic surveys to test the predictive performance of krill habitat models in the Scotia Sea J. Freer, C. Liszka, S. Fielding, G. Tarling, S. Thorpe, S. Hill, B. Krafft and G. Macaulay
WG-EMM-2023/35	Evaluating sensitivity of the stock assessment tool for the Antarctic krill fishery to seasonal trends in natural and fishing mortality E.D. Johannessen, B.A. Krafft, C. Donovan, R. Wiff, B. Caneco and A. Lowther
WG-EMM-2023/36	Draft conservation measure for a Weddell Sea marine protected area – Phase 2 Delegation of Norway
WG-EMM-2023/37	Seabirds assemblages, abundance and distribution in the African sector of the southern Indian Ocean A.B. Makhado, R. Reisinger, M. Masotla, S.M. Seakamela, F. Shabangu and F. Dakwa
WG-EMM-2023/38	Zooplankton communities near the Prince Edward Islands – recent progress from image analysis J.A. Huggett, N. Mdluli and D. Thibault

WG-EMM-2023/39	Searching spatial–temporal changes in intrinsic productivity of Antarctic krill (*Euphausia superba*) in a fishery management context M. Mardones, G. Watters and C. Cárdenas
WG-EMM-2023/40	Identifying prey capture events in chinstrap penguins using accelerometer data and deep learning S. Schoombie, L. Jeantet, M. Chimienti, G. Sutton, P. Pistorius, E. Dufourq, A. Lowther and C. Oosthuizen
WG-EMM-2023/41	Unreliable inferences about chinstrap penguin population trends: a statistical critique and reanalysis C. Oosthuizen, M. Christian, A. Makhado and M. Ngwenya
WG-EMM-2023/42	The CCAMLR Ecosystem Monitoring Program – discussion points for a one-day special focus topic C.M. Waluda, S.L. Hill and M.A. Collins
WG-EMM-2023/43	Monitoring Antarctic breeding flying seabirds with nest cameras – a consideration for extending CEMP L. Emmerson, A. Lashko, M. Salton and C. Southwell
WG-EMM-2023/44	Grym assessment parameters for Divisions 58.4.1 and 58.4.2 *Euphausia superba* populations D. Maschette, S. Wotherspoon, H. Murase and S. Kawaguchi
WG-EMM-2023/45	Land-based monitoring of Antarctic breeding seabirds for krill fisheries management across East Antarctica by the Australian Antarctic Program L. Emmerson, C. Southwell, S. Kawaguchi, N. Kelly and P. Ziegler
WG-EMM-2023/46	Assessing phylodiversity spatial patterns of Southern Ocean fauna for biodiversity conservation A. Kondratyeva and M. Eléaume
WG-EMM-2023/47	Scientific evidence in support of the draft conservation measure for a Weddell Sea marine protected area Phase 2 Delegation of Norway
WG-EMM-2023/48	Applying the management strategy evaluation tool *openMSE* to the Antarctic krill fishery case E.D. Johannessen, B. Caneco, C. Donovan, R Wiff and A. Lowther

WG-EMM-2023/49	Summary of the dedicated sighting survey under the Japanese Abundance and Stock structure Surveys in the Antarctic (JASS-A) in four austral summer seasons (2019/20 to 2022/23) T. Isoda, T. Katsumata, Y. Kim, H. Murase and K. Matsuoka
WG-EMM-2023/50	Improve the understanding of population connectivity of Antarctic krill in CCAMLR Area 48 through multidisciplinary research Y. Zhao, Y. Ying, X. Wang, K. Liu, X. Mu and X. Zhao
WG-EMM-2023/51	Large-scale pelagic acoustic ecoregionalisation in the eastern part of the sub-Antarctic region F.E. Dakwa, F. Shabangu, L. Izard and A.B. Makhado
WG-EMM-2023/52	First records of *Chionodraco hamatus* nesting at Silverfish Bay (Terra Nova Bay, Ross Sea) E. Carlig, D. Di Blasi, S. Canese, M. Vacchi, S. Grant and L. Ghigliotti
WG-EMM-2023/53	Comparison of the density and distribution of krill larvae during the summer seasons of 2019 and 2020 in contrast with salps densities in the Mar de la Flota/Bransfield Strait and Elephant Island surroundings E. Rombolá, M. Sierra, F. Capitanio, C. Franzosi, W. Carhuapoma Bernabé, B. Meyer, C. Reiss and E. Marschoff
WG-EMM-2023/54	Opportunities for IWC-CCAMLR collaboration to contribute to CCAMLR's revised Krill Fishery Management approach N. Kelly, S. Parker, D. Maschette and C. Miller
WG-EMM-2023/55	Scientific use of the Sailbuoy unmanned surface vehicle to monitor Antarctic krill S. Menze, G. Skaret and B.A. Krafft
WG-EMM-2023/56	Chilean operation in the Antarctic krill fishery, years 2021 to 2022 P.M. Arana and R. Rolleri
WG-EMM-2023/57	Disentangling spatial and temporal patterns from multifrequency active acoustic data reveals pelagic structuring in the eastern sub-Antarctic region L. Izard, V. Djian, A. Kristiansen, E. Goberville and C. Cotté
WG-EMM-2023/58	Using CPR surveys to map distributions of trophically important subantarctic prey species K. Swadling, J. Huggett, L. Brokensha, E. Goberville, J. Melvin, J. Kitchener and P. Koubbi

Other Documents

WG-EMM-2023/P01	Antarctic krill (*Euphausia superba*) catch weight estimated with a trawl-mounted echosounder during fishing B.A. Krafft, L.A. Krag, R. Pedersen, E. Ona and G. Macaulay *Fish. Manag. Ecol.*, 30 (3) (2023): 323–331, doi: 10.1111/fme.12625
WG-EMM-2023/P02	Distribution and biomass estimation of Antarctic krill (*Euphausia superba*) off the South Orkney Islands during 2011–2020 G. Skaret, G.J. Macaulay, R. Pedersen, X. Wang, T.A. Klevjer, L.A. Krag and B.A. Krafft *ICES J. Mar. Sci.*, 0 (2023): 1–15, doi: 10.1093/icesjms/fsad076
WG-EMM-2023/P03	Ross Sea Research Planning Meeting Oct 3 to 5 2022, University of Colorado Boulder S. Stammerjohn, C. Brooks, G. Ballard, A. DuVivier and M. LaRue Published 2022, http://www.rosssearesearch.org/
WG-EMM-2023/P04	Sperm whales forage year-round in the Ross Sea region G. Giorli and M.H. Pinkerton *Front. Remote Sens.*, 4 (2023), doi: 10.3389/frsen.2023.940627
WG-EMM-2023/P05	CRITTERBASE, a science-driven data warehouse for marine biota K. Teschke, C. Kraan, P. Kloss, H. Andresen, J. Beermann, D. Fiorentino, M. Gusky, M.L.S. Hansen, R. Konijnenberg, R. Koppe, H. Pehlke, D. Piepenburg, T. Sabbagh, A. Wrede, T. Brey and J. Dannheim *Scientific Data*, 9:483, doi: https://doi.org/10.1038/s41597-022-01590-1
WG-EMM-2023/P06	Decreasing trends of chinstrap penguin breeding colonies in a region of major and ongoing rapid environmental changes suggest population level vulnerability L. Krüger *Diversity*, 15 (3) (2023): 327; doi: 10.3390/d15030327

WG-EMM-2023/P07	Contrasting environmental conditions precluded lower availability of Antarctic krill affecting breeding chinstrap penguins in the Antarctic Peninsula N. Salmerón, S. Belle, F. Santa Cruz, N. Alegria, J. Grohmann Finger, D. Corá, M.V. Petry, C. Hernández, C.A. Cárdenas and L. Krüger *Scientific Reports*, 13 (2023): 5265, doi: 10.1038/s41598-023-32352-7
WG-EMM-2023/P08	Phenology-based adjustments improve population estimates of Antarctic breeding seabirds: the case of Cape petrels in East Antarctica K. Kliska, C. Southwell, M. Salton, R. Williams and L. Emmerson *Royal Society Open Science*, 9 (2022): 211659, doi: 10.1098/rsos.211659
WG-EMM-2023/P09	Emerging evidence of resource limitation in an Antarctic seabird metapopulation after six decades of sustained population growth C. Southwell, S. Wotherspoon and L Emmerson *Oecologia*, 196 (2021): 693–705, doi: 10.1007/s00442-021-04958-z
WG-EMM-2023/P10	Environment-triggered demographic changes cascade and compound to propel a dramatic decline of an Antarctic seabird metapopulation L. Emmerson and C. Southwell *Glob. Chang. Biol.*, 28 (2022): 7234–7249, doi: 10.1111/gcb.16437

Appendix D

Protocol for length frequency measurements, sex and stage determination of Krill (*Euphausia superba*) on board fishing vessels using the continuous trawl pumping system.

Background:

Length measurements and sex and stage determinations of krill will provide data that gives insight into its demographic structure (proportion of juvenile and adult krill, sex ratio). By determining the sex and length of a random subsample of ~200 krill individuals, a representative picture of the targeted krill swarm`s demography can be drawn. Simultaneous collection of simple metadata on position, date, time of day, fishing depth and bathymetry, provides valuable insights into understanding krill distribution, behaviour, and life history across seasons and may contribute to managing the krill fishery.

Material:

- 3x Plastic buckets (~5 L volume), can be white or transparent (see example in figure 1)
- 2x Graduated measuring jugs (500 ml volume, see Figure 1)
- 1x Ladle 
- 1x Laminated millimetre paper (spanning at least 0 to 70 mm)
- Paper tissue
- 1x Stereomicroscope (requirements following CCAMLR recommendation)
- Set of forceps

Protocol:

Collecting Meta-Data:

On the continuous pumping trawlers, the krill take approximately 10 minutes (e.g. on the FV Antarctic Endurance) to travel from the mouth of the net through the pumping system to the dewatering location (ask the captain or one of the officers to get the exact time span of the continuous pumping trawler you are on, as this depends on the length of the hose). Metadata, including position, sampling date and time (UTC), should be noted on the bridge before taking a sample at the appropriate time when the krill reach the dewatering location.

On the traditional trawler, metadata including haul number, sampling date and time (UTC), must be collected before the sample is taken from the catch.

Sampling

Prior to the krill sampling procedure, have all the devices you need in place (see material above) and check the steps in Figure 1:

Three buckets, with two of them filled with cool surface seawater; two Graduated measuring jugs, a ladle.

When possible, krill should always be sampled from the same dewatering location (e.g. port side), where krill are pumped onto a wide grate, retained while the remaining seawater is pumped overboard and the krill continue into holding tanks.

- Three shovels of krill should be taken from three different spots on the grate, placed into a bucket that is not filled with seawater, and mixed gently without damaging the krill (see step 1 in Figure 1).
- From this bucket, one graduated measuring jug has to be filled to the ~200 ml mark with the ladle and the other one to the ~50 – 100 ml mark (see step 2 in Figure 1).
- The krill in each jug should be transferred to each separate buckets filled with cool surface seawater to prevent degradation of the krill (see step 3 in Figure 1).
- In the laboratory, place the bucket with the 200 ml krill, when possible, on ice and store the bucket with the backup subsample in a fridge (see step 4 in Figure 1).

The bucket with fewer krill numbers will be used as a backup sample in case the first bucket does not contain at least 200 krill. Have the laminated millimetre paper, forceps and paper tissue beside the stereomicroscope in place before starting the length-frequency measurements and sexing the krill.

On the Traditional trawler, the procedure of taking krill subsamples from the catch to be discussed on the KFO-workshop (WS-KFO-2023).

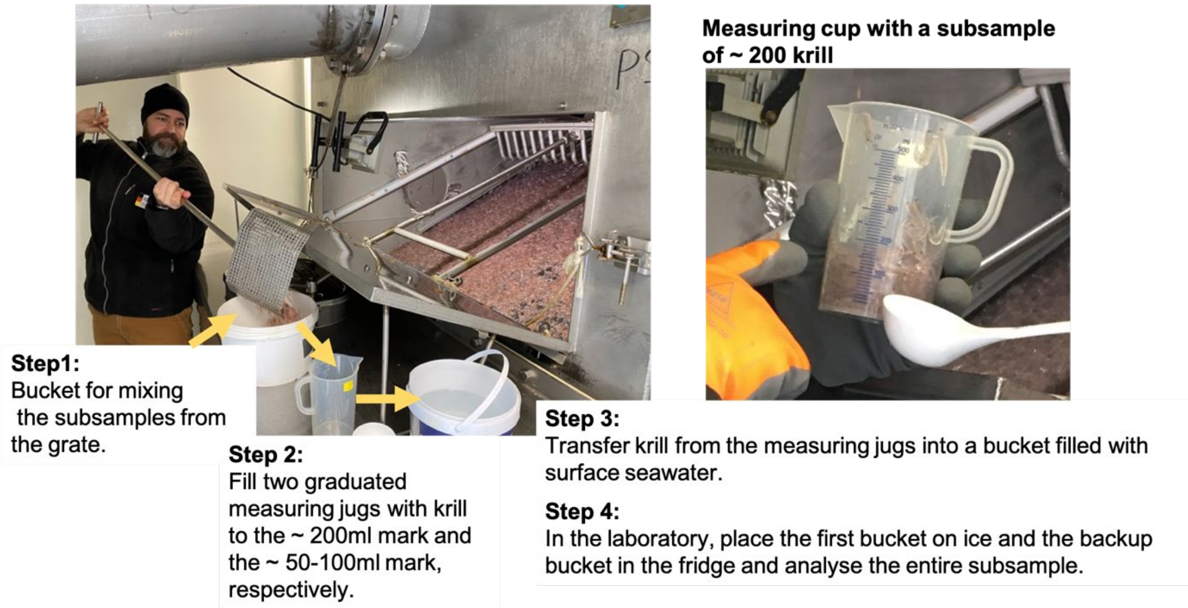

Figure 1: Procedure of krill sampling from the grate in the de-watering location.

Length-frequency measurements and sexing krill

To ensure a representative measurement of the length-frequency and sex distribution of the sampled krill, it is essential that always **all** krill individuals in a bucket are processed (length and sex determination), irrespective of the number of individuals in the bucket. Therefore, start with the bucket with the 200 ml krill and process **all** krill as described below. If all krill in this bucket are processed, and the number of krill is below 200, process **all** krill from the back-up bucket.

For each krill individual, determine and note the length and sex. To determine the length, take one individual with a forceps from the bucket and tap them a few times on the paper tissue to remove the water. Place the krill on the laminated millimetre paper (make sure the animal is stretched out horizontally), and measure the length from the anterior margin of the eye to the tip of the telson, excluding the setae (see Figure 2), to the nearest millimetre below.

To determine the sex, krill must be checked for the presence of the male and female copulatory organs, petasma and thelycum, respectively, under the stereomicroscope (see Figure 3 for positions). For this, place the individual on its back to look at it ventrally and check between the last pair of exopods for the thelycum (female copulatory organ; see Figure 4B for developmental stages of the thelycum). In addition, check the inner side of the first pleopod for the presence of a petasma (male copulatory organ; see Figure 4A and 4C for developmental stages of the petasma). Individuals with a petasma are classified as male and those with thelycum as female. If no petasma or thelycum can be found, krill are categorized as juvenile when smaller than 31mm and when larger than 31 mm as unknown

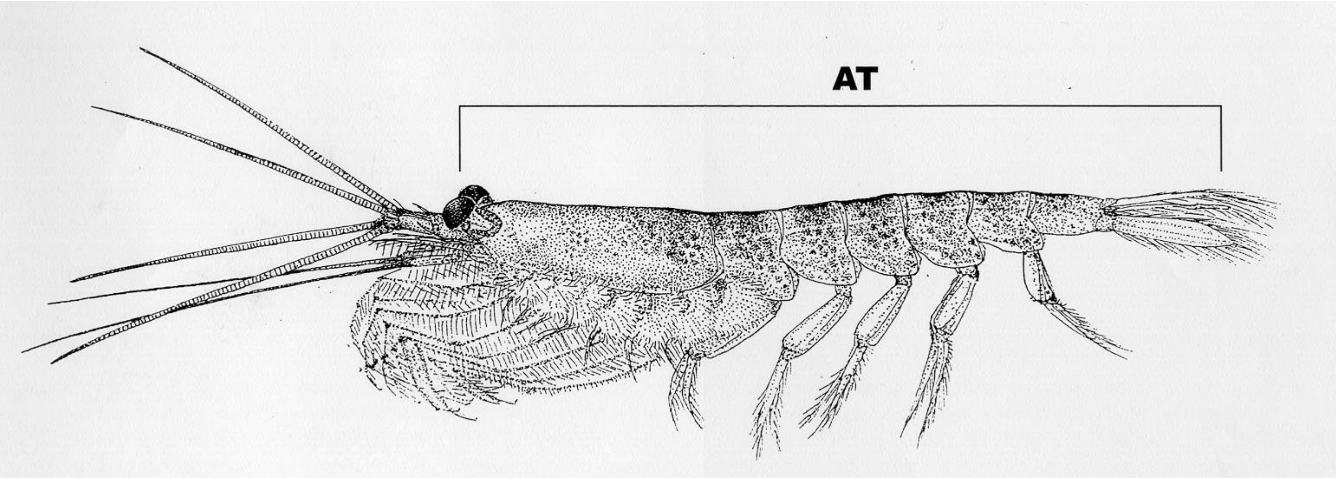

Figure 2: Method of length measurement of krill from the anterior margin of the eye to the tip of the telson, excluding the setae.

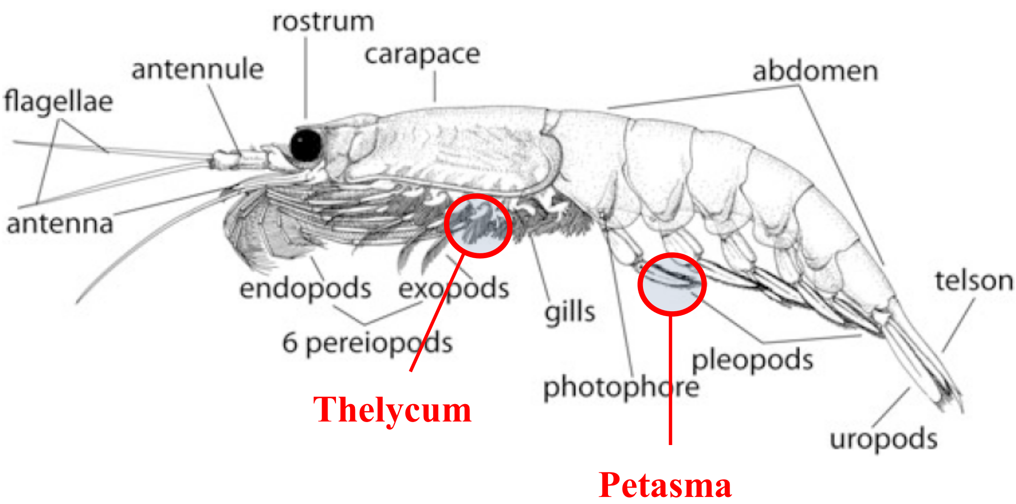

Figure 3: External morphology of *Euphausia superba*, depicting the position of male (petasma) and female (thelycum) copulatory organs (adapted after Siegel et al. (2016)).

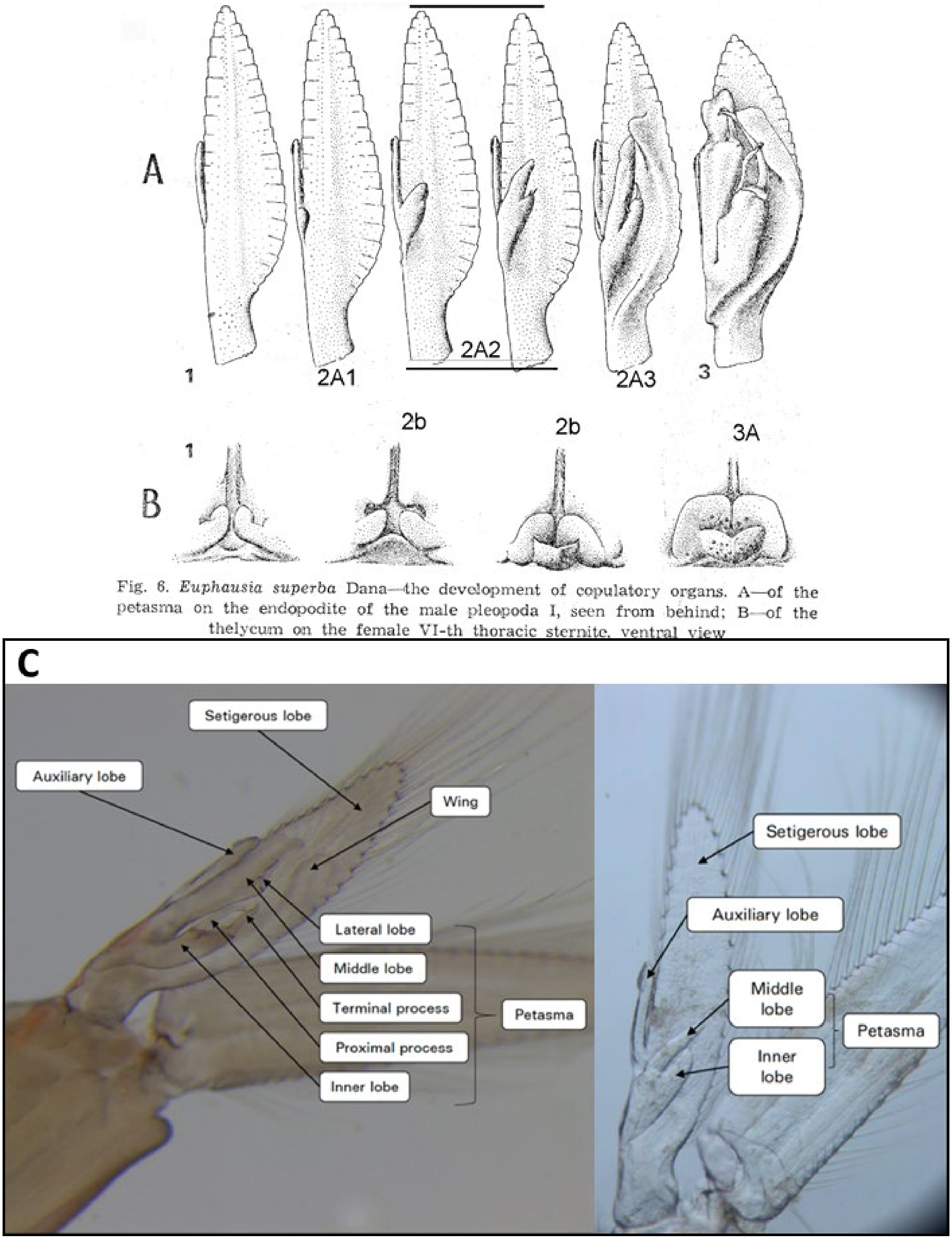

Figure 4: Developmental stages of the copulatory organs of *E. superba* after Makarov and Denys (1981). A) male petasma. B) female thelycum. C). Photos of first pleopods inner side, with petasma under the microscope (photo credit So Kawaguchi).

Appendix E

Title: Workshop on harmonisation of conservation measures in the Antarctic Peninsula Region

Objectives: Provide recommendations to CCAMLR for steps to harmonise the implementation of the revised krill fishery management approach and the establishment of the Domain 1 MPA in the Antarctic Peninsula Region, and recommendations for practical and cost-effective collection and analysis of data.

Terms of Reference:

<u>Part I: Continue discussion of CAMLR-41-BG/43 and terms of reference from e-group. This can occur within normal discussions under spatial management agenda items in both the Scientific Committee and Commission (See WG-EMM-2023 paragraph 4.45).</u>

1) Provide a forum to bring together SC-CAMLR and CCAMLR delegates, representatives from the krill fishing industry, and other CCAMLR observers with relevant expertise in ecosystem and fisheries research and monitoring, climate change, conservation and resource management, and operations in the krill fishery to progress conservation in the Antarctic Peninsula region.

2) Promote understanding within CCAMLR (WGs, SC, Commission and observers) of the current spatial management initiatives in the region, including:

a. the needs for developing a revised krill fishery management approach, including the state of knowledge of krill population in Area 48,

b. proposed management units for distributing catch limits in the krill fishery in Subarea 48.1, and the D1MPA, including the ARK VRZs,

c. that the Commission may need to revise several Conservation Measures related to the krill fishery in the region.

<u>Part II: Science workshop to develop scenarios</u>

3) Provide recommendations to CCAMLR for steps to harmonise the implementation of the revised krill fishery management approach and the establishment of the D1MPA in the Antarctic Peninsula Region.

4) Provide recommendations for practical and cost-effective collection and analysis of data and status indicators to support periodic CCAMLR decisions in the region including:

a. priority elements of an RMP pertaining to the krill-based ecosystem for the Domain 1 MPA,

b. the development of a data collection plan for the krill fishery, including data collected within the CCAMLR Ecosystem Monitoring Program (CEMP), standardised at-sea krill predator observations, as well as data to allow regular updates to krill biomass estimates, stock assessments, spatial-overlap analyses, and monitoring of reference areas as well as data standardisation.

c. Identifying contributions by national programs, the fishing industry, e.g., autonomous platforms and remote-sensing.

Host: TBD
Convener(s): TBD
Venue: TBD, possibly alongside WG-SAM-2024
Date: Prior to EMM-2024
Duration: 5 days
Invited experts: Yes
Observers or external organisations: CCAMLR observers
Funding required by CCAMLR: TBD
Secretariat Support required: Yes
Ability to submit papers: Yes
Output: Chair’s report
Reported to: Scientific Committee

Report of the Working Group on Incidental Mortality Associated with Fishing 2023 (WG-IMAF-2023)

(Hobart, Australia, 5 to 10 October 2023)

Contents

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Report of the Working Group on Incidental Mortality Associated with Fishing 2023 (WG-IMAF-2023)
(Hobart, Australia, 5 to 10 October 2023)

Opening of the meeting

Introduction

1.1 The meeting of the Working Group on Incidental Mortality Associated with Fishing (WG-IMAF) was held in Hobart, Australia, from 5 to 10 October 2023.

1.2 The Co-convenors, Dr M. Favero (Argentina) and Mr N. Walker (New Zealand) opened the meeting and welcomed participants.

Adoption of the Agenda

1.3 The provisional agenda for the meeting was discussed and adopted with minor amendments (Appendix A).

1.4 The participants thanked Dr Favero and Mr Walker for their work in preparing for the meeting.

1.5 Dr D. Agnew (Executive Secretary) welcomed all participants to the CCAMLR Secretariat. He looked forward to 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.

1.6 The report was prepared by J. Barrington (Australia), J. Clark (Norway), S. Kawaguchi (Australia), E. O'Shea (Secretariat), E. Pardo (New Zealand), R. Phillips (UK), C. van Werven (Secretariat), and Y.P. Ying (China) and includes a List of Registered Participants (Appendix B) and a List of Documents considered at the meeting (Appendix C).

1.7 In this report, paragraphs that provide advice to the Scientific Committee have been highlighted. A list of these paragraphs is provided in Item 10.

Review of incidental mortality in CCAMLR fisheries

2.1 WG-IMAF-2023/12 presented the important progress achieved by CCAMLR in addressing seabird incidental mortality in longline fisheries, as well as the challenges still to be faced to address seabird and marine mammal incidental mortality to the same level of effectiveness in more complex CCAMLR trawl fisheries. The paper reviews key considerations in addressing incidental mortality of seabirds and marine mammals in CCAMLR fisheries, identifying key issues that may require attention such as underestimations due to cryptic mortality, the need of accounting for spatial and temporal stratification of the fishing effort, incidental mortality analysis at a smaller scale than currently used, the potential concentration of observations in high risk areas/periods and the resultant impacts on extrapolation analyses, matters requiring further monitoring and advice on urgent issues, such as the use of net monitoring cables in continuous trawlers and cetacean interactions, and mitigation measures.

2.2 The Working Group reflected on the importance of relating observed interactions and incidents to the behaviour and ecology of species, so that this information could be correctly interpreted and used to improve the mitigation of incidental mortality.

2.3 The Working Group noted that information only based on surface observation of pinnipeds' interaction with trawl nets does not necessarily help to understand their interaction underwater, and does not account for cryptic mortality, underscoring the need for underwater observation. The Working Group further noted the importance of recording bird warp strike severity for estimating cryptic mortality and obtaining more accurate extrapolation figures.

2.4 WG-IMAF-2023/02 presented an analysis of bycatch data collected by SISO observers during the 2010-2020 fishing seasons on the Antarctic krill fishery, with 20 (± 9%) coverage of fishing activity of total catch of Antarctic krill analysed. The catch increased from 200,000 tonnes to 450 000 tonnes, with the greatest increase over the last 3 years. Except in 2010 (2.2%), the bycatch ratio was stable and ranged 0.1–0.3%. Fish dominated the bycatch, followed by tunicates and other crustaceans. The paper reports that the observer coverage was high, and bycatch levels were generally low across gear types. Given that accurate information on bycatch is important for sustaining developing fisheries, the paper states that maintaining high observer coverage in this fishery will be important for detecting impacts from a warming climate and for moving back into historical fishing grounds.

2.5 The Working Group noted that this study describes bycatch not only of fish and crustacea, but for a wide range of taxa, although excluding incidental mortality of seabirds and marine mammals. While appreciative of the information presented, the Working Group further noted that the subject matter of the paper was of more relevance to WG-FSA and encouraged the authors to present the paper at WG-FSA-2024.

2.6 WG-IMAF-2023/03 Rev. 1 presented a summary of incidental mortalities of seabirds and marine mammals associated with fishing during the 2023 fishing season from data reported by the vessels and SISO observers. It also presented a draft method for the extrapolation of IMAF and warp strikes based on a spatial (40 000 km^2 or 200 x 200 km grid cells) and temporal (month) aggregation of records rather than on a per-vessel-cruise basis, as has been done previously. The total per-vessel-cruise extrapolated figures for longline fisheries is 132 seabirds caught as of 2 October 2023, higher than 2022 (15), but lower than in 2021 (142). Twelve elephant seals and one unidentified seal were also recorded as marine mammal incidental mortalities in longline fisheries.

2.7 The Working Group welcomed the information presented by the Secretariat, noting the utility of the information presented for understanding where seabird and marine mammal interactions with fisheries were occurring. The Working Group made the following recommendations regarding the draft methods in the paper to the Secretariat for future analyses:

(i) The spatial scale of 40 000km^2 used to present the results of the analyses was considered appropriate. The Working Group reflected that it would also be useful to explore a way to query the dataset to allow data to be extracted interactively at different spatial resolutions, as this may provide more detailed information on individual species.

(ii) Using an extrapolation approach to raise observed cetacean mortalities was not considered to be appropriate, as detection of cetacean entanglements eventually becomes obvious to both vessel crews and observers.

(iii) The observation period for extrapolating from observed IMAF events (eq. 1) should include the total time the net is in the water, as the Working Group noted the importance of clearly defining the unit of observation effort to undertake extrapolation of IMAF data.

(iv) Future versions of extrapolations should include estimates of uncertainty and the Working Group recommended the Scientific Committee task WG-SAM with undertaking approaches to estimate uncertainty.

2.8 With regard to the extrapolation of IMAF events (paragraph 2.7 (iv)), the Working Group considered that the temporal period of an IMAF observation is from the net entering the water until the net is retrieved on board the vessel, and noted that for continuous trawl vessels this period can extend for many days, rather than a single two-hour fishing period.

2.9 The Working Group drew attention to the lack of strikes reported for conventional trawlers in recent years and underscored the need to understand reasons for this result.

2.10 The Working Group recommended to the Secretariat that future iterations of the paper include a column indicating (i) the overall percentage of warp strike observation effort for each trawl vessel, and (ii) the total number of hauls for which IMAF data was recorded (defined in paragraph 2.7 (iv)), so that observer coverage is more easily comparable across all vessels in the fleet.

2.11 The Working Group recalled that warp strike severity will be recorded by observers (SC-CAMLR-2022, paragraph 5.11) from season 2024, and requested the Secretariat include these estimates in future paper revisions.

2.12 The Working Group noted possible underestimation of extrapolated strikes, as observers are instructed to only observe the warp on the side of the vessel from which any discharge takes place, and the extrapolated method does not scale up estimates for the total number of warps used by a vessel. However, the Working Group reflected that as observations are made on the warp on the high-risk side (i.e., where offal is discharged), any underestimation may not be as low as 50%. The Working Group further noted that the number of warps per net could be extracted from the gear information submitted with the fishery notifications if any scaling factor were to be applied.

2.13 The Working Group noted that it was complex to account for differing warp strike risk levels. The Working Group considered that it would be too onerous to request observers to track the trawl phases and risk periods throughout fishing activities.

2.14 The Working Group noted that historical data on bird abundance around trawl vessels have been recorded by observers for certain taxa during warp strike observation periods, and such data may be useful to estimate risk levels for species interacting with trawl fisheries and the relative probability of incidents. However, the Working Group reflected that the collection of such data involved considerable time allocation for observers.

2.15 The Working Group further noted the importance of data quality and acknowledged that there are limitations in types of data that can be collected by the current observer program due to its purpose. Therefore, to effectively collect data from the observer program it is important to identify the issues and develop a set of priority research questions to address, which could be tasked to intersessional work programs to develop.

2.16 WG-IMAF-2023/10 presented a summarised history of the issue of juvenile humpback whale mortalities in the continuous krill trawl fishery, and of the assistance provided by the IWC's Non-deliberate Human Induced Mortalities subcommittee for the development of a draft data collection form for cetacean incidental mortality events in the krill fishery. The draft data form in this paper reflects the recommendations made by the WS-KFO-2023 and ready for consideration by the Working Group.

2.17 The Working Group noted that many of the data fields for 'Basic Fishery/Haul Data' and 'High-level incident data' in the draft data collection form could be retrieved from data recorded in C1 and/or Observer Form.

2.18 The Working Group recommended the Scientific Committee endorse the inclusion of a dedicated cetacean data collection form for SISO observers to complete in the event of a cetacean mortality.

2.19 The Working Group further recommended the Secretariat engage with the IWC task group (Intersessional task 2.1, WG-IMAF-2022, Table 1) and Members to finalise the form and associated data collection instructions through the SISO e-group.

Marine mammal incidental mortality

3.1 WG-IMAF-2023/15 presented an analysis of the interaction between Antarctic fur seals and krill trawling gear. Antarctic fur seals exhibited distinct behavioural modes when the trawl net was retrieved on sea surface, which is the period of highest incidental mortality risk. Behaviour appeared to depend on the vertical distribution of the krill swarm and level of krill recruitment (proportion of small krill). The paper considers that when krill recruitment is low and krill swarms are mainly in deeper waters, fur seals are more aggressive towards the trawl and hence more vulnerable to incidental mortality.

3.2 The Working Group welcomed the paper and noted the plans for further studies and potential for coordination of studies on fur seal behaviour with other ongoing studies in Subarea 48.3 (WG-EMM-2023, paragraphs 6.1 to 6.6). The Working Group agreed on the advantages of using video monitoring to improve understanding of fur seal interactions with the trawling gear, and encouraged the authors to examine the relationships with fur seal behaviour on a haul-by-haul basis, noting that such analyses are in progress and are taking advantage of new acoustic approaches to characterise krill swarms developed by WG-ASAM.

3.3 The Working Group had a brief discussion on potential move-on rules for vessels if there is a high level of interaction between fur seals and fishing vessels. The Working Group noted that the design and implementation of such rules would be complex.

Incidental mortality and risk assessments of
marine mammals in CCAMLR fisheries

3.4 WG-IMAF-2023/P01 (updated since WG-EMM-2023/30; WG-EMM-2023 paragraphs 6.7 to 6.10) presented an evaluation of threats to the subpopulation of Antarctic fur seals at the South Shetland Islands, which is the most southerly breeding population, is genetically distinct, and in steep decline. The decline was attributed largely to predation by leopard seals. Resource competition and potential incidental mortality in krill fisheries were among the threats classified as serious. The authors suggested that consideration be given to how krill fishing could be managed to minimise the threats, including the progression of the CCAMLR Krill Spatial Overlap Analysis, a re-evaluation of the protection provided by the D1MPA, inclusion of the South Shetland Islands fur seal subpopulation in the "harmonisation" discussion, and the adoption of time-area closures of krill fishing in the main area used by dispersing juvenile fur seals from April to September.

3.5 The Working Group welcomed this paper which provided a review of potential risk factors for this declining subpopulation. The authors clarified that the threat of disease from Highly Pathogenic Avian Influenza Virus (HPAI) was not currently affecting the sub-population, but considered it likely to do so in the near future, and that the death of a small number of female fur seals could have a major detrimental impact on the subpopulation. The Working Group noted that a fur seal mortality has not been recorded in Subarea 48.1 since 2010 (Krill Fishery Report 2022, Table 7). The provenance of fur seals killed to date in the Area 48 krill fishery has not been determined, hence it is unknown whether any incidental mortalities are from this subpopulation.

3.6 The Working Group considered whether competition with recovering cetacean populations may have been partly responsible for the seal population decline, and noted that the study indicated that this was unlikely because the fur seal population initially increased at the same time as cetacean numbers. The Working Group also noted the possibility that marine debris may be impacting this subpopulation, given its common occurrence on beaches around the breeding site at Cape Shirreff.

3.7 The Working Group discussed potential threats from the krill fishery, and welcomed the presentation from the authors during the meeting of satellite tracking data to evaluate potential overlap with krill fishery operations. The Working Group noted that the population decrease was not attributed to the krill fishery, but the authors considered that a temporary time-area closure could be instituted on a precautionary basis as the fur seal recruitment rate was very low, indicating high juvenile mortality after weaning. The area proposed by the authors during the meeting is bounded by a polygon from 61.9°S, 66.5°W to 59.2°S, 56.2°W to 60.8°S, 54.0°W to 63.6°S, 64.2°W, with an overall extent of 560 500 km^2 (Figure 1), with time of closure from April to June.

3.8 Some participants noted that the new krill management plan, when implemented, may result in vessels shifting fishing effort to the north of South Shetland Islands, which would increase the spatial overlap with juvenile fur seals (tracked post-weaning). It was clarified that the proposed temporary closure of the area would be reviewed if the new krill management strategy is implemented, taking account of the potential risk to juvenile fur seals.

3.9 To further inform the discussion on the proposed temporary closure area, the Working Group requested a presentation from the Secretariat on catches and trawling effort both within and outside of the closure area from 2000 to 2023 (Figure 1). The Working Group noted that catches and effort within the proposed closure area had declined in the last decade, and represented only a small fraction of current overall effort and catches in Subarea 48.1.

3.10 There was considerable discussion in the Working Group on the potential implementation of a temporary krill-fishing time-area closure to minimise overlap with juvenile fur seals from the South Shetland Islands. However, the Working Group could not reach consensus on the proposed closure and requested further discussion on the proposal.

Data collection needs from marine mammal interactions

3.11 WG-IMAF-2023/08 presented draft protocols for pinniped identification, sexing, and length measurement, designed to improve assignment of seal mortalities in fisheries to different species, sexes and age classes, as requested in the WG-IMAF-2022 work program. The authors indicated their intention to expand the guide to other pinnipeds that might be captured incidentally in CCAMLR fisheries, and suggested that once completed, the guide should be provided to all SISO observers, and the sex and length fields be added to the data collection forms.

3.12 The Working Group thanked the authors for the work and made the following suggestions for improvements:

(i) Photos in the guide should include some of dead animals to aid identification. The Secretariat noted that these could be obtained from previous photographs of seal incidental mortalities in observer reports with permission.

(ii) Photographs of juveniles and information on how to determine age class (e.g. from body length or other characteristics) should be included.

(iii) Inclusion of species-specific pictures for sexing seals instead of stylised illustrations, and pictures of teeth from each species and sex, would be helpful for the observers.

3.13. The Working Group recommended to the Scientific Committee that the following changes should be made to the observer data collection forms:

(i) “Band” on the observer form should be changed to “Band/tag” as seals are marked with flipper tags, and formerly with brands.

(ii) Additional categories should be added to the “Samples taken” field in the trawl observer forms that are appropriate for seals.

3.14 The Working Group noted advice from the Secretariat that the next opportunity to implement updated observer forms is for the 2025 season. The Working Group recommended that discussion should take place between interested members intersessionally within the SISO e-group to refine both the contents of the guide and the observer forms.

3.15 The Working Group recognised the value of collecting samples for assigning genetic provenance for seals, but noted that this needs to be associated with guidance on minimising the associated human health risk. This applies to handling of seal carcasses in particular. The Working Group also noted the considerable amount of paperwork required to obtain a permit to import CITES-listed species, and that this may require that samples are stored on vessels for long periods (WG-IMAF-2022, paragraph 4.13).

3.16 The Working Group recommended that guidelines developed by ACAP concerning the risk of transmission of HPAI from seabirds and seals should be provided to fishing vessel crew and observers, and requested that the Secretariat collate and circulate these materials.

3.17 WG-IMAF-2023/10 presented a draft data collection form in the event of incidental mortality of cetaceans in the krill trawl fishery. This is an adapted version of the form provided by the US Marine Mammal Commission, and takes account of further amendments suggested by the IWC-SC and CCAMLR Krill Fishery Observer Workshop (SC-CAMLR-42/05). The paper also confirmed that the Intersessional Correspondence Group of the IWC-SC on cetacean incidental mortality in the krill trawl fishery had been reconvened to assist in refining the cetacean mortality data collection form and, in the longer term, providing advice for krill trawling operators to minimise cetacean entrapments, and refining designs of the marine mammal exclusion cetacean device.

3.18 The Working Group thanked the authors and IWC-SC, specifically, the subcommittee on Non-deliberate Human Induced Mortality of Cetaceans (HIM), for their work in developing the form, and noted the benefit of this collaboration with the IWC. The Secretariat noted that data in the categories of "Basic Fishery/Haul Data", "High-level Incident Data" were already included in SISO forms, and suggested that the other aspects of data recording and sample collection should be included as a standalone form given the rarity of cetacean incidental mortality.

3.19 Using this guidance, the Working Group discussed a draft form for the collection of cetacean mortality data, and recommended that the Secretariat undertake work through the relevant SISO e-group and experts to finalise forms and training material for the 2024 fishing season.

Mitigation methods for marine mammals

3.20 WG-FSA-2023/72 presented progress in developing the CCAMLR gear library for the collation of detailed information on fishing gear configuration, including marine mammal exclusion devices. Currently just two fields; "type" (two options) and a diagram are available for recording information on the exclusion devices, and the level of detail on those already in use is highly variable. The paper also presented new, generic diagrams that should improve consistency on how aspects of trawl gear are described, and on other aspects of the gear library.

3.21 The Working Group welcomed the development of the gear library, noting the utility of the generic gear diagrams as they highlight which fields are currently reported in the C1 form and gear notifications, and which information is not currently captured.

3.22 The Working Group reflected that although a marine mammal exclusion device is a mandatory requirement in CCAMLR fisheries (Conservation Measure 51-01, paragraph 7), there is no CCAMLR specification of what constitutes a marine mammal exclusion device. The Working Group discussed a list of data fields that would be useful to specify marine mammal exclusion devices (Appendix D) and requested the proposed trawl vessel workshop (SC-CAMLR-2022, Table 1) consider including such fields in vessel notifications or a revised C1 form.

3.23 The Working Group further noted that observers are requested to verify if notification details on gear are accurate, and considered whether observers may be able to provide details on seal and cetacean exclusion devices to better understand the variety of designs employed by vessels.

3.24 The Working Group recommended to the Scientific Committee that cetacean exclusion devices and seal exclusion devices be described in separate forms within the Fishery Notification, as they represent two distinct mitigation measures.

3.25 The Working Group requested that the proposed trawl vessel workshop (SC-CAMLR-2022, Table 1) consider the addition of fields in any redesigned C1 form, to define and link net configurations and marine mammal excluder devices to the trawl nets used for a particular fishing event.

3.26 WG-IMAF-2023/01 provided an update on the net monitoring cable and cetacean mitigation devices on Norwegian continuous krill trawl vessels. The cetacean exclusion device has been moved to the mouth of the net, the tension has been increased and a seal-exclusion device is also fitted behind the cetacean exclusion net. Banana pingers continue to be used, but whether these are a deterrent or a potential attractant for baleen whales is unknown. The authors concluded that the original design of the cetacean exclusion device was not effective as it was fitted too far into the body of the trawl net. No mortalities were reported during the 2023 season, and there were no observations of marine mammals coming into contact with the net.

3.27 The Working Group welcomed the development of the cetacean exclusion device and noted the discussion in SC-CAMLR-42/BG/34, which indicated that the IWC-SC considered that the cetacean exclusion device currently on the Norwegian vessels may not be effective for humpback whales, as they are known to become entangled in static nets. The Working Group also noted that the IWC-SC had discussed the observation that, during a study in January/February 2023 on board a Norwegian continuous krill trawler around the South Orkney Islands, humpback whales were the most commonly observed species in close proximity to the vessel. These animals were frequently observed actively approaching the vessel or following at distances apparently consistent with the distance from the vessel to the trawl mouth, and all individuals observed following the vessel for extended periods were small, suggesting they were juveniles. These observations are consistent with the entanglements that have been reported in CCAMLR fisheries.

3.28 The Working Group encouraged Members to develop systems such as underwater cameras, mechanical sensors such as a stretch sensor, and acoustic systems to detect cetaceans, as these may determine their proximity and behaviour if encounters with the trawl net occurred. The Working Group also encouraged further research into the behaviour of cetaceans around krill trawl operations, which could include video observations and short-term tag deployments to record high-resolution 3D movement data.

3.29 WG-IMAF-2023/09 presented further development of seal exclusion devices for conventional krill trawlers. This included in situ observation of the device during the high-risk period when the net is on the surface. The paper recommended (i) the use of strengthening ropes

(6 cm thick) to maintain the shape of net openings and enhance visibility of the escape windows for seals, and (ii) that the total area of any escape opening(s) should cover more than 2/3 of the top trawl net panel.

3.30 The Working Group welcomed the developments concerning seal exclusion devices, and requested that video be provided of seals escaping through the net openings if it becomes available to examine seal behaviour.

Seabird incidental mortality

4.1 WG-IMAF-2023/11 presented a global analysis of the overlap of ACAP Priority Populations of albatrosses and petrels with the fisheries of RFMOs and Range States. ACAP covers 31 species of albatrosses and petrels. Among the breeding populations of these species, ACAP has identified nine ACAP High Priority Populations that: (a) represent a sizeable proportion (>10%) of the global total for the species; (b) are declining rapidly (>3% per annum); and (c) are declining mainly because of incidental mortality in fisheries. There are seven ACAP High Priority Populations that overlap with CCAMLR waters: Wandering Albatross, Grey-headed Albatross and Black-browed Albatross (South Georgia), Tristan Albatross (Gough Island), Sooty Albatross (Crozet Islands), Indian Yellow-nosed Albatross (Amsterdam Island), and Antipodean Albatross (Antipodes Islands).

4.2 The Working Group recognised that continued efforts to minimise seabird incidental mortality should remain a high priority, as even small levels of incidental mortality of the affected species can result in population declines.

4.3 The Working Group recommended that the Scientific Committee consider:

(i) improving engagement and coordination among Members, and with ACAP Parties, before and during relevant regional fisheries meetings

(ii) emphasising CCAMLR's performance history at relevant regional fisheries meetings, given that CCAMLR's seabird incidental mortality mitigation efforts in demersal longline fisheries are an exemplar of best practice and what can be achieved.

4.4 WG-IMAF-2023/14 presented an analysis of the overlap of White-chinned Petrel, *Procellaria aequinoctialis* and fisheries as a proxy for incidental mortality. The White-chinned Petrel is listed by ACAP and considered as Vulnerable by IUCN. The overlap analysis of the species' populations with CCAMLR fisheries facilitates targeting of mitigation efforts in 'risk hotspots' for this commonly bycaught species.

4.5 The Working Group noted the value of identifying risk hotspots for threatened seabird species, as this may facilitate improved management measures.

Population status of seabirds in the CAMLR convention area

4.6 WG-IMAF-2023/06 presented an update from ACAP about the development of best practice measures and guidelines for fisheries and populations. Species assessments are being updated for the 31 ACAP albatross and petrel species, and ACAP's advice on population levels and trends will be updated in 2024. ACAP High Priority Populations were a focus of discussions, including the analysis provided in WG-IMAF-2023/11. ACAP now strongly discourages the use of high-energy laser technologies for seabird incidental mortality mitigation, as there is currently no evidence of effectiveness, and serious concerns remain in terms of the potential impacts on the health of individual birds. ACAP has developed new protocols about the impact of HPAI on seabirds, and is monitoring the likely spread of this disease to albatross and petrel breeding populations. The disease affects both seabirds and marine mammals, and poses a risk to human health.

4.7 The Working Group noted that best practice mitigation advice is not available for krill continuous trawling, and that CCAMLR is well-situated to provide ACAP with advice about the specification of mitigation measures used in this fishery and the effectiveness of these measures. The Secretariat advised that it was not aware of any use of lasers in CCAMLR fisheries.

4.8 The Working Group noted the benefit of collaboration with ACAP to:

(i) develop and refine mitigation measures to reduce the incidental mortality of seabirds in continuous trawl fisheries

(ii) provide CCAMLR with guidance for fishing and research vessels operating in the Convention Area about HPAI on handling of bycaught seabird and marine mammal species.

Seabird incidental mortality and risk assessments in CCAMLR fisheries

4.9 WG-IMAF-2023/12 was presented in Agenda Item 2 (paragraph 2.1).

4.10 WG-IMAF-2023/05 presented a review of CCAMLR warp strike protocols against ACAP recommended protocols. The Working Group noted that existing ACAP guidance could be reviewed considering additional variables are collected in CCAMLR fisheries.

4.11 The Working Group recommended that the Secretariat work intersessionally with Members to:

(i) refine observer the instructions to clarify the definition of aerial or sea surface strikes (as detailed in Appendix E)

(ii) develop guidance for observation protocols to include other fishing gear used during continuous trawling that may result in seabird strikes

(iii) cooperate with ACAP to review the existing ACAP guidance about warp (and any other fishing gear) strike observation protocols for conventional and continuous trawl fisheries.

4.12 WG-IMAF-2023/16 presented a power analysis to estimate required observation rates for range of simulated strike rate values, and credible detection limits. The results indicated that for high-frequency warp strike rates (e.g., 0.1 or 0.05 strikes per hour) the current observation rates were adequate to detect changes beyond a presumed strike rate, as well as within the 95% credible limits. However, when the warp strike rates are lower, the current level of observation is unlikely to be sufficient to reliably detect: (1) the true strike rate with any reliability; and (2) a change beyond a critical threshold. The results also indicate that an increase in observation is required to gain better precision when low strike rates are being encountered by the fishery. Additionally, the paper recommends the inclusion of number of cables used on each net (either net monitoring or warp), as well as the number observed in the C1 and Observer data respectively, an increase observation rates to accurately detect, and precisely estimate, low strike rates, and the development a standardised observation procedure that reflects the potential variability in warp strike risks during krill trawling to allow for a better estimation of overall warp strike rates.

4.13 The Working Group discussed the analysis and noted potential biases in the observation process including whether observers were monitoring one or both warps, and that monitoring is focused on ‘high-risk’ periods. The Secretariat advised that observers are instructed to monitor one warp, prioritising ‘high risk’ periods (e.g. vessel turning), and that there is a category for reporting monitoring of ‘non high-risk’ periods. The Working Group further noted that currently only warp and net monitoring cables are observed but not any ropes or additional cables associated with fishing gear (for example ropes supporting the continuous trawling vessels’ pump). The Working Group also noted that electronic monitoring will likely improve the ability to detect warp strikes.

4.14 Some participants reported that in practice the observers may watch both warps on stern trawlers simultaneously because if observers stand at the side of the stern area, their field of view can cover both warps without any need to change their perspective. Some other participants noted that warp strikes are difficult to observe if you do not focus on a single warp.

4.15 At the time of report adoption, the Working Group considered that this topic may need further investigation and has implications for reporting and interpretation of data provided by observers.

4.16 The Working Group recognised that an increased level of observations would be required to improve the precision of estimates of warp strike rates. This increased level of observation can be achieved through a combination of increased rates of direct observations, and video capture and review.

4.17 The Working Group recommended the Scientific Committee consider:

(i) introducing an increase in the level of warp strike observations to 2.5% of fishing time on a per-vessel basis for the 2023/24 season

(ii) encouraging the level of warp strike observations to reach a minimum of 5% of fishing time on a per-vessel basis ideally from the 2024/25 season onwards, provided this does not impact on other priority tasks and overall workload of the observers.

(iii) encouraging the development and use of warp and net cable mitigation measures on trawl vessels during the 2023/24 fishing season (e.g. paired streamer lines on conventional trawl vessels, and warp scarers or 'socks' on continuous trawl vessels), and the introduction of mandatory mitigation measures on trawl vessels once suitable mitigation specifications have been developed

(iv) the development and implementation of a standardised observation procedure that reflects the potential variability in warp strike risks during krill trawling, to allow for a better estimation of overall warp strike rates.

4.18 The Working Group noted that tasking observers to conduct an average of two 15-minute observation periods per day in the krill fishery would achieve approximately 5% coverage rate of total fishing time for conventional trawl vessels.

4.19 The Working Group noted the value of retaining video footage of seabird interactions with warps and net monitoring cables, and the review of this footage for use as training materials to assist observers to differentiate between differing types of bird strikes.

4.20 The Working Group encouraged Members to:

(i) utilise video monitoring to help quantify bird strikes in trawl fisheries

(ii) investigate and develop artificial intelligence (AI) systems to automatically review video footage to detect bird strikes with warps and other fishing gears

(iii) undertake dedicated research to better resolve the underlying environmental factors influencing seabird strikes with trawl fishing gear.

Mitigation methods for seabirds

4.21 WG-IMAF-2023/01 presented an update from Norway on further trials of mitigation measures in krill continuous trawl fisheries where a net monitoring cable was used. Total observation effort across the three vessels of 10.8% was achieved over a period of 188 days. During this time, 89 strikes were observed. Of these, 54 were observed on the net monitoring cable, the majority of which were aerial strikes, and the bird was seen to fly away, apparently unharmed. Fifty of these strikes occurred on a single vessel with half (27) occurring over a five-day period between 29/04/2023 and 03/05/2023. The 'sock' mitigation measure was subsequently extended in length to be closer to the sea surface by 2.3 m, with only two bird strikes observed against the warp cables and none against the net monitoring cable (7.5% coverage) recorded thereafter (roughly over a month). Direct monitoring of warp strikes and review of video footage was resource-intensive, and problematic in poor visibility and bad weather conditions.

4.22 During the meeting, the Working Group was presented with a preliminary analysis of the bird strikes per 1 000 hours of continuous trawling that varied between the three vessels involved in the trial: *Antarctic Endurance* 41 strikes/1000 hours, *Antarctic Sea* 19 strikes/1000 hours, and *Saga Sea* 218 strikes/1000 hours. Video observations recorded 147 bird strikes/1000 hours, and direct observations reported 108 bird strikes/1000 hours. From 21 June to 13 September, one strike was recorded on the net monitoring cable and three on the warps representing 10.5 and 31.5 strikes per 1 000 hours respectively. Total observer coverage was 6.7%.

4.23 The Working Group noted that there was a total of 54 observed bird strikes with the net monitoring cable, that all strikes were Cape Petrels, and although no mortalities were reported, most corresponded to 'heavy' strikes which are considered a proxy for mortality (Sullivan et al., 2006). The Working Group additionally noted the number of bird strikes on the warp cable (31), were about half of those on the monitoring cable. During the meeting, an extrapolated total of 747 bird strikes was estimated by the author for the period of the reported trial (188 days).

4.24 The Working Group recommended the Scientific Committee consider:

(i) maintaining the existing derogation of the prohibition on use of the net monitoring cable in Conservation Measure 25-03, paragraph 1, footnote 2

(ii) clarifying in the second footnote to paragraph 1 of Conservation Measure 25-03 that "on-vessel observation coverage" includes both on deck observations and review of video footage in meeting the observer coverage requirements.

4.25 WG-IMAF-2023/17 presented information from China on the preliminary results of the trial of a net monitoring cable seabird-strike mitigation measure ('sock' with pennants, and streamer lines) for continuous trawling on the vessel *Shen Lan*. Continuous trawl was conducted only during 22 December 2022 to 15 January 2023, and observations occurred (4 x 15 min visual observations and 6 x 15 min review of video footage) over 65.5 h (7.8% of total fishing hours) with no seabird interactions observed. For conventional trawl, standard warp strike observation protocols were followed, which comprised 44.5 h (2.2% of total fishing hours) with no seabird interactions observed. Seabird abundance was generally low, higher levels of abundance were observed during net retrieval. All monitoring video footage have been stored for further analysis. The trial will continue during the 2023/24 fishing season.

4.26 The Working Group noted the preliminary results and looked forward to receiving further information about the ongoing trial. The Working Group highlighted the importance of assessing the effect of changes in the sock mitigation design.

4.27 The Working Group encouraged continuous trawl vessel operators to continue to develop mitigation devices to protect the area surrounding the end of the trawl booms (where warp and net monitoring cables are deployed), to reduce the risks of seabirds contacting warp and net monitoring cables, and report back to WG-IMAF on the development and effectiveness of such mitigation devices.

4.28 WG-IMAF-2023/07 presented a review of existing seabird mitigation measures and best practices for trawl fishing vessels within the Convention Area. The paper noted that current Conservation Measures provide general and specific measures for finfish and krill trawling, and the development of mitigation for conventional and continuous trawl fishing gear is still evolving. The paper included several recommendations for reducing the attraction of vessels to seabirds, reducing seabird strikes with warps, reducing net entanglements, and reducing seabird strikes with net monitoring cables.

4.29 The Working Group discussed the review noting: (1) streamer lines may not be effective for continuous trawl operations, where speed is under 2 kt, (2) the use of 'jigglers' and lighter streamer lines, as used by demersal longline vessels, may have application to trawl vessels, (3) improved drogue designs may help in achieving improved aerial extent of streamer lines, and (4) previous studies into seabird olfactory sense suggest that 'stick water' may be attractive to seabirds and further research may be required to understand its attractiveness to seabirds and improve mitigation.

4.30 WG-IMAF-2023/18 Rev. 1 reviewed CCAMLR conservation measures for seabird incidental mortality mitigation in demersal longline fisheries and assessed whether there had been any recent developments concerning seabird incidental mortality mitigation technologies and techniques, particularly those of ACAP, which would have application to CCAMLR's demersal longline fisheries. The paper identified several mitigation measures, already in use, for consideration by the Working Group that may improve conservation outcomes.

4.31 The Working Group encouraged Members to:

(i) Consider the refinement of streamer line specifications for demersal longline vessels in consultation with the fishing industry, to include recent additional configurations. This includes use of multiple streamer lines; using boom-bridle setups – where the streamer lines can be moved laterally as required, with the ability to extend coverage beyond the lateral extent of the vessel; and use of 'jigglers' – where the streamer line can be 'jiggled' back and forth to create an additional element of deterrence.

(ii) consider whether a 'moon pool' meets the operational characteristics of a bird exclusion device (BED) during hauling operations, and include a description of a moon pool as an example of an effective BED on the CCAMLR website.

4.32 The Working Group recommended the Scientific Committee consider:

(i) the inclusion of a definition of 'night' in paragraph 5 of Conservation Measure 25-02 to reduce ambiguity

(ii) the consistency between paragraphs 3 and 4 of Conservation Measure 25-02 and the indicative figures in Annex 25-02/C.

Observer reports and data collection

5.1 WG-IMAF-2023/04 presented a review of current SISO warp strike data collection protocols with those recommended by ACAP, detailed the full ACAP protocols for recording warp strikes and proposed changes to the current SISO warp strike data collection protocols to align with current guidelines developed by ACAP under their 'Data collection guidelines for observer programmes'.

5.2 The Working Group noted that the ACAP protocol had been used successfully by observers in the New Zealand trawl fishery for a number of years, and can be conducted in addition to their other tasks.

5.3 The Working Group noted that the paper had reviewed the observer finfish trawl form rather than the krill observer form, and that both heavy and light strike contacts will be recorded from season 2024 in CCAMLR krill fisheries. Other fields such as fishing stage, mitigation used, and offal discharge location can be derived or are included elsewhere. The main missing fields were related to environmental conditions and the angle of the warp cable.

5.4 The Working Group expressed concern about the practicality of measuring the angle of the warp but noted that this could be achieved through measuring the angle of the warp against calibrated markings on the trawl block.

5.5 The Working Group discussed the collection of environmental variables during warp strike observations, and noted that many of these variables could be derived from other sources.

5.6 The Working Group noted that the definition of a 'heavy strike' in the current CCAMLR protocols differs from the ACAP definition. While the CCAMLR protocol describes a heavy contact resulting in the bird coming in contact with the water, the ACAP protocol describes which part of the bird contacts the cable. The Working Group further noted that there may be some ambiguity in the definitions of the 'water' and 'sinker' categories, and that wording should be added to highlight that for the 'water' category the bird is on the water when it first comes into contact with the cable.

5.7 The Working Group considered the practicality and value of recording species-specific bird counts around the vessel, the potential timing of conducting such observations, and whether observers were able to do this by species without extensive training. The Working Group also noted that the search area for abundance observations differs between CCAMLR and ACAP guidelines.

5.8 The Working Group recommended that the Scientific Committee consider:

(i) the addition of fields to the current warp strike recording form indicating the angle of the warp and which warp is sampled

(ii) species specific estimation of bird abundance around the vessel prior to each observation, noting that this will impact on the observers' time for other tasks and potentially require additional training

(iii) the definition of 'heavy strikes' be more clearly defined using ACAP guidelines for 'water' and 'sinker' categories to ensure these are only recorded for birds struck by a cable while the bird is on the water (Appendix E).

Marine debris effects on seabirds and marine mammals

6.1 WG-IMAF-2023/P01 was presented under agenda item 3.2 (paragraph 3.4) and marine debris aspects of the paper were considered by the Working Group.

6.2 The Working Group noted that the CCAMLR marine debris monitoring program started in 1986, and an Intersessional Correspondence Group was formed in 2019. Fishing industry, national programs, tourist vessels, etc. provide data on marine debris under the current program.

6.3 The Working Group noted that marine debris discussions take place in several other Working Groups (e.g., WG-EMM-23, paragraph 4.68). In order to avoid duplication of marine debris considerations, the Working Group requested J. Barrington to summarise and present relevant information from the Intersessional Correspondence Group – Marine Debris (ICG-MD) to future meetings of WG-IMAF.

Light pollution effects on seabirds

7.1 WG-IMAF-2023/13 presented light pollution guidelines for wildlife, and mitigation standards for reducing light-induced vessel strikes of seabirds with fishing vessels developed by Australia and New Zealand. The paper noted that Conservation Measures 25-02 and 25-03 seek to minimise artificial light at night, but specifications are not provided about how minimisation of any light pollution can be applied. Additionally, the paper noted that the guidelines presented are highly relevant for CCAMLR and have been endorsed by ACAP and the Convention for Migratory Species (CMS).

7.2 The Working Group noted that no systematic recording of light-induced vessel strikes currently takes place, and that the level of mortalities from light-induced strikes may be considerable. The Working Group additionally noted that data on light-induced strikes have been collected around South Georgia, and a project quantifying all potential impacts on seabirds is currently ongoing.

7.3 The Working Group noted that the collection of light-induced vessel strike mortality data was more appropriate for vessels rather than observers, and modifications of the data collection forms and instructions would be required to achieve this.

7.4 The Working Group recommended the Scientific Committee consider encouraging Members to:

(i) apply the light pollution guidelines

(ii) collect data regarding their effectiveness and report back to CCAMLR working groups

(iii) present reports on mortalities on light-induced vessel strikes.

7.5 The Working Group noted that the Convention Area is used by many other vessels beyond fishing vessels.

Future work

8.1 The Working Group noted WG-FSA-2023/06, which provided a summary of the status of current vessel and observer forms and associated manuals. The paper highlighted the evolutionary nature of the form development process, recognising the considerable amount of time required to implement the recommendations from the Scientific Committee and its Working Groups across the different data forms.

8.2 The Working Group thanked the Secretariat for compiling this paper, noting the challenges that arise when forms are developed in an ad-hoc manner in response to Member requests. The Working Group considered the relevant proposals in the paper relating to marine debris, further noting that the appropriate forum for proposing changes to the C1 trawl vessel data forms is at the upcoming trawl fishery data workshop.

8.3 The Working Group recommended that the Scientific Committee consider the progress of the 2023 tasks along with the upcoming potential future tasks for future intersessional work, as described in Table 1.

Other business

Collaboration with relevant organisations

9.1 Dr Favero initiated a discussion on mechanisms to foster engagement between CCAMLR and other organisations outside of the Convention Area, as referenced to in WG-IMAF's terms of reference (Appendix F).

9.2 The Working Group recalled that CCAMLR has a Memorandum of Understanding (MoU) or similar arrangement with many international organisations, including regional fisheries management organisations (RFMOs), ACAP and IWC, further emphasising the importance of collaboration and cooperation between these bodies and noting that many RFMOs take guidance from CCAMLR on assessing IMAF-related issues.

9.3 The Working Group reflected on ACAP's engagement beyond the Convention Area. The Working Group request ACAP provide a summary of their engagement strategy to WG-IMAF for consideration, further noting that this summary would assist in enhancing the MoU between the two bodies and may include reports on any engagement with Members undertaken by ACAP on a periodic basis.

9.4 The Working Group highlighted the importance of effective collaboration with other relevant intergovernmental and industry organisations, noting that the collaboration with invited experts at the meeting had greatly improved the understanding of participants on relevant issues through targeted engagements and had enhanced the provision of advice to the Scientific Committee.

9.5 The Working Group noted that the attendance of invited experts allowed for ongoing feedback through various expert subgroups on outstanding issues (e.g., the Sub-Committee on Non-deliberate Human-Induced Mortality of cetaceans within IWC and ACAP Working Groups and Advisory Committee meetings).

9.6 The Working Group further noted the increasing level and importance of cooperation with other regional organisations to reduce the incidental mortality of seabirds and marine mammals within fisheries bordering the Convention Area.

Review of WG-IMAF terms of reference

9.7 The Working Group reviewed its terms of reference and priorities that were endorsed by the Scientific Committee at SC-CAMLR-41, and recommended the Scientific Committee consider the updated terms of reference in Appendix F.

Meeting modalities

9.8 The Secretariat informed the Working Group on several logistical and management issues concerning the meeting of WG-IMAF currently overlapping with WG-FSA, including:

(i) considerable difficulties for the Secretariat in resourcing both support and equipment for the meeting

(ii) difficulties for assigning and managing rapporteurs and presentations, as many attendees switch between meetings depending on the stage of the respective meeting agendas

(iii) an increased burden on translation for the Secretariat, as both the reports of WG-FSA and WG-IMAF are required to be translated prior to the Scientific Committee meeting.

9.9 The Working Group discussed options including holding WG-IMAF at a separate time, or adjacent to the meeting of WG-EMM, as many of the relevant experts attend both meetings. However, the Working Group noted that holding WG-IMAF at a different time and venue to the current arrangements may result a significant financial impost and time commitment for Members.

9.10 The Working Group recommended the Scientific Committee consider options such as holding WG-IMAF biennially or having a one-year hiatus to allow time for recommended data collection changes and mitigation measures to be implemented, and the collection of such data and subsequent analyses.

9.11 The Working Group noted that if either of these options were to be exercised, the Scientific Committee would need to consider sequencing future meetings of WG-IMAF to ensure that its advice is timely and fit for purpose.

Advice to the Scientific Committee

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

(i) determination of uncertainty estimates (WG-SAM) for future IMAF extrapolations (paragraph 2.7 (iv))

(ii) inclusion of a cetacean data collection form for SISO observers to complete in the event of a cetacean mortality (paragraph 2.18)

(iii) modify fields on the trawl observer forms to specify “band/tag” and create additional categories in the “Samples taken” field that apply for seals. (paragraph 3.13)

(iv) specify cetacean and seal exclusion devices separately within Fishery Notifications (paragraph 3.24)

(v) improving engagement and coordination among Members, and with ACAP Parties before and during relevant regional fisheries meetings (paragraph 4.3).

(vi) specify a minimum level of observation coverage for warp strike observations to 2.5% of fishing time on a per-vessel basis for the 2023/24 season, encourage the level of warp strike observations to reach a minimum of 5% of fishing time on a per-vessel basis ideally from the 2024/25 season onwards (paragraph 4.17)

(vii) encouraging the development and use of warp and net cable mitigation measures, and a develop a standardised warp strike observation procedure on trawl vessels (paragraph 4.17)

(viii) maintain and review the existing net monitoring cable derogation (paragraph 4.24)

(ix) specify the definition of ‘night’ in Conservation Measure 25-02 and consider more indicative figures in Annex 25-02/C (paragraph 4.32)

(x) consider additional data collection fields in the current warp strike recording form, and collection of species-specific estimation of bird abundance around the vessel (paragraph 5.8)

(xi) clarify the definition of ‘heavy strikes’ (paragraph 5.8)

(xii) encourage Members to apply the light pollution guidelines, collect data regarding their effectiveness and report on associated mortalities (paragraph 7.4)

(xiii) consider the progress of the 2023 tasks along with the upcoming potential future tasks for future intersessional work, as described in Table 1 (paragraph 8.3).

(xiv) consider the updated WG-IMAF Terms of Reference (paragraph 9.7 and Appendix F)

(xv) consider the future modality of the meeting such as holding WG-IMAF biennially or having a one-year hiatus (paragraph 9.10).

Adoption of the report

11.1 The report of the meeting of WG-IMAF was adopted.

Close of the meeting

11.2 At the close of the meeting, Mr Walker and Dr Favero thanked all participants, including invited experts, for their engagement, effective collaboration and patience that had allowed the Working Group to make significant progress in addressing the priorities of the Scientific Committee. They also thanked the rapporteurs and the Secretariat for providing requested analyses and support throughout the meeting.

11.3 On behalf of the Working Group, Mr I. Forster (Secretariat), thanked Mr Walker and Dr Favero for their helpful guidance during the meeting, noting that while there was a reduced agenda to progress significant work, the Co-convenors alongside the participants contributed to the development of a considerable workplan for WG-IMAF.

References

Sullivan B.J., T.A. Reid and L. Bugoni. 2006. Seabird mortality on factory trawlers in the Falkland Islands and beyond. *Biol. Conserv.*, 131:495-504.

Table 1. Intersessional work plan for WG-IMAF. Timeframe periods are short = 1–2 years, medium = 3–5 years and long = 5+ years. AI = artificial intelligence, EM = electronic monitoring, MMED = marine mammal exclusion device.

Theme	Task	Timeframe	Contributors	Secretariat participation
1. Review of incidental mortality	1.1 Presentation of incidental mortality information at a finer scale (spatial and temporal) (supplemental information in addition to Secretariat report to WG-IMAF)	Short	Dr Favero, Mr Walker and Prof. Phillips	Yes
	1.2 Development of a web-based tool to allow examination of interactions and incidental mortality data across CCAMLR fisheries	Medium	Dr Favero, Mr Walker and Prof. Phillips	Yes
2. Marine mammals – incidental mortality	2.1 Refine design of additional data to be collected by observers and crew when whale entanglements occur (see list developed under paragraph 4.17)	Short (to be completed intersessionally 2024)	Dr Kelly and Mr Pardo	Yes
	2.2 Investigate the use of underwater sensor/cameras attached to the net (and AI) to provide information on the occurrence of whale interactions and any subsequent entanglements/capture (continuous)	Short	Dr Kelly, Dr Lowther and Dr Lindstrøm	-
	2.3 Development of data collection protocols for pinniped mortalities and training materials	Short (to be completed intersessionally in 2024)	Mr Pardo	Yes
3. Seabirds and Marine mammals – risk assessment	3.1 Consider developing risk assessment for seabirds and marine mammals	Medium	Dr Lindstrøm, Dr Kelly and Prof. Phillips	-
4. Marine mammals – mitigation	4.1 Review designs of marine mammal exclusion devices and develop specifications for those in use in CCAMLR trawl fisheries (including consideration towards a convex shape to the exclusion mesh to deflect whales (and seals) away from the net mouth)	Ongoing	Dr Kelly, Dr Lowther, Mr Pardo and Dr Lindstrøm	-
	4.2 Undertake experiments into effectiveness of different MMED designs (for various species)	Medium	Dr Kelly, Dr Lowther, Dr Lindstrøm and Dr Ying	-

(continued)

Table 1 (continued)

Theme	Task	Timeframe	Contributors	Secretariat participation
5. Seabirds – incidental mortality	5.1 Power analysis of required observer sampling required for warp strikes	Update if required	Dr Kelly, Dr Hinke and Mr Walker	-
	5.2 Redesign the warp strike observation protocols	Short	Dr Debski	Yes
	5.3 Exploration of approaches to undertake warp strike extrapolations	Short	Dr Favero, Dr Hinke and Mr Walker	Yes
	5.4 Review required levels of observer sampling for seabird incidental mortality with longline fishery	Short	Mr Zhu, Dr Kawaguchi	Yes
6. Seabirds – mitigation	6.1 Consider performance of trawl warp/cable strike mitigation approaches utilised by continuous trawl vessels (including environmental conditions and other factors) including the improvement and specification development for the 'sock' design.	Short	Dr Debski and Dr Arata	-
	6.2 Review existing use of and consider mitigation requirements in conventional trawl vessels and develop specifications for suitable mitigation	Short	Dr Debski and Dr Arata	-
	6.3 Review developments in demersal longline mitigation	Update if required	Mr Barrington, Dr Debski and Mr Arangio/ Mr McNeill	-
7. Observer reports and data collection	7.1 Consider IMAF-related tasks for observers in the various CCAMLR fisheries	Ongoing	Mr Clark	Yes
	7.2 Consider use of EM and AI to improve the efficiency of data collection to aid observers	Medium/ Long	Mr Clark	-
8. Marine debris effects on seabird and marine mammals	8.1 Review information on the effect of marine debris on marine mammals and seabirds in the Convention Area	Short	Mr Barrington	Yes
9. Light pollution effect on seabirds	9.1 Consider options for the management of light pollution for vessels fishing in the Convention Area	Update if required	Mr Barrington	-

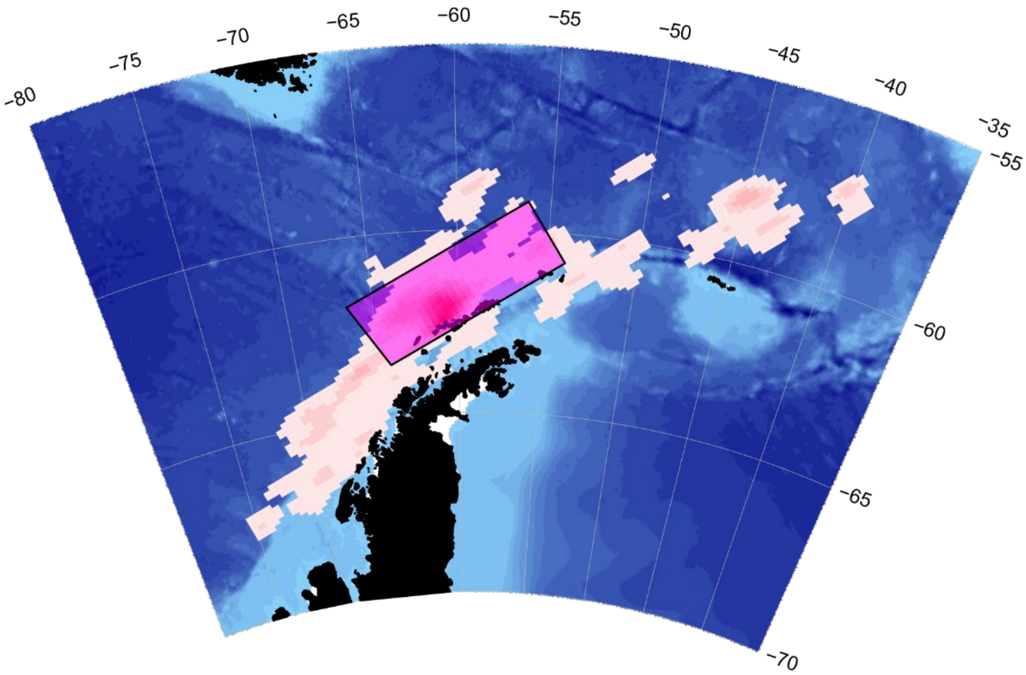

Figure 1. Proposed April–June temporary fishery closure area to mitigate risks to South Shetland Antarctic Fur Seals (pink polygon) sub-population, overlaid on the utilisation distribution of tracked juvenile fur seals from this population.

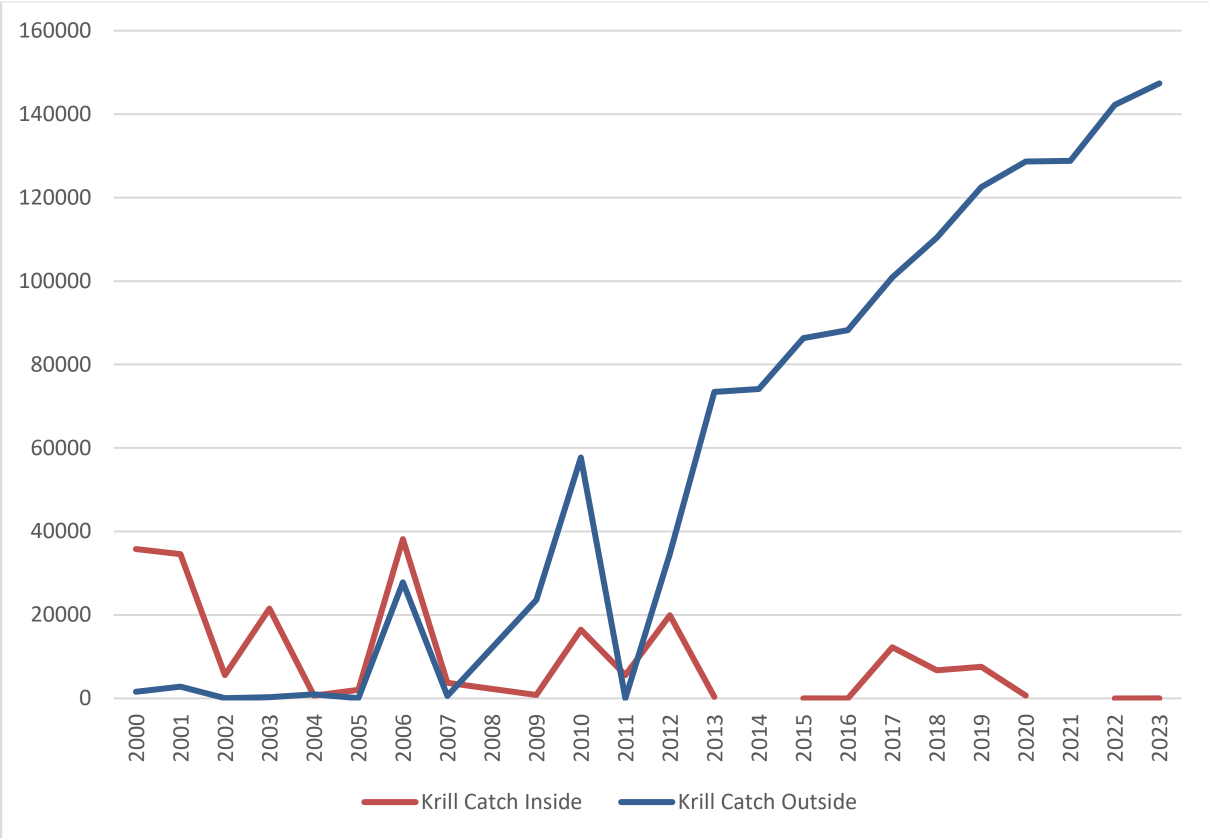

Figure 2. Annual catches of krill both within and outside of the proposed temporary fishery exclusion area in April – June from 2000 to 2023.

Appendix A

Agenda

Working Group on Incidental Mortality Associated with Fishing
(Hobart, Australia, 5 to 10 October 2023)

1. Opening of the meeting

   1.1 Introduction

   1.2. Adoption of the agenda

   1.3 Review of terms of reference and the work plan

2. Review of incidental mortality in CCAMLR fisheries

3. Marine mammal incidental mortality

   3.1 Population status of marine mammals in the CAMLR Convention Area

   3.2 Incidental mortality and risk assessments of marine mammals in CCAMLR fisheries

   3.3 Data collection needs from marine mammal interactions

   3.4 Mitigation methods for marine mammals

   3.5 Advice to the Scientific Committee regarding marine mammals and CCAMLR fisheries

4. Seabird incidental mortality

   4.1 Population status of seabird species in the CAMLR Convention Area

   4.2 Seabird incidental mortality and risk assessments in CCAMLR fisheries

   4.3 Mitigation methods for seabirds

   4.4 Advice to the Scientific Committee regarding seabirds and CCAMLR fisheries

5. Observer reports and data collection

6. Marine debris effects on seabirds and marine mammals

7. Light pollution effects on seabirds

8. Future work

9. Other business

10. Advice to the Scientific Committee

11. Adoption of the report and close of meeting

Appendix B

List of Participants

Working Group on Incidental Mortality Associated with Fishing
(Hobart, Australia, 4 to 10 October 2023)

Chair	Dr Marco Favero National Research Council (CONICET, Argentina)
Chair	Mr Nathan Walker Ministry for Primary Industries
Invited Expert	Mr Rhys Arangio Coalition of Legal Toothfish Operators (COLTO)
Invited Expert	Dr Javier Arata Association of Responsible Krill harvesting companies (ARK)
Invited Expert	Dr Igor Debski Agreement on the Conservation of Albatrosses and Petrels (ACAP)
Invited Expert	Dr Mike Double Agreement on the Conservation of Albatrosses and Petrels (ACAP)
Invited Expert	Mr Brad Milic COLTO
Invited Expert	Dr Iain Staniland IWC
Argentina	Dr María Mercedes Santos Instituto Antártico Argentino
Australia	Mr Jonathon Barrington Australian Antarctic Division, Department of Climate Change, Energy, the Environment and Water
	Dr Jaimie Cleeland Institute for Marine and Antarctic Studies (IMAS), University of Tasmania
	Dr So Kawaguchi Australian Antarctic Division, Department of Climate Change, Energy, the Environment and Water

	Dr Nat Kelly Australian Antarctic Division, Department of Climate Change, Energy, the Environment and Water
	Mr Dale Maschette Institute for Marine and Antarctic Studies (IMAS), University of Tasmania
China	Mr Haifeng Hua Jiangsu Sunline Deep Sea Fishery Co., Ltd
	Mr Hongliang Huang East China Sea Fisheries Research Institute, Chinese Academy of Fishery Science
	Mr Wan Yong Wang Jiangsu Sunline Deep Sea Fishery Co., Ltd
	Dr Yi-Ping Ying Yellow Sea Fisheries Research Institute
	Mr Han Yu Liaoning Pelagic Fisheries Co., Ltd
	Ms Haiting Zhang Shanghai Ocean University, IMAS, University of Tasmania
	Mr Jiancheng Zhu Yellow Sea Fisheries Research Institute, Chinese Academy of Fishery Science
	Professor Guoping Zhu Shanghai Ocean University
Japan	Dr Takehiro Okuda Fisheries Resources Institute, Japan Fisheries Research and Education Agency
Korea, Republic of	Dr Sangdeok Chung National Institute of Fisheries Science (NIFS)
	Mr Sang Gyu Shin National Institute of Fisheries Science (NIFS)
New Zealand	Dr Clare Adams Ministry for Primary Industries

	Mr Enrique Pardo Department of Conservation
Norway	Mr James Clark MRAG
	Dr Ulf Lindstrøm Institute of Marine Research
South Africa	Mr Sobahle Somhlaba Department of Agriculture, Forestry and Fisheries
	Mrs Melanie Williamson Capricorn Marine Environmental (CapMarine)
United Kingdom	Dr Martin Collins British Antarctic Survey
	Professor Richard Phillips British Antarctic Survey
	Ms Georgia Robson Centre for Environment, Fisheries and Aquaculture Science (Cefas)
United States of America	Dr Jefferson Hinke National Marine Fisheries Service, Southwest Fisheries Science Center
	Dr George Watters National Marine Fisheries Service, Southwest Fisheries Science Center
CCAMLR Secretariat	Isaac Forster Fisheries and Observer Reporting Coordinator
	Eldene O'Shea Compliance Officer
	Claire van Werven Research, Monitoring and Compliance Analyst

Appendix C

List of Documents

Working Group on Incidental Mortality Associated with Fishing
(Hobart, Australia, 5 to 10 October 2023)

WG-IMAF-2023/01	Update on Net Monitor Cable and whale mitigation devices on krill vessels Moir Clark, J., B. Viney, K. Mackey, U. Lindstrøm and B. A. Krafft
WG-IMAF-2023/02	Bycatch in the Antarctic krill (*Euphausia superba*) trawl fishery Krafft, B.A., A. Lowther and L.A. Krag
WG-IMAF-2023/03	Summary of Incidental Mortality Associated with Fishing activities data collected during the 2023 season, and a draft method for the extrapolation of IMAF and warp strikes Secretariat
WG-IMAF-2023/04	Developing a protocol to assess seabird strikes in the krill fishery Arata, J. and I. Debski
WG-IMAF-2023/05	Seabird warp strike observation protocols for trawl fisheries Debski, I.
WG-IMAF-2023/06	Update on ACAP activities and advice ACAP
WG-IMAF-2023/07	Review of Mitigation Measures for reducing Seabird interactions with fishing gear in trawl fisheries Arata, J. and I. Debski
WG-IMAF-2023/08	CCAMLR protocols for pinniped identification, sexing, and length measurement Pardo, E., D. Krause, R. Borras-Chavez and H. McGovern
WG-IMAF-2023/09	Develop efficient and robust Escape-Opening of Seal Exclusion Device for conventional Antarctic krill midwater trawl Ying, Y., H. Huang and X. Zhao
WG-IMAF-2023/10	Draft data collection form for whale incidental mortality events in the krill trawl fishery Kelly, N., R. Leaper and L. Leach

WG-IMAF-2023/11	Global political responsibility for the conservation of ACAP Priority Populations of albatrosses and petrels of relevance to CCAMLR Phillips, R.A., P. Catry, M. Dias, S. Oppel, D.J. Anderson, K. Delord, G. Elliott, D. Nicholls, K. Walker, R. Wanless, H. Weimerskirch and M. Beal
WG-IMAF-2023/12	Key considerations in addressing seabird and marine mammal bycatch in CCAMLR fisheries Favero, M., N. Walker, I. Debski and R.A. Phillips
WG-IMAF-2023/13	Light pollution guidelines and their application in CCAMLR fisheries Barrington, J.
WG-IMAF-2023/14	Metapopulation distribution shapes year-round fisheries bycatch risk for a circumpolar seabird Rexer-Huber, K., T.A. Clay, P. Catry, I. Debski, G.C. Parker, R. Ramos, B.C. Robertson, P.G. Ryan, P.M. Sagar, A. Stanworth, D.R. Thompson, G.N. Tuck, H. Weimerskirch and R.A. Phillips
WG-IMAF-2023/15	Observation on the interaction between Antarctic fur seal and krill fishing operation in Subarea 48.3 during the fishing season in 2020 Ying, Y., J. Zhang, X. Wang, X. Zhao, X. Yu, J. Zhu and Z. Huang
WG-IMAF-2023/16	Power and precision of warp strike observation rates in the Area 48 krill fishery Maschette, D., S. Wotherspoon, N. Walker, M. Double, P. Ziegler and N. Kelly
WG-IMAF-2023/17	Preliminary results of the trial on net monitoring cable/warp seabird-strike mitigation measures conducted by the Chinese F/V SHEN LAN during the 2022/23 fishing season Wang, Z., B. Su, G. Fan, H. Huang, Y. Ying, H. Hua and X. Zhao
WG-IMAF-2023/18 Rev. 1	Review of seabird bycatch mitigation in CCAMLR demersal longline fisheries Barrington, J., R. Arangio, I. Debski and M. McNeill

Other documents

WG-IMAF-2023/P01	Evaluating threats to South Shetland Antarctic fur seals amidst population collapse Krause, D.J., R.L. Brownell Jr., C.A. Bonin, S.M. Woodman, D. Shaftel and G.M. Watters *Accepted for publication at Mammal Review. DOI: 10.1111/MAM.12327.

Appendix D

Suggested data fields for the specification of marine mammal exclusion devices

Seal exclusion mesh

- Material/diameter
- Mesh size
- Position in net

Seal exclusion grid

- Bar material/diameter
- Bar spacing
- Position in net

Seal escape holes/hatches

- Number
- Position/s
- Size of holes

Whale exclusion mesh

- Material/diameter
- Mesh size
- Position in net
- Comments

Appendix E

Suggested changes to heavy warp strike definitions

Air: Bird strikes warp in the air and hits the water with little to no control of its flight.

Water: [*The bird is on the water and the*] warp strikes bird driving any part of the body beneath the surface of the water, but not fully submerged.

Sinker: [*The bird is on the water and the*] warp strikes bird and the entire body is submerged.

Appendix F

Working Group on Incidental Mortality Associated with Fishing (WG-IMAF)
Terms of Reference [1]

1. The purpose of the Working Group on Incidental Mortality Associated with Fishing (WG-IMAF) is to contribute to the conservation of Convention Area seabirds and marine mammals through the provision of advice to the CCAMLR Scientific Committee and its working groups, including consideration of the impacts of climate change on its advice. To achieve this, WG-IMAF will address the following terms of reference:

(i) the level and significance of direct impacts of interactions and incidental mortality associated with fishing

(ii) the efficacy of mitigation measures and avoidance techniques currently in use, and improvements to them, taking into account experience from both inside and outside the Convention Area

(iii) the level and significance of direct impacts of marine debris originating from fishing activities on seabirds and marine mammals within the Convention Area

(iv) improvements ~~and/ or additions~~ to the reporting and data collection requirements regarding incidental mortality

(v) approaches to improve the conservation status of seabirds and marine mammals directly impacted by fishing outside the Convention Area, by Collaborating and coordinating with relevant organisations that the Commission has a cooperative arrangement with, including with invited experts as required ~~including cooperation with adjacent regional fisheries management organisations (RFMOs)~~.

2. ~~Collaborate and coordinate with relevant organisations that the Commission has a cooperative arrangement with, including with invited experts as required.~~

~~3.~~ To provide any other advice, within its area of expertise, to the Scientific Committee and its working groups as directed by the Scientific Committee.

[1] 2023~~2~~

Annex 8

Report of the Working Group on
Fish Stock Assessment 2023 (WG-FSA-2023)
(Hobart, Australia, 2 to 13 October 2023)

Contents

Page

Report of the Working Group on
Fish Stock Assessment 2023 (WG-FSA-2023)
(Hobart, Australia, 2 to 13 October 2023)

Opening of the meeting

1.1 The 2023 meeting of the Working Group on Fish Stock Assessment (WG-FSA) was held in Hobart, Australia, from 2 to 13 October 2023. 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.

Introduction

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 seeing the outcomes of the meeting being presented to the Scientific Committee and the Commission and noted the that the large number of papers submitted to the meeting highlights the level of engagement by Members in progressing the work of CCAMLR.

Adoption of the agenda

1.4 The Working Group reviewed and adopted the agenda (Appendix B).

1.5 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. A glossary of acronyms and abbreviations used in CCAMLR reports is available online at https://www.ccamlr.org/node/78120.

1.6 The Working Group noted that scheduling the various topics during the meeting was complicated by having WG-IMAF occurring at the same time, which prevented individuals or small delegations from attending both meetings and made meeting planning and rapporteuring assignments complex.

1.7 In this report, paragraphs dealing with advice to the Scientific Committee have been highlighted. These paragraphs are listed under “Advice to the Scientific Committee”.

1.8 The report was prepared by S. Rodriguez-Alfaro (European Union), J. Cleeland (Australia), J. Devine (New Zealand), A. Dunn (New Zealand), T. Earl (United Kingdom), M. Eléaume (France), J. Fenaughty (New Zealand), P. Hollyman (United Kingdom), D. Maschette, S. Kawaguchi and C. Masere (Australia), F. Massiot-Granier (France), T. Okuda

(Japan), F. Ouzoulias (France), S. Parker (Secretariat), G. Robson (United Kingdom), M. Santos (Argentina), S. Thanassekos (Secretariat), G. Watters (USA), M. Williamson (South Africa) and G. Zhu (China).

Review of terms of reference and the work plan

1.9 The Working Group reviewed the terms of reference developed during SC-CAMLR-41 and distributed in SC-CIRC 23/52. The Working Group noted that the revised terms of reference explicitly include the effects of climate change in the Working Groups advice to the Scientific Committee. The Working Group further noted that having the terms of reference readily available for review at the start of each meeting was helpful and recommended that these be provided along with the agendas for the Working Group meetings.

1.10 The Working Group recalled the workplan agreed from SC-CAMLR-41 Table 8 and agreed to revisit it under Future Work, to identify tasks that have been completed and new tasks that may arise during the meeting.

Review of CCAMLR fisheries in 2022/2023 and notifications for 2023/2024

2.1 CCAMLR-42/BG/08 Rev. 1 presented a summary of all notifications received by the Secretariat for research fisheries, exploratory fisheries for toothfish and krill fisheries for the 2023/24 fishing season.

2.2 The Working Group welcomed this contribution and noted that the vessel Helena Ndume (formerly known as Matilda), notified by Namibia to fish in Subareas 88.1 and 88.2, submitted a preliminary assessment of the potential significant adverse impacts on vulnerable marine ecosystems required by Conservation Measure (CM) 22-06 after the deadline of 1 June 2023.

2.3 The Working Group noted the paper included a notification under a Research Plan submitted by Uruguay for Subarea 48.6 (WG-SAM-2023/07) which has not yet been scientifically evaluated by either WG-SAM (WG-SAM-2023, paragraph 8.1) or WG-FSA. The Working Group noted two papers (WG-FSA-2023/01, WG-FSA-2023/02) that relate to this vessel notification were discussed under the Scheme of International Scientific Observation.

2.4 The Working Group noted SC-CAMLR-42/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 2021/22 and 2022/23 seasons, and from research fishing under CM 24-05.

2.5 CCAMLR-42/BG/09 detailed the operation of the fishery forecasting algorithms for the fisheries in the 2022/23 fishing season and assessed the implementation of the current procedures.

2.6 The Working Group welcomed the paper and noted that the algorithm for forecasting toothfish closures was generally working well and had stabilised in recent years. The Working Group considered that a forecasting procedure was not required in areas covered by a Research Plan as vessels coordinate to manage catch and large overruns are uncommon. The Working Group also noted that, in the future, a summary of the outcomes from the forecast estimates should be presented in the Secretariat's annual catch report paper (i.e., SC-CAMLR-42/BG/01) instead of a separate paper, unless there were significant issues that should be brought to the attention of the Working Group.

Recommendations from other Working Groups

2.7 SC-CAMLR-42/09 presented the Report of the Working Group on Statistics, Assessment and Modelling (Kochi, India, 26 to 30 June 2023). Several paragraphs of the WG-SAM report explicitly indicated the necessity of further discussion, submission of a revised paper, and reporting progress at WG-FSA-2023, including:

(i) an updated version of WG-SAM-23/13, the risk assessment for the Antarctic starry skate (*Amblyraja georgiana*)

(ii) validation of Casal2 models compared with the CASAL models

(iii) revision of the Chilean research proposal for *Dissostichus* spp. in Subarea 48.2

(iv) further results of Ukrainian icefish research in Subarea 48.2

(v) referred items in the report of the joint COLTO–CCAMLR Workshop for tagging toothfish and skates

(vi) developing the terms of reference of the in-person workshop for age determination.

2.8 SC-CAMLR-42/10 presented the Report of the Working Group on Ecosystem Monitoring and Management (Kochi, India, 3 to 14 July 2023). The report highlighted the status of the review of CCAMLR's Ecosystem Monitoring Program (CEMP) and topic areas that enhanced CEMP may include:

(i) supporting the implementation of the revised krill fishery management approach in Subarea 48.1,

(ii) enhancing circumpolar ecosystem monitoring in the context of climate change and the effects of fishing

(iii) supporting MPA design and monitoring.

2.9 WG-EMM-2023 also noted the development of a revised protocol for sampling length frequency distribution of krill and that further development would occur through the Krill Fishery Observer Workshop (WS-KFO-2023) and be made available for review by WG-FSA-2023.

Data collection forms and instructions

2.10 WG-FSA-2023/06 presented an update on the status, priorities for the development of fishery data forms and manuals and identified the need to coordinate changes to vessel and observer forms simultaneously to standardise appearance and terminology to reduce ambiguity.

The Working Group noted the substantial efforts and developments made recently to improve the functionality and data collection of various vessel and observer forms.

2.11 The Working Group recommended the Scientific Committee consider replacing CE reporting in the longline fishery with submission of the C2 form if the reporting period was every 5 days or greater, given that there is some duplication between the CE and C1 or C2 forms.

2.12 The Working Group noted that the C1 form is used in both finfish and krill trawl fisheries and recommended that the current form be separated into finfish and krill-specific data collection forms as both fisheries have different data collection requirements.

2.13 The Working Group recommended to the Scientific Committee that a trawl fisheries data workshop occur during the intersessional period to discuss the revisions to the C1 form including the potential replacement of CE reporting in the krill fishery with submission of the C1 form.

2.14 The Working Group noted that the C2 forms and manuals have been recently revised and updated, and requested the Secretariat to revise the manual to reflect that tagging data is not required to be reported to CCAMLR by vessels in Division 58.5.2.

2.15 The Working Group recommend that the B2 form be removed because all fisheries now have 100% observer coverage (making this form redundant) and noted the proposal to retire CM 23-05, which governs the submission of this form (CCAMLR-42/12).

2.16 The Working Group noted that research vessels which undertake research trawls surveys are regulated under CM24-01 Annex A and should report data using the C4 form. The Working Group recommended that the Scientific Committee review the C4 form in light of Scientific Committee requirements (e.g. changes to the CEMP).

2.17 The Working Group noted that C5 forms are currently used by only a small number of Members and requested that the Secretariat work directly with those Members to revise this form.

2.18 The Working Group requested that the Secretariat continue to keep a register of issues with forms and manuals and present a summary of issues with proposed revisions to relevant Working Groups as required.

2.19 The Working Group requested the Secretariat to group forms, instructions, and manuals together on the CCAMLR website for easy downloading as this information is currently in several locations and can be difficult to find.

2.20 The Working Group noted the proposal to modify the observer logbook to include the revised skate injury codes provided in Table 1. The Working Group noted that this revision was based on recent developments reported in WG-FSA-2022/19 and included several new codes to support future post-release survival analyses and to include superficial injuries, bruising on the disc or tail and healed injuries in the mouth/jaw region which could be reflective of past capture events.

2. 21 The Working Group recommended the skate injury codes be incorporated into the observer logbook for the 2024/25 season on the tag release, tag recapture and biological data collection sheets, including multiple codes for a single skate.

2.22 The Working Group tasked the Secretariat with assessing the feasibility of developing a photo repository for images of tags recovered from recaptured skates that can be linked to tag metadata and noted a photo naming convention already existed (WG-FSA-15/76) and could be implemented after skate tag recapture.

Illegal, unreported and unregulated fishing

2.23 CCAMLR-42/15 Rev. 1 presented a summary of information received by the Secretariat in relation to illegal, unreported and unregulated (IUU) fishing in 2022/23 relevant to CCAMLR, as well as unidentified gear retrieved from October 2022 to August 2023, including proposed updates, amendments, inclusions and removals from IUU vessel lists.

2.24 The Working Group welcomed this contribution and noted the challenges with attributing unidentified gear to IUU activity. It recommended that future reports separate observations of unidentified gear into different gear types to enable the identification of IUU activity using gill nets. Furthermore, the Working Group noted that improvements to vessel forms for lost gear and observer forms for recovered gear would provide greater insight into IUU activity.

2.25 The Working Group considered methods, including the marking of fishing gear, to ascertain whether gear found belonged to the legal fishery, which would help improve estimates of IUU fishing activity and recalled that the ‘Unidentified fishing gear in the Convention Area’ e-group had been created to address this issue.

2.26 The Working Group noted that the limited ability to identify IUU fishing activities can impact the scientific advice by the Working Group.

2.27 The Working Group noted that the analysis of the VMS data provided by Bolivia for the proposed NCP IUU Vessel *Cobija* for the period 19 November 2017 to 15 April 2018 indicated the vessel navigated to a known fishing location in Division 58.4.3b, where it possibly undertook fishing activities. The Working Group noted that the direct transit to and from this location would indicate knowledge of prior fishing locations in the area.

2.28 WG-FSA-2023/21 presented evidence from albatrosses equipped with GPS and a radar-detection device of a possible detection of IUU activity in the BANZARE Bank region in Division 58.4.3b in 2018 and 2019. The area where detections were made was nearby where Australian Research Vessel (RV) *Aurora Australis* found illegal fishing gear in 2020.

2.29 The Working Group welcomed the study and noted the region where the IUU detections were made was also near the location in Division 58.4.3b where CCAMLR-42/15 Rev. 1 reported IUU activity in 2017 and 2018. The Working Group noted that the use of evidence from tagged albatrosses to detect IUU vessels may increase the mortality risk to all albatrosses and that this issue should be considered by WG-IMAF.

Marine debris

2.30 WG-EMM-2023/14 reported on the CCAMLR Marine Debris Monitoring Programme (MDMP) that was established in 1986 to monitor marine debris in the Convention Area. The

MDMP data included data submitted by CCAMLR Members from beach surveys, seabird colony surveys, observations of marine mammal entanglements, hydrocarbon soiling events, opportunistic sightings, gear lost by fishing vessels, and marine debris (including fishing gear from other sources) observed at-sea by SISO observers. The paper noted that while spatial patterns in the amount of longline fishing gear lost generally reflect spatial patterns in fishing effort, some areas show higher rates of loss, likely due to a combination of sea ice dynamics, local currents, and seafloor characteristics.

2.31 The Working Group welcomed the report and noted that current C2 forms do not allow for the reporting of loss of depredation mitigation devices, specific components of gear lost, or an indication of where the loss occurred.

2.32 The Working Group noted the marine debris programme summary (WG-EMM-2023/14) was developing two forms to improve documentation of items, including fishing gear lost from longline vessels, as part of the C2 form, as well as a form to be included in observer logbooks to document marine debris including fishing gear recovered during trips.

2.33 The Working Group suggested the Secretariat include an "other" free text field for vessels to note other items lost and the date the item(s) were lost to aid in linking to the location of the vessel, as items can be lost outside of fishing activities.

2.34 The Working Group noted that a standalone lost marine debris form for fisheries other than longline could be implemented immediately instead of waiting for developments to the C1 form for the krill and finfish trawl fisheries, but noted that if a separate form was needed, the relevant CMs would need modification.

2.35 The Working Group noted that observers currently record any items lost overboard or found at sea in cruise reports, but that a form would allow more detail and structured data.

2.36 The Working Group discussed that other vessels other than fishing vessels, such as tourist vessels, can report marine debris in a similar manner using the 'opportunistic marine debris' form, as having reports from all vessels would improve the available information.

2.37 The Working Group recommended that the Scientific Committee consider whether marine debris lost by the vessel should be reported as part of C1, C2 or C5 forms or in a new form.

Krill

3.1 WG-FSA-2023/34 presented a preliminary analysis of seasonal and annual variations in sea ice within Subareas 48.1 and 48.2 and how they may affect the ability of krill-fishing vessels to access important fishing areas. Trends presented in the paper indicate that the period when sea ice limits access to important krill-fishing areas in the Bransfield Strait has decreased from about 4 to 3 months (over the period 1997-2022), from 5 to 2 months around Elephant Island (over the period 1980-2022), and from 6.5 to 4 months in Subarea 48.2 (over the period 1980-2022). The authors conclude that sea ice determines access to krill-fishing grounds and is the primary factor that determines where krill fishing occurs. The authors further conclude that access should be considered during the development of the revised management strategy for the krill fishery, particularly during the austral winter.

3.2 The Working Group agreed that sea ice plays an important role in determining where the krill fishery operates, however it noted that ARK's Voluntary Restricted Zones (VRZs) have also affected the distribution of krill fishing. The VRZs in Subarea 48.1 may have contributed to an increased concentration of krill fishing in Subarea 48.2, and this concentration of fishing occurs in relatively close proximity to breeding colonies of krill-dependent predators. The Working Group recommended this situation be further considered by WG-EMM.

3.3 The Working Group noted that as sea ice cover continues to decline, areas on the continental shelf and near shore will become more accessible to vessels. Since these areas are critically important to krill-dependent predators, the Working Group considered that the Scientific Committee and its working groups should pay careful attention to the issue of distributing krill catches onshore and offshore as well as within fishing seasons.

3.4 The Working Group agreed that it will be important to monitor changes in sea ice and to consider these changes during the implementation of the revised management strategy for the krill fishery. As access to fishing grounds changes in response to sea ice, it may be necessary to change the distribution of catch limits between seasons or among management units.

3.5 WG-FSA-2023/64 discussed the selectivity function described by Krag et al. (2014) and used in recent applications of the Grym for krill. The authors summarised several shortcomings in the work by Krag et al., including that the results were based on observations collected from three different krill fishing vessels in three different fishing seasons, and thus the study had not adequately controlled for differences between vessels and years. The authors concluded that the results of Krag et al. (2014) should not be used in applications of the Grym for krill.

3.6 The Working Group noted that there are no alternatives to the selectivity function described by Krag et al. (2014), and, thus, it remains the best available science. It noted that WG-EMM also determined that the selectivity function developed by Krag et al. is the best available science (WG-EMM-2023, paragraph 4.24). A selectivity function is required to simulate fishery removals in the Grym, and the authors of WG-FSA-2023/64 were encouraged to develop, test and submit an alternative selectivity function for further consideration.

3.7 The Working Group recalled the reports from WG-SAM-2023 (paragraph 3.3) and WG-EMM-2023 (paragraph 4.23), and recommended further work investigating whether, for krill, results from the Grym would be sensitive to changes in the parameterization of fishery selectivity. It noted that this question could be investigated through a set of sensitivity tests (e.g., by comparing gamma values produced with different parameter values in the selectivity function) and by comparing length-frequency data collected by SISO to expectations from the model developed by Krag et al. (2014).

3.8 WG-FSA-2023/53 presented an analysis of the intrinsic productivity, inferred from the Length Based Spawning Potential Ratio (LBSPR) method, of krill in Subarea 48.1; this work was conducted by a current CCAMLR Scholarship recipient, Mr. Mauricio Mardones (Chile). Using selectivity and life-history parameters, LBSPRs were estimated from fits to length frequency data from SISO. Life-history parameters were taken from recent applications of the Grym to krill in Subarea 48.1 (e.g., WG-FSA-2021/39). The length frequency data were binned by fishing season and management unit, with management units defined as in recent applications of the spatial overlap analysis for the krill fishery in Subarea 48.1 (see, e.g., WG-EMM-2022/17 and WG-FSA-2022/39). The paper documented differences in the size composition of the krill catch among management units as well as interannual changes within management units. These differences and changes in size composition were considered to reflect differences and changes in the Spawning Potential Ratio, with the highest ratios occurring in the Elephant Island management unit, and the smallest ratios occurring in the Extra (Gerlache Strait) management unit. Spawning Potential Ratios in the Elephant Island management unit showed an increasing trend, driven by shifts in the size compositions of the catch from this area. The authors concluded that spatial differences in the Spawning Potential Ratio could inform development of the revised management strategy for the krill fishery, for example by characterising spatial differences in intrinsic productivity to inform spatial overlap analyses.

3.9 The Working Group congratulated Mr. Mardones and welcomed his work as a new CCAMLR Scholar. The Working Group acknowledged it was unaware whether the LBSPR approach had previously been applied in a spatially disaggregated manner and noted that, given the connectivity of krill between management units in Subarea 48.1, it might be useful to compare the results from the current analysis with five management units to new results from an analysis in which all management units are combined. Such a comparison might allow for consideration of temporal variation in Spawning Potential Ratio for the subarea as a whole. The Working Group further asked whether targeted fishing within management units (e.g., in areas with high krill densities) and changes in sampling requirements for observers (e.g., which might affect observed size compositions) might bias results from the LBSPR approach. Some participants commented that, in their view, it was unlikely the krill fishery is affecting the intrinsic productivity of the krill stock in Subarea 48.1 given the low harvest rates occurring therein.

3.10 WG-FSA-2023/54 identified four spatial inconsistencies, or mismatches, in different components of the work to establish a revised management approach for the krill fishery in Subarea 48.1. First, the polygon defining the Joinville management unit is cropped in one spatial overlap analysis (WG-EMM-2022/17) but not in another spatial overlap analysis (WG-FSA-2022/39) nor in calculations of areas (WG-ASAM-2023/01). Second, polygons defining the Powell Basin and Drake Passage management units are cropped in both spatial overlap analyses but not in calculations of total krill biomass (WG-ASAM-2023, Table 1). Third, a small area near the tip of the Antarctic Peninsula (in and around Antarctic Sound) is included within the Powell Basin management unit in one spatial overlap analysis and within the Drake Passage management unit in the other overlap analysis. The authors questioned whether this small area near the tip of the Antarctic Peninsula could be excluded from future implementation of the revised management approach for the krill fishery. Finally, both spatial overlap analyses and calculations of areas all use different map projections, which leads to different catch limits and estimates of biomass in each management unit.

3.11 The Working Group did not provide a recommendation on how to address the first mismatch (whether the Joinville management unit should be cropped) but noted that this mismatch is likely to only have a small effect on calculations related to the revised management approach for the krill fishery.

3.12 The Working Group did not agree about whether or how to address the second mismatch (whether the Powell Basin and Drake Passage management units should be cropped). The Working Group noted that WG-ASAM advised the use of very conservative estimates of krill density in the Powell Basin and Drake Passage management units, but it also noted that biomass estimates are calculated by multiplying these density estimates by the areas (km2) of the management units. The Powell Basin and Drake Passage management units are very large and cropping them (or not) thus significantly affects the estimate of total krill biomass in Subarea

48.1 and the catch limit that would, on the basis of the spatial overlap analysis, be distributed through all management units. It was also noted that it might be appropriate to split the Drake

Passage management unit into two or more smaller units. However, to avoid unintended concentration of fishing due to changes in the distribution of krill, management units should be at an appropriate spatial scale for management.

3.13 The Working Grouped noted that there are few acoustic estimates of krill density in the Powell Basin and Drake Passage management units, and new acoustic surveys in these units might reduce uncertainty associated with extrapolating density estimates to these large areas.

3.14 The Working Group did not provide a recommendation how to address the third mismatch (how to treat the small area near the tip of the Antarctic Peninsula). However, the Working Group noted that krill fishing occurs in and around Antarctic Sound at a low level and agreed that this area should not be excluded from the implementation of the revised management approach for the krill fishery.

3.15 To address the fourth mismatch (use of different map projections), the Working Group noted the recommendations in WG-ASAM-2023 (paragraph 3.9) on geospatial operations within CCAMLR. Noting that the use of georeferenced polygons is a widespread discussion within CCAMLR, the Working Group reviewed and expanded on these recommendations to assist in future implementations.

3.16 The Working Group noted that the map projection proposed by WG-ASAM-2023 is consistent with the projection endorsed by WG-FSA-2019 (paragraph 4.34). It discussed the differing sources of coastline data and the classification of land, permanent sea ice, and glaciers within. The Working Group noted that currently the SCAR Antarctic Digital Database (ADD) only has coastline south of 60° S and suggested an expansion of this in the future to the entire CCAMLR area would be beneficial to the CCAMLR community.

3.17 The Working Group noted that there are few Southern Ocean geospatial specialists actively developing methods of data quality control and analysis. As such, the Working Group thanked Dr Michael Sumner (Australia) for his continuing work in this field and assistance to the CCAMLR Secretariat on these matters.

3.18 Building upon recommendations from WG-ASAM-2023 and the Secretariat, the Working Group recommended the Scientific Committee request Members apply the following geospatial rules:

(i) geographical information system (GIS) objects use the EPSG 6932 projection

(ii) lines of more than 0.1 degree of longitude be densified

(iii) polygon vertices be given clockwise in decimal degrees with at least five decimal places

(iv) vertices be added where polygons meet (see Figure 1)

(v) inland vertices be used for polygons that are bound by any coastline (continent and islands)

(vi) polygons be clipped to all coastlines (continent and islands) based on the most recent available coastline data.

(vii) the coastline be based on the latest available coastline data, as obtained from the SCAR Antarctic Digital Database (ADD) and other sources where needed (e.g., www.naturalearthdata.com).

(viii) analyses cite CCAMLR geospatial data (i.e. shapefiles) as CCAMLR. [Year]. Geographical data layer: [Layer name]. Version [Version], URL: [URL]

(ix) all maps cite data sources and projection used

3.19 In order to enable this the Working Group requested:

(i) the Secretariat develop a data form for Members to submit coordinates of polygon vertices when proposing new spatial polygons

(ii) the Secretariat work with Members to develop standard tests and diagnostics to verify the validity of spatial polygons.

3.20 WG-FSA-2023/68 presented updated precautionary catch limits for *Euphausia superba* in Divisions 58.4.1 and 58.4.2-East based on recent biomass estimates from a 2019 survey conducted by Japan in Division 58.4.1 and a 2021 survey conducted by Australia in Division 58.4.2-East. These biomass estimates were combined with Grym stock assessments to estimate precautionary harvest rates for krill in Divisions 58.4.1 and 58.4.2-East and derive precautionary catch limits.

3.21 The authors of WG-FSA-2023/68 recommended that:

(i) in Division 58.4.1, the total catch limit be set at 366 243 tonnes, with a subdivision of 132 725 tonnes west of 103°E, 54 462 tonnes between 103°E and 123°E, and 179 056 tonnes east of 123°E;

(ii) in Division 58.4.2, the total catch limit be set at 2 005 280 tonnes, with a subdivision of 1.448 million tonnes west of 55°E and 557 280 tonnes east of 55°E; and

(iii) the current trigger levels in CM 51-03 for both subdivisions of Division 58.4.2 remain in force until such time that an updated spatial overlap analysis can inform on a spatial allocation of catch within this Division.

3.22 The Working Group welcomed the efforts by Australia and Japan to bring forward updated catch limits for these two divisions following the same process agreed in 2019 and undertaken in 2021 for Subarea 48.1 (WG-FSA-2021/39).

3.23 The Working Group noted that the parameters for this assessment had been reviewed and agreed by WG-EMM-2023 (paragraphs 4.6 to 4.8). It further noted the size of maturity is larger in East Antarctica compared to that for Southwest Atlantic sector, and considered whether this is a biological characteristic of krill in this region or the result of bias that may have arisen through the length-frequency observations. The authors of WG-FSA-2023/68 clarified that the demographic data for Divisions 58.4.1 and 58.4.2-East were collected by different research groups in different field seasons, yet the parameter values were almost identical, indicating that these maturity parameters reflect actual krill biology in these regions.

3.24 The Working Group noted that the catch limits recommended in WG-FSA-2023/68 are based upon updated biomass estimates in these Divisions, which did not survey within the sea-ice zone (WG-ASAM-2021, paragraph 2.26).

3.25 Some participants noted that the use of these results may need further discussion, due to the biomass being estimated based on a survey that may not have included areas which may be important krill habitats (e.g., sea-ice zone).

3.26 Some other participants noted the biomass estimates have been agreed by WG-ASAM-2021, SC-CAMLR-2021, published within peer reviewed literature and further discussed by WG-ASAM-2023, and provide the best available estimates of biomass in these areas. They also considered these estimates to be precautionary in this area.

3.27 The Working Group endorsed the assessment on the harvest rates for *E. superba* in Divisions 58.4.1 and 58.4.2-East.

3.28 The Working Group recommended the Scientific Committee consider the proposed catch limits in Tables 2 and 3 be used to update CMs 51-02 and 51-03. The Working Group further recommended the current trigger levels in CM 51-03 remain in force for both subdivisions of Division 58.4.2 until such time that an updated spatial overlap analysis can inform on a spatial allocation of catches within this Division.

3.29 WG-FSA-2023/14 presented preliminary results from a pilot implementation of an integrated assessment model for krill in Subarea 48.1 using the Casal2 framework. The authors cautioned the Working Group to consider the potential of the assessment rather than the specific results, and, in this regard highlighted how an integrated assessment will enable use of multiple data sets and multiple types of data collected by multiple Members (see also WG-SAM-2023/25). The authors also highlighted how commonly used model-selection approaches (e.g., AIC) can be used within an integrated assessment framework to evaluate competing hypotheses. Personnel from the U.S. AMLR Program plan to further develop integrated assessment models for krill, including diagnostics presentations and comparisons with alternative modelling frameworks (e.g., Stock Synthesis 3), with the aim of using such an assessment to provide management advice in the next 3-5 years.

3.30 The Working Group welcomed the work to develop an integrated assessment for krill in Subarea 48.1 and reiterated the previous advice of WG-SAM (WG-SAM-2023, paragraphs 4.2 and 4.3), particularly advice related to diagnostics and comparisons with the Grym. The Working Group noted this model could be useful for estimating selectivity within the krill fishery.

3.31 The Working Group noted that Dr. D. Kinzey (USA) has now retired and thanked him for his efforts to progress krill modelling over the past decade.

3.32 If a new scientist is hired to continue Dr. Kinzey's work, participants offered to assist with Casal2 and suggested that they subscribe to the Casal2 GitHub repository (WG-SAM-2023, paragraph 6.31) hosted by the Secretariat.

Krill fishery observer workshop

3.33 SC-CAMLR-42/05, the Report of the Krill Fishery Observer Workshop (WS-KFO), was presented by Professor G. Zhu (China) and Dr S. Kawaguchi (Australia), the co-conveners of WS-KFO-2023. The Workshop gathered CCAMLR krill scientists, scientific observers, and the fishery operators to review and discuss management of appropriate workload, refinement of sampling and reporting protocols.

3.34 The Working Group thanked the co-conveners and congratulated the Workshop for its successful outcomes, which helped improving the understanding of how the observers are operating on krill vessels, explored the ways to address difficulties that observers are facing in the field, and considered improved sampling protocols to ensure the data quality.

3.35 The Working Group noted the increasing and diversifying sampling tasks required within the observers' demanding workload. It was noted that sometimes observer deployments may extend for a long time (see WG-FSA-2023/07 Rev. 2) due to unexpected conditions, for example, the impact of COVID-19 restrictions, and the Working Group reiterated the importance of ensuring the health and wellbeing of the observers.

3.36 The Working Group noted the importance of work that observers are undertaking as it contributes to the conservation of Antarctic marine living resources and that providing feedback to the observers on how the collected data are used for the management is also important.

3.37 The Working Group noted that observers are sometimes asked to support data collection that are the vessel's responsibility. The Working Group recalled 'Functions and tasks of Scientific Observers appointed in accordance with the Scheme of International Scientific Observation' described in Appendix 2 of the 'Scheme of International Scientific Observation Scientific Observer's Manual-Krill Fisheries' which clarifies SISO responsibilities and that these need to be conveyed to both the observers and the vessels to provide clarity on their responsibilities.

Fish by-catch observation

3.38 The Working Group noted the difficulty that observers face when they encounter high numbers and frequencies of by-catch species in their by-catch samples. The Secretariat clarified that occurrence of high by-catch levels is low, but it is important to ensure that accurate data are collected for these rare events.

3.39 The Working Group confirmed that by-catch should be sorted and weighed from the entire 25 kg subsample. If it is impractical to measure and count all individuals of a species due to large numbers, then observers may only measure an agreed threshold number of individuals (e.g., 200 individuals per species) which could then be scaled using the total weight of the subsample for the species to determine a total sampled number and length composition. The Working Group noted that more work could be needed to determine the sample number required and that changes to the observer form could be required (see paragraph 3.41 (iii)).

3.40 The Working Group noted that some data collected by observers are rarely used or are currently being collected because they were previously required to address specific questions. Additionally, some data fields in the observer logbook may need modification to improve the clarity and reduce the uncertainties in the observation.

3.41 The Working Group reviewed the krill observer logbook and recommended that:

(i) The 'feeding colour' column be removed from the 'krill biological' tab, as this data is not used.

(ii) Add 'unknown,' and make it a default, in the 'krill biological' tab under the 'maturity stage' pulldown menu

(iii) Add 'subsampled number and weight' columns in the 'by-catch sampling' tab to make extrapolation possible in case the observer encounters high numbers of by-catch and needs to subsample the species.

3.42 The Working Group noted that otoliths of toothfish are valuable for stock assessment and the understanding of life history, and therefore retaining such samples when toothfish are in the by-catch may be valuable. The Working Group further noted that a mechanism to deliver these otoliths to Members ageing toothfish would need to be developed.

3.43 The Working Group agreed that fish by-catch in the krill fishery provides an excellent opportunity to inform studies of early life history of fishes in the Convention area, and discussed the value of having "focus species" on which to collect biological data, especially on early life stages, from fish by-catch in the krill fishery (e.g., during a "Year of *C. gunnari*" collection of biological data could be prioritized for this species). The table of prohibited species for directed fishing in Area 48 in CM 32-03, combined with analyses of fish by-catch data to understand the distributions of bycaught fishes, provide useful guidance to decide on priority by-catch species for focused data collection.

Krill length-frequency data collection protocol

3.44 The Working Group endorsed the updated krill length-frequency data (LFD) collection protocol developed by WG-EMM and WS-KFO and recommended the Scientific Committee consider them be included in the krill observer manual, and further made the following comments.

(i) Seasonal length-frequency and maturity data are essential for the development of a Krill Stock Hypothesis and informing future length-based stock assessments of krill, and hence decision making related to krill-fishery management.

(ii) Requirements for minimum numbers of measurements and levels of precision depend on the questions to be addressed. The Working Group clarified that there will be multiple types of data analysis, with specific analyses depending on the questions being addressed, and data requirements may change as these analyses progress.

3.45 The Working Group recommended that the current requirement to measure the length of at least 200 krill should be continued until otherwise advised based on a review of research questions and data-collection needs, to be completed by each Working Group (see paragraphs 3.47 and 3.48).

Priority data collection in the krill fishery

3.46 The Working Group noted that this was the first occasion that estimated observer time allocation for tasking in the krill fishery had been summarised. The Working Group clarified that estimates of total time required for observers in the krill fishery to complete tasks are based on a time budget for one experienced observer. It is estimated that time required to complete all tasks is 14.5 hours and 12.2 hours for continuous and traditional trawlers respectively, assuming all tasks are completed once in a single day. However, as every task is not necessarily undertaken every day, the actual average daily time required for the observers to undertake tasks as specified in conservation measures is approximately 6.5 to 7 and 4.2 to 4.7 hours respectively for continuous and traditional trawlers under the current SISO program depending on the time of year.

3.47 The Working Group agreed on the usefulness of Table 1 from SC-CAMLR-42/05 as a guidance to design sampling instructions for the observers so that data collection can be as efficient as practicable and achieve levels of sampling and data-quality standards required for the management of CCAMLR fisheries, while ensuring the wellbeing of the observers.

3.48 The Working Group noted that WG-EMM, WG-ASAM, WG-IMAF and WG-SAM may have additional and different priorities for data collection from the krill observer program, all of which may lead to different requirements for data resolution and the types of data to be collected. For example, WG-EMM has data-collection needs for the development of a Krill Stock Hypothesis, and WG-ASAM requires krill LFD for fishery-based acoustic biomass estimates. Therefore, to establish a data-collection plan across all Working Groups the Scientific Committee may need a list of data requirements from each Working Group.

3.49 The Working Group recommended that the Scientific Committee task all Working Groups to review their list of priority questions, within their respective Terms of Reference, that need to be addressed from krill-fishery observer data. The Working Group recommends that all Working Groups provide details of data requirements to include number of samples and the spatial and temporal scales required to address these questions.

3.50 The Working Group noted that once a list of data collection requirements to address the priority questions from all Working Groups had been compiled, the Scientific Committee consider assigning priorities to the data collection tasks taking into account the wellbeing of the observers with regards to their workload.

Fish

Trend analysis rules

4.1 WG-FSA-2023/71 summarised the method to link tagged, released and recaptured toothfish and skates in the tagging database held by the Secretariat. The paper noted that over 98% of the tags recaptured were linked to their release event and that improvements to that percentage were generally small because the overall data quality was high, particularly in recent years. The paper also presented a summary of tagged fish movements as requested by WG-FSA (WG-FSA-2022, paragraph 4.10).

4.2 The Working Group thanked the Secretariat and noted that detailed reports would only be needed when the integrated toothfish assessments are updated or an important change to the analysis is conducted.

4.3 The Working Group noted that the summary of tagged fish movement was useful to help understand potential stock connectivity between areas. The Working Group requested that the Secretariat add the biological information of tagged fish and diagrams of fish movement presented in WG-FSA-2023/71 to the Fishery Reports (in the relevant Species Descriptions) and consider publishing a paper on the analysis of movements of tagged fish in the scientific literature in collaboration with interested Members.

4.4 The Working Group noted that investigating historical tagging data quality issues might be a suitable topic for a future scholarship project.

4.5 WG-FSA-2023/05 presented biomass estimates for research blocks in data-limited fisheries using the trend analysis decision rules, following provisional estimates that were presented to WG-SAM-2023 (WG-SAM-2023/16).

4.6 The Working Group thanked the Secretariat for the work and noted that IBSCO bathymetry data are presented at a finer resolution then GEBCO bathymetry data and could be evaluated for use in the seabed area calculations for the trend analysis.

4.7 The Working Group recommended catch limits for research blocks in data-limited toothfish fisheries for the 2023/24 season using the trend analysis decision rules as given in Table 4.

4.8 The Working Group noted the latest vulnerable biomass estimates as will used for the trend analysis calculations next year for Division 58.5.2 and the Ross Sea region; in Division 58.5.2 (assessment presented in WG-FSA-2023/26 Rev. 1), the 2023 estimate was 25 043 tonnes (CV 0.0976), and in the Ross Sea region (assessment presented in WG-FSA-2023/13), the 2023 estimate was 89 809 tonnes (CV 0.0594).

4.9 WG-FSA-2023/08 described Agent-Based Models (ABMs) to support Management Strategy Evaluations (MSEs) of the CCAMLR trend analysis and illustrated the core components of the model as recommended by WG-SAM-2023, paragraph 7.3(i).

4.10 The Working Group noted that the development of ABMs had been requested by WG-FSA (WG-FSA-2022, paragraphs 4.66 to 4.67), and that the paper was helpful to aid understanding of how ABMs work.

4.11 The Working Group recalled that ABMs can have advantages over other approaches because the model can accommodate "memory", where past events can be used to influence future events among groups of individuals in the model, allowing the ABM framework to simulate processes such as site fidelity and migration scenarios, and evaluate how these may affect the Chapman estimates of biomass.

4.12 The Working Group noted the recommendations of WG-SAM (WG-SAM-2023 paragraph 7.3(iii)) that in addition to the ABM, other approaches of simple and medium complexity be developed to be compared with the ABM approach in management strategy evaluations (MSEs).

4.13 The Working Group recalled that WG-SAM-2023 (paragraphs 7.3 to 7.4) included a list of tasks to further the ABM work and encouraged Members to collaboratively engage on this work program using a dedicated e-Group as recommended (WG-SAM-2023, paragraph 7.4).

Age determination

4.14 WG-FSA-2023/43 Rev. 1 presented the report of the Age Determination Workshop (WS-ADM-2023), co-convened by Dr P. Hollyman (United Kingdom) and Dr J. Devine (New Zealand), held virtually from 9 to 11 May 2023, and attended by 36 participants from 12 Members. The workshop terms of reference were outlined in WG-FSA-2022 paragraph 4.20. The report noted that progress had been made against all the terms of reference, but that assistance was needed from WG-SAM and WG-FSA to progress several tasks. To further develop age determination and quality control procedures, an in-person workshop with ageing experts from each lab was recommended to assess agreement on otolith age interpretation and to develop agreed reference sets for the different processing methods.

4.15 The Working Group welcomed the report (Appendix D) and the progress made in ageing methodologies. The Working Group agreed that a second ageing workshop should be conducted to bring together ageing experts to develop best practice guidelines and reference sets. The Working Group noted the tasks the Workshop had asked WG-FSA to consider for their work plan.

4.16 The Working Group recommended that when ageing otoliths for the next workshop, different laboratories age the same otoliths (using sister otoliths if different processing methods are used), read them without knowledge of fish length, area, or other biological characteristics, and complete an evaluation of reader comparison for WG-SAM-2024 and conduct statistical analyses such as estimating CVs.

4.17 The Working Group recommended the Secretariat address recommendations in paragraphs 6.1.2 and 6.1.3 of the paper when developing the ageing database and otolith library (Appendix D, Table 3).

4.18 The Working Group recommended that the Scientific Committee consider the following recommendations from the Age Determination workshop:

(i) All papers that use production ageing data include the distribution of the readability scores, add readability scores to inter-reader comparison plots to indicate where potential biases may arise, and standardise reporting methods, such as by creating common scripts to be added to the CCAMLR GitHub or to the e-Group for the Workshop on Age Determination (WG-FSA-2023/43 Rev. 1, paragraph 2.12.5)

(ii) the Scientific Committee resurrect the CCAMLR Otolith Network for Members to exchange knowledge and work together for ageing purposes (WG-FSA-2023/43 Rev. 1, paragraph 2.17.1)

(iii) Members continue to work on age validation methods, particularly for non-toothfish species (WG-FSA-2023/43 Rev. 1, paragraph 3.1.1)

(vi) Members create sets of up to 60 high-quality images, including notations (where currently available), for each species they age, beginning with toothfish, which will then be used by to build the reference otolith set (WG-FSA-2023/43 Rev. 1 paragraph 7.1.1)

(v) Members submit otolith images for Antarctic and Patagonian toothfish to the Secretariat by 1 March 2024 (WG-FSA-2023/43 Rev. 1 paragraph 7.1.2).

4.19 The Working Group recommended that WG-SAM consider paragraphs 2.12.3 and 2.16.2 in WG-FSA-2023/43 for inclusion in their workplan in 2024 and give this work a high priority (Appendix D, Table 3).

4.20 The Working Group recommended that the Scientific Committee support the second Workshop on Age Determination Methods (WS-ADM2). The workshop would be conducted in-person and provide a Conveners' report that details the ages agreed by the Workshop for a reference set of otoliths.

4.21 The Working Group recommended the Scientific Committee endorse the WS-ADM2 arrangements, objectives and terms of reference as detailed in the Proposal for a workshop for age determination (Appendix E).

4.22 Paper WG-FSA-2023/12 presented an alternate, lower cost method for preparing toothfish otoliths, and length and age composition data and growth curves for Antarctic toothfish in the Ross Sea region caught by the Russian longline vessel, *Sparta*, in the 2018/19 season.

4.23 The Working Group thanked the author for the paper and noted that new approaches to reduce the cost of preparing otoliths was welcome, but that the paper did not address the health and safety issues with this approach, which are very important. The Working Group noted that it was helpful to have more Members ageing otoliths and that validation of age data was important to ensure ages are consistent with other data from the same area.

4.24 The Working Group recalled that large numbers of otoliths had been collected in the Amundsen Sea by Russian vessels (WG-FSA-2023/62, Table A2.2 and Appendix 4) and encouraged ageing of these otoliths be given a high priority once reference set ages had been validated. The Working Group encouraged Russian age technicians to take part in the next Age Determination Methods Workshop (paragraph 4.16).

4.25 The Working Group noted that growth relationships using data from individual vessels or years should determine whether they are consistent with similar work and, if different, investigate potential causes for the difference, and that when presenting statistical analyses, that more detail is needed, such as the error distribution, whether otoliths were randomly selected for ageing, and whether the age composition was scaled to the catch.

Tagging workshop

4.26 SC-CAMLR-42/03 presented the report of the COLTO–CCAMLR Tagging Workshop held in Hobart, Australia, 14 to 17 March 2023. The workshop had requested that WG-FSA consider:

(i) requesting observers record details of fish handling aids and other tagging equipment using video clips and photos which could be helpful in designing and communicating innovations across the fleet

(ii) reviewing an increase in the minimum tag-size overlap statistic (currently 60%)

(iii) advising on how to incorporate depredation on tagged fish within the stock assessment.

4.27 The Workshop requested that the Secretariat consider and develop proposals to progress the following recommendations:

(i) including information on tagging procedures, which was part of a survey carried out from 2019 to 2020 by the Secretariat but did not include all vessels, as part of the fishery notification process to aid in documenting and better understanding tagging performance among vessels

(ii) updating the Commercial Data Collection Manual – Longline Fisheries to include guidance for holding tank design subject to vessel configuration constraints

(iii) including a viability assessment of the fish kept in holding tanks to be included in the Commercial Data Collection Manual – Longline Fisheries and that the tagging training manual be updated to reflect the categories for fish fate, matching those in the electronic logbooks

(iv) collecting additional information on release operations from vessels using moon pools to understand how their use might affect release mortality of toothfish and skates

(v) using shortened alpha-numeric sequences on tags in the future as this could potentially reduce transcription errors

(vi) developing a list of common tag release and recapture data errors to be included as part of the tag training manual, as this would assist those collecting tagging data in identifying part of the process that were error prone

(vii) considering a mechanism to enable the reporting of a subset of information on tag recaptures directly to vessels upon request, to further engagement in the CCAMLR tagging program.

4.28 The Working Group recommended updating both the Commercial Data Collection Manual – Longline Fisheries and the Observer Longline Manual to specify the conditions that exclude fish from being tagged and released and to specify guidelines regarding the recapture of tagged fish (SC-CAMLR-42/03, paragraph 2.38)

4.29 The Working Group noted that observers currently record information on tagging aides used by vessels and that COLTO is currently exploring providing a reward innovation and improvements in equipment designed to recover fish in the best condition during landing.

4.30 The Working Group recalled that CapMarine agreed to revise the observer tagging training manual including its translation, and COLTO had agreed to translate any needed materials for the vessel (Appendix F; WS-TAG-2023, paragraph 2.12; WS-TAG-2023, Appendix E).

4.31 The Working Group suggested that both self-sticking and waterproof paper posters could be created by the Secretariat for the vessels and distributed with tagging kits.

4.32 In discussing tagging fish representative of the size distribution of the catch (paragraph 4.26), the Working Group recalled that WG-SAM-12/24 had investigated the tag overlap statistic and determined that a high overlap statistic was needed to improve precision in the assessments. The Working Group noted that only 5% of the vessels had a tag overlap statistic less than 60% since the 2019 season and that the mode was at 85% (Figure 2).

4.33 The Working Group noted that there were valid reasons that a lower tag overlap statistic could occur, and that reporting on this to the Working Group would improve understanding of these factors and enable targeting additional training resources to vessels as required (SC-CAMLR-42/03, paragraphs 1.14 and 2.44).

4.34 The Working Group recommended the Scientific Committee set a target tag overlap statistic of 80% while maintaining the current 60% minimum threshold for compliance. Members of vessels achieving between 60 and 80% would be notified by the Secretariat and report to WG-FSA for review to better understand the issues causing a low tag overlap statistic.

4.35 The Working Group recalled WG-SAM-2023/18, which highlighted that non-random sampling may introduce bias in length frequency distributions of the catch (WG-SAM-2023, paragraph 5.5). The Working Group agreed with WG-SAM-2023, which recommended the Secretariat amend the biological sampling forms to record if the sampling associated with a biological sample was random or non-random.

4.36 The Working Group recommended that CM 41-01 Annex C paragraph 2(i) link to the best practice tagging protocol, (Appendix G), that CM 41-01 Annex C paragraph 2(v) remove reference to the 'Year of the Skate' and instead link to the best practice tagging protocol (Appendix G). The Working Group noted that changes are needed to the observer manual that reference these changes.

4.37 The Working Group recommended that Scientific Committee consider the following recommendations from SC-CAMLR-42/03 relative to the tagging programme for inclusion in working group workplans in 2024:

(i) the method used by the vessel in selecting fish to be tagged be recorded in the observer's cruise report (SC-CAMLR-42/03, paragraph 2.6)

(ii) explore options to improve quality and linking of historical tagging release and recapture data, potentially through a scholarship

(iii) develop fishery- and vessel-specific tag shedding rates to identify vessels which can benefit from additional training.

4.38 WG-FSA-2023/74 presented the reconciliation of the *Dissostichus* spp. Catch Documentation Scheme (CDS), and monthly fine-scale catch and effort data. The Secretariat had been asked to review the thresholds by WG-FSA-2022 (paragraph 3.6) to determine whether the relative (10%) and absolute (200 kg) thresholds were appropriate to identify records for further investigation. These thresholds were able to identify that 30% of records had a weight difference of 200kg or less and 88% had a percentage difference in weight of 10% or less and asked for advice from WG-FSA on whether these thresholds should be kept or revised.

4.39 The Working Group thanked the Secretariat for their work and noted that some errors will occur because of conversion factors, but that the new C2 form and e-CDS upgrade has been designed to eliminate some of these issues. The Working Group recalled that since reconciliation had begun, many Members had begun to report on their own reconciliations undertaken during inspections of their vessels which has resulted in better reporting. The Working Group noted that reporting of catches from Subareas 88.1 and 88.2 in CDS documents had often been problematic due to the confusion arising from the management of the Ross Sea crossing the two Subareas.

4.40 The Working Group noted that the current thresholds captured most problems and that there was no need to modify the thresholds. The Working Group recommended that future reconciliations be kept to the last two years, and that the current thresholds of a relative (10%) and an absolute (200kg) difference were appropriate to identify records for further investigation.

Incorporation of climate change in advice

4.41 WG-FSA-2023/63 presented a summary of the report from Australia's Heard Island and McDonald Island Fishery Climate Change Adaptation Workshop and introduced the Handbook for the Adaptation of Fisheries Management to Climate Change, which had been presented to the Climate Change Workshop (WS-CC-2023/02). The Handbook outlines adaptive and ecosystem-based management approaches designed to guide fisheries managers, scientists and industry through a risk assessment process to identify options for responding to climate change. WS-CC-2023 (paragraphs 2.10 to 2.11) noted that the approach provided by this handbook could be used for initial risk assessments of stocks within CCAMLR and WG-FSA was asked to review the suitability of the approach for application to CCAMLR's adaptation of fisheries management to climate change.

4.42 The Working Group noted the approaches presented would provide a useful framework for CCAMLR to develop a similar approach to determine the effects of climate change on the management of CCAMLR's resources. The Working Group further noted that the handbook could be part of a toolbox on the theme of climate change. It noted that stock assessments should summarise parameters that might be affected by climate change, the underlying trends or patterns in those parameters, and whether assessments were currently integrating any trends (paragraph 4.44).

4.43 The Working Group noted two long-term survey series undertaken within the Convention Area (WG-FSA-2023/45 and WG-FSA-2023/49) have not detected any substantial change in fish species composition. However, the Working Group noted that the shift in range for many species could be a gradual process, and that long-term data series on species composition are valuable to detect range shifts or new species entering the Convention Area.

4.44 The Working Group noted paper WS-CC-2023/20 which built on the advice from paragraph 3.51 of SC-CAMLR-XXXVII to provide a template to document changes to parameters and productivity assumptions through time. The Working Group reviewed and refined the table, noting that not all the parameters suggested could be precisely measured. The Working Group further noted that whilst trends in parameters may be observed, it may not be possible to determine the underlying drivers.

4.45 The Working Group considered the recommendations from WS-CC-2023, including investigations of temporal trends in biological parameters. As a practical approach to this issue, it developed an example of a table of parameters and processes that could be investigated within stock assessments (Table 5), which could be included in future iterations of the stock annex for each fishery.

4.46 The Working Group noted that climate change is now explicitly included in the terms of reference for WG-FSA and recommended its inclusion as an agenda item in future meetings.

General considerations of integrated toothfish stock assessments

4.47 The Chair of the Scientific Committee, Dr D. Welsford (Australia) presented a summary and a list of recommendations from the 2023 independent review of CCAMLR toothfish assessments (SC-CAMLR-42/02 Rev. 2). As recommended by the Scientific Committee in 2022 (SC-CAMLR-41 paragraph 4.39), the independent review of CCAMLR toothfish stock assessments was conducted in August 2023 by a panel of three independent reviewers provided by the Centre for Independent Experts. The review considered the assessments of *Dissostichus eleginoides* in Subareas 48.3 and 48.4, and Division 58.5.2, and *D. mawsoni* in the Ross Sea region. Based on the papers provided and the discussions conducted online with CCAMLR scientists, the independent review panel concluded that the assessments reviewed were consistent with global best practice and constituted the best available science for CCAMLR to make decisions regarding the status and catch limits for these stocks.

4.48 The Working Group expressed gratitude to all scientists involved as this endeavour had required significant time and effort. It noted the panel's recommendations, including on the transition to the use of Casal2 software, the estimation of biological parameters, the generation of fishery-independent data, analyses of parameter trends in space and time, incorporation of environmental and ecosystem parameters, evaluation of biases introduced by interannual spatial patterns in fishing effort and tagging data, undertaking retrospective analyses, exploration of alternative methods for determining recruitment used in projections, investigations of alternative decision rules, and use of Management Strategy Evaluations (MSE).

4.49 The Working Group further noted that the review panel concluded no evidence of statistical trends in biological parameters such as size at maturity or size at age were evident in Subarea 48.3. It also noted that there was no evidence that size or maturity of catches were misrepresented in the assessment models, and the fact that all toothfish fisheries catch a proportion of juvenile fish was accounted for in the estimate of stock status and catch limits and was consistent with CCAMLR decision rules. The independent review panel concluded that the 2021 assessment for *D. eleginoides* in Subarea 48.3 was consistent with best practice and the best available science to estimate status and catch limits in this fishery.

4.50 The Working Group noted that significant progress has been made to address the recommendations of the 2018 independent review (SC-CAMLR-XXXVII/02 Rev. 1), and that this had been recognised by the 2023 independent review panel. The Working Group also noted that the transition from CASAL to Casal2 was recommended by the 2023 independent review panel, and this work had been completed with this year's assessments (WG-FSA-2023/13, WG-FSA-2023/15 Rev 1., WG-FSA-2023/17, WG-FSA-2023/18, WG-FSA-2023/26 Rev 1.).

4.51 The Working Group recommended that the Scientific Committee note the conclusion by the independent review panel that the reviewed integrated assessments for *D. eleginoides* in Subareas 48.3 and 48.4, and Division 58.5.2, and *D. mawsoni* in the Ross Sea region were consistent with global best practice and constituted the best available science for CCAMLR to make decisions regarding the status and catch limits for these stocks.

4.52 The Working Group summarised its responses to the summary recommendations in SC-CAMLR-42/02 Rev. 2 to guide future stock assessment work in Table 6 and developed a high priority workplan (paragraphs 4.52-4.59).

Work programme for addressing issues in the integrated toothfish stock assessments

4.53 The Working Group discussed the effects of spatial distribution of fishing effort and tag-recapture data on abundance and recruitment estimates from stock assessments. The Working Group also noted that several of the integrated assessments showed strong trends in the recruitment estimates over time.

4.54 To evaluate the impact of tagging data on biomass and recruitment estimates in the stock assessment over time, a 'tagging retrospective analysis' was conducted during the meeting, where tagging data were incrementally removed year-by-year from the 2023 stock assessments in Subarea 48.3, Division 58.5.1, Division 58.5.2 and the Ross Sea. The results of these analyses are presented for each stock below.

4.55 The Working Group noted that the tagging retrospective analyses suggested changes of biomass and patterns of relative recent recruitment that may reflect the effect of a spatial bias due to changes in the spatial distribution of the fishing effort.

4.56 The Working Group noted that assumptions of future recruitment strongly influence the management advice resulting from the integrated stock assessments.

4.57 The Working Group recommended that the Scientific Committee undertake work to evaluate biases introduced by interannual spatial patterns (specifically those identified from the tagging retrospective analyses), exploration of alternative methods for determining recruitment used in projections, investigations of CCAMLR decision rules with MSE (paragraph 4.58). The Working Group recommended that these were high priority items and should be progressed with urgency over the short term.

4.58 While more specific recommendations for each assessment are given in the following sections of the report, the Working Group recommended the following work be conducted, with methods to be presented to WG-SAM-2024 and then conclusions of the research to WG-FSA-2024:

(i) Analyses of current and alternative decision rules, including building on the work of WG-FSA-2019/08, WG-SAM-2021/08, SC-CAMLR-38/15 and WG-FSA-2023/28 to investigate alternative rules and assumptions about future recruitment, and addressing the recommendations 6.1 and 6.2 of the report of the independent review (SC-CAMLR-42/02 Rev. 2)

(ii) Work towards estimating and correcting for the effect of changing spatial distribution of fishing effort in assessments, including:

(a) an analysis of the spatial and temporal patterns of fishing effort, and tag release and recapture data

(b) localised and stock-based estimates of abundance using Chapman estimators to be included as abundance time series as an alternative to the inclusion of individual tag release and recapture data

(c) sensitivity tests when including alternative time series of tag-recapture information in the Casal2 stock assessments

4.59 The Working Group recommended that Members conducting these assessments work collaboratively over the intersessional period and develop approaches to addressing the high priority and urgent concerns identified above.

4.60 The Working Group agreed that the assessments will need to be revised with models that address the issues identified in the priority workplan (paragraphs 4.53 to 4.59). Specifically in Subarea 48.3, Division 58.5.1, Division 58.5.2 and the Ross Sea the revisions will be needed in the short term.

Secretariat verifications of CASAL and Casal2 model runs

4.61 In assessment years, the Secretariat verifies that stock assessments submitted to WG-FSA using CASAL (Table 7) are reproducible, using a three-step verification process:

(i) CASAL version: all assessments are required to use the same version of CASAL for WG-FSA-23 all assessments used CASAL v2.30-2012-03-21 rev.4648;

(ii) Parameter files verification: the files population.csl, estimation.csl and output.csl used in each assessment reported in meeting papers are used as inputs to a CASAL run performed by the Secretariat. If no errors are reported during the process, the files are considered as verified;

(iii) Maximum Posterior Density (MPD) estimate verification: the virgin spawning stock biomass (B_0) estimate produced by a given model run is compared to that reported in the accompanying meeting paper.

4.62 CASAL versions and parameter files were successfully verified for the CASAL assessments submitted to WG-FSA in 2023. Verifications of the MPDs produced the same B_0 estimates as supplied (Table 7).

4.63 The Secretariat verified Casal2 assessments following the WG-SAM guidelines (WG-SAM-2022, Appendix D, Part A; noting the re-wording of step (iii) for clarity). Part A of the verification process requires that the Secretariat verify that the Casal2 parameter files can be used to reproduce the key results reported by those papers and confirm that:

(i) from a simple run (casal2 -r), the software used in the assessment accepts the input files and produces no error messages

(ii) from an estimation run (casal2 -e), the parameter files match the MPD results reported in the assessment papers

(iii) using the proposed yield from MCMC projections, the risks (1 and 2) are consistent with the decision rules

(iv) the accepted base case from the previous accepted assessment passes the above validation using the current version of software and uses the total objective function and B_0 @assert commands in the configuration files; and confirm that the proposed assessment models contain equivalent @asserts for testing in future years.

4.64 All steps but (iv), since this is the first iteration of Casal2 assessments producing advice and cannot be compared to those assessments using previous versions of Casal2, were successfully verified (Table 8).

4.65 The Working Group recommended future Casal2 stock assessment reports include a table collating the values to be verified (Table 9), with, for the purpose of the Secretariat verifications, MPD values rounded to the nearest integer and risks rounded to two significant digits.

Area 48

Champsocephalus gunnari in Subarea 48.3

4.66 The fishery for mackerel icefish (*Champsocephalus gunnari*) in Subarea 48.3 operated in accordance with CM 42-01 and associated measures. In 2022/23, the catch limit for *C. gunnari* was 1 708 tonnes. Details of this fishery and the stock assessment of *C. gunnari* are contained in the Fishery Report (https://fisheryreports.ccamlr.org/).

4.67 The Working Group noted that in recent years, low amounts of fishing effort were being deployed in Subarea 48.3 and that this had resulted in very low catches by the fishery.

4.68 WG-FSA-2023/45 reported on a bottom trawl survey in Subarea 48.3 in February 2023, that the UK undertook as part of its regular monitoring program. The mean biomass of *C. gunnari* was estimated at 61 567 tonnes. The survey caught *D. mawsoni* (2) for the first time in the survey history.

4.69 The Working Group noted that both *C. gunnari* and *D. eleginoides* showed high estimates of biomass in this survey and recommended including time series of relative biomass indices for these species and other prominent species in future iterations of the survey reports.

4.70 WG-FSA-2023/38 presented an assessment for *C. gunnari* in Subarea 48.3 fitting a length-based assessment in R with the FLCore package using the results of the trawl survey described in WG-FSA-2023/45. Projecting forward from the lower 5th percentile of biomass resulted in yields of 5 138 tonnes for 2023/24 and 3 579 tonnes for the 2024/25 season. These yields allow for 75% escapement of the unfished projected biomass and satisfy the CCAMLR decision rules.

4.71 WG-FSA-2023/60 presented a Stock Annex describing the method used in the assessment presented in WG-FSA-2023/38, intended as a public-facing document for inclusion with the fishery reports on the CCAMLR website.

4.72 The Working Group recommended that the Stock Annex be included in the fishery reports on the CCAMLR website.

Management advice

4.73 The Working Group recommended that the catch limit for *C. gunnari* in Subarea 48.3 should be set at 5 138 tonnes for 2023/24 and 3 579 tonnes for 2024/25 seasons.

4.74 WG-FSA-2023/44 and WG-FSA-2023/46 presented results from a survey conducted by Argentina in Subarea 48.3. The papers covered a range of research undertaken in the survey, including oceanography, acoustic and zooplankton sampling, biogeochemistry, and fish sampling. The papers noted that fish sampling was hindered by the adverse hydrometeorological conditions experienced by the cruise, as well as the difficulty of the underwater topography for carrying out the hauls leading to the net being damaged.

4.75 The Working Group noted the large amount of work on a wide range of research issues was undertaken during the survey. It also noted that the acoustic data may be useful to WG-ASAM in developing the krill fishery management in this area, particularly in relation to the krill detected near the seafloor. The Working Group further noted that despite the low sample sizes due to trawl gear issues, the length compositions of icefish measured in this survey were consistent with those presented in WG-FSA-2023/45.

4.76 The Working Group noted the survey had many objectives which had been achieved, however the survey only caught a single *D. eleginoides* so the specific objectives concerning spatial distribution and length composition of that species could not be addressed.

4.77 WG-FSA-2023/61 presented analyses of reproductive potential of three icefish species (*C. gunnari, Pseudochaenichthys georgianus, Chaenocephalus aceratus*) and *Notothenia rossii* sampled during the survey described in WG-FSA-2023/46. The results were generally consistent with those of the previous Argentinian survey in this Subarea undertaken in 2013 (WG-FSA-2013/59).

4.78 The Working Group noted the utility of research into reproductive potential, but suggested the low sample sizes in this study may limit the power to accurately estimate the size at maturity of these species.

4.79 The authors noted that more research related to the environmental variables analysed (WG-FSA-2023/44) will be presented to the relevant Working Groups in 2024.

Icefish research survey proposal in Subarea 48.2

4.80 WG-FSA-2023/48 presented the results of an acoustic and trawl survey for *C. gunnari* undertaken in Subarea 48.2 by Ukraine. The paper noted that all components of the survey had been completed, however few *C. gunnari* were encountered. It further noted that the survey contained a large workload for the observers on board and thanked Australia for providing the 38-kHz acoustics equipment.

4.81 The Working Group recalled the discussion from WG-ASAM-2023 (paragraphs 7.1 to 7.4) regarding calibration of the acoustic equipment. The Working Group noted that the video data in the net combined with the acoustic data collected during the survey would be useful for detecting differences in krill distribution in the water column and recommended results be presented to WG-ASAM for consideration once analyses had been finalised.

4.82 WG-FSA-2023/03 presented a research plan notified under CM 24-01 for a continuation of the acoustic and trawl survey for *C. gunnari* in Subarea 48.2 in the 2023/24 and 2024/25 seasons. The authors noted during the meeting that due to vessel issues, research would not be undertaken in the 2023/24 season and that the research plan should be resubmitted next year (Table 10).

4.83 The Working Group recommended the research plan be considered by WG-ASAM-2024, requesting advice on any modifications to the survey which may facilitate the collected acoustic data being used in the Subarea 48.2 krill fishery management strategy.

Dissostichus eleginoides in Subarea 48.3

4.84 The catch of *D. eleginoides* in Subarea 48.3 in 2022/23 was 1 615 tonnes. Details of the fishery for *D. eleginoides* in Subarea 48.3 and the stock assessment are contained in the Fishery Report (https://fisheryreports.ccamlr.org/).

4.85 WG-FSA-2023/15 Rev. 1, along with WG-FSA-2023/16, WG-FSA-2023/31 and WG-FSA-2023/56, presented an updated integrated assessment model for *D. eleginoides* in Subarea 48.3 using Casal2, associated diagnostics, the characterization of the toothfish fishery in Subarea 48.3 and the stock annex. WG-FSA-2023/15 Rev. 1 indicates that the current status of the stock is at 47% of B_0. Projections indicate that a constant catch of 2 000 tonnes in the 2023/24 and 2024/25 seasons would be consistent with the CCAMLR decision rule after accounting for recent mammal depredation rates.

4.86 The Working Group noted the large amount of work presented and involved in transitioning to Casal2. It also noted the autocorrelation in some MCMC chains for the survey selectivity parameters and recognised that it might be related to the inclusion of the survey data as proportions at length.

4.87 The Working Group noted that the projection uses the lognormal empirical randomisation method of recruitment estimated using recruitment strengths from 1993 to 2016, but with the application of a multiplier of 0.85 to reflect the previous CASAL projections.

4.88 The Working Group noted that the package R4casal2 has been very useful in producing diagnostics, and that using a standard approach helped improve the comparability between different assessments.

4.89 The Working Group encouraged further work to investigate the effects of including survey and tag compositions by age rather than by length, and to investigate whether alternative survey selectivity parameterisation may be more appropriate.

4.90 The Working Group noted that the assessment continued to show trends in the likelihood profiles, with successive tag release events being consistent with smaller estimates of the initial spawning stock size B_0 (WG-FSA-2023/16, Figure 23).

4.91 The tagging retrospective analysis for this assessment conducted during the meeting indicated results which were consistent with the trends in the likelihood profiles, showing that the SSB_0 estimates throughout the assessment period increased as successive years of tag recaptures were removed. This was associated with trends in recruitment becoming less steep. After the removal of five years of tagging data, trends in SSB and SSB status showed a less steep decline in the final years of the assessment (Figure 3).

4.92 During the meeting, three sensitivity analyses based on the retrospective run with tagging data up to 2014 were also conducted. The MPD was projected forward with the proposed catch limit of 2 000 t from WG-FSA-2023/15 Rev. 1 and either the same recruitment assumptions as the assessment (0.85 multiplier applied to a lognormal-empirical distribution) or recruitments resampled from the last 10 years of the assessment. These runs resulted in SSB status at the end of the 35-year projection period being at 58% (lognormal) or 46% (10-year recent recruitment series) compared with 50% of SSB_0 using the assessment and forecast proposed for advice (Figure 4).

4.93 The Working Group recommended that the Stock Annex (WG-FSA-2023/56) be included as part of the Fishery Reports on the CCAMLR website.

4.94 WG-FSA-2023/15 Rev. 1 proposed that the catch limit for *D. eleginoides* in Subarea 48.3 be set at 2 000 tonnes for 2023/24 and 2024/25 (which corresponds to a total removal of 2 098 tonnes including depredation) based on the outcome of the assessment and the application of the decision rule.

4.95 The Working Group noted that although the catch limits follow the Decision Rule, catches at the level of this catch limit would be expected to reduce the stock status further below the 50% target in the short term, however spatial bias and patterns in recent recruitment make this conclusion uncertain.

Management advice

4.96 The Working Group recommended that the catch limit for *D. eleginoides* in Subarea 48.3 be set at 2 000 tonnes for the 2023/24 season based on the outcome of this assessment.

4.97 The Working Group recommended that the Scientific Committee require a revised stock assessment addressing the issues identified in the workplan (paragraphs 4.53 to 4.59) be provided to WG-FSA in 2024.

Dissostichus eleginoides in Subarea 48.4

4.98 The fishery for *D. eleginoides* in Subarea 48.4 operated in accordance with CM 41-03 and associated measures. The catch limit for *D. eleginoides* in Subarea 48.4 in 2022/23 was 23 tonnes and 5 tonnes were taken. Details of the fishery for *D. eleginoides* in Subarea 48.4 and the stock assessment are contained in the Fishery Report (https://fisheryreports.ccamlr.org/).

4.99 WG-FSA-2023/17, along with WG-FSA-2023/18, WG-FSA-2023/30 and WG-FSA-2023/57, presented a new Casal2 integrated assessment model and bridging analysis *D. eleginoides* in Subarea 48.4, associated diagnostics, the characterization of the toothfish fishery in Subarea 48.4, and the stock annex. The 2023 assessment included updated catch data to 2023 and observations to the end of 2022, minor data revisions, re-estimation of length-weight parameters, tag loss rates and inclusion of an updated maturity ogive. It indicated that the current status of the stock is at 59.5% of B_0. Projections indicate that a constant catch of 19 tonnes in the 2023/24 and 2024/25 seasons would be consistent with the CCAMLR decision rule as it would achieve 64% of B_0 after a 35-year period.

4.100 The Working Group welcomed the updated assessment and noted that the proposed catch limit was based on projections that achieve an SSB of 64% of B_0 after a 35-year period because recruitment was estimated to be sporadic, and there remains uncertainty about whether recruitment occurs within Subarea 48.4, or whether the recruitment comes from part of the Subarea 48.3 stock.

4.101 The Working Group noted there were variations in annual age-composition data as well as some spikes in the fits to tagging data by length which may in part be due to low fishing effort and sampling size.

4.102 The Working Group recommended that the stock annex (WG-FSA-2023/57) be included as part of the fishery reports on the CCAMLR website.

4.103 The Working Group noted that effort within Subarea 48.4 was spread consistently throughout the fishable area and so advice could be provided for two years.

4.104 WG-FSA-2023/17 proposed that the catch limit for *D. eleginoides* in Subarea 48.4 be set at 19 tonnes for 2023/24 and 2024/25 based on the outcome of the assessment and the application of the CCAMLR decision rules.

4.105 The Working Group agreed that a catch limit of 19 tonnes for *D. eleginoides* in Subarea 48.4 for 2023/24 and 2024/25 would be consistent with CCAMLR's decision rules.

Management advice

4.106 The Working Group recommended that the catch limit for *D. eleginoides* in Subarea 48.4 be set at 19 tonnes for the 2023/24 and 2024/25 seasons based on the outcome of this assessment.

Dissostichus mawsoni in Subarea 48.4

4.107 The fishery for *D. mawsoni* in Subarea 48.4 operated in accordance with CM 41-03 and associated measures. The catch limit for *D. mawsoni* in Subarea 48.4 in 2022/23 was 42 tonnes and 26 tonnes were taken. Details of the fishery for *D. mawsoni* in Subarea 48.4 and the stock assessment are contained in the Fishery Report (https://fisheryreports.ccamlr.org/).

4.108 WG-FSA-2023/39, along with WG-FSA-2023/30, presented an updated estimation of the local biomass of *D. mawsoni* in CCAMLR Subarea 48.4 from tagging returns, giving a five-year average of 1 130 tonnes since 2019. Applying the CCAMLR agreed precautionary assumption of setting harvest rates based on a 5-year average biomass, and harvest rate of γ = 0.038, results in catch limit of 43 tonnes for the 2023/24 season.

4.109 The Working Group recalled that a precautionary approach has been applied by treating *D. mawsoni* in Subarea 48.4 as a separate stock. Based on the biological characteristics of the catches in Subarea 48.4 and the surrounding regions, *D. mawsoni* around the southern South Sandwich Islands are hypothesised as being part of a much larger stock that extends south into Subareas 48.2, 48.6 and possibly 48.5. The current method of assessment, based on tag returns, consequently, is considered to provide an estimate of the local biomass.

4.110 The Working Group noted that the method was appropriate to assess local biomass and that an integrated stock assessment was not currently under development for the population of Antarctic toothfish in Subarea 48.4. It noted initial evidence of a northward shift *D. mawsoni* in Subarea 48.4 and that both *Dissostichus* species co-occur in other areas within the CAMLR Convention area such as in the northern parts of Subarea 88.1.

Management advice

4.111 The Working Group recommended that the catch limit for *D. mawsoni* in Subarea 48.4 be set at 43 tonnes for the 2023/24 season.

Research plans targeting *D. mawsoni* in area 48 notified under CM 21-02 or CM 24-01

4.112 The Working Group considered the advice of WG-SAM-2023 and reviewed updates on research plans in Area 48 that were presented in WG-SAM-23, considering the recommendations from WG-SAM-23 and the trend analysis results.

4.113 Research plans were evaluated against the agreed criteria outlined in WG-FSA-2019/55. The results following the review schedule presented in Table 10 are presented in Table 11.

4.114 WG-FSA-2023/36 set out a proposal by Chile to undertake research for *Dissostichus* spp. under CM 24-01 in Subarea 48.2 during the 2023/24–2025/26 seasons, previously submitted to WG-SAM-2023 (WG-SAM-2023/05). There are four specific objectives:

(i) explore the connectivity based on the modelling of spatial distribution, relative abundance, and length and age structure

(ii) review the fisheries potential impacts on dependent and related species

(iii) improve the hauling and tagging process to help with standardisation procedure

(iv) improve the knowledge of near-bottom and seabed marine ecosystems using scientific electronic monitoring.

4.115 The survey design is based on five fishing zones, 48.2 N and 48.2 S and areas A, B and C, with 12 sets distributed across four depth strata. For the 2023/24 season, the authors propose a total catch limit of 379 tonnes, divided into 150 tonnes for 48.2N and 48.2S and 229 tonnes for areas A, B, and C.

4.116 The Working Group noted the discussion from WG-SAM-2023 (paragraphs 8.2 to 8.9) and noted that it was unclear how this feedback had been fully incorporated into the revised research plan.

4.117 In particular, the Working Group noted the previous research activities on *Dissostichus* spp. undertaken by Ukraine (WG-FSA-2019/51), and the UK (WG-FSA-2021/22) on connectivity, catch rates, and *Dissostichus* species composition in this region of Subarea 48.2, as the proposed research area in WG-SAM-2023/05 overlaps with areas from these previous studies.

4.118 The Working Group noted it was unclear why most of the research objectives could not be completed with existing data in this region and recommended that this be undertaken to inform future research proposals based upon the results.

4.119 The Working Group further noted that integrating previous discussions from evaluations of research in Subarea 48.2 by WG-SAM and WG-FSA would assist in improving the planning of this research proposal.

4.120 In relation to the survey design, the Working Group noted that there had been some revisions to the proposal, taking into account the evaluation of WG-SAM-2023, but that this had not been fully addressed.

4.121 The Working Group noted that the distribution of the two species was mapped in WG-FSA-21/22, and that this information should be used in the survey design. The Working Group noted that small numbers of *D. eleginoides* had only been encountered in the northern portion of each of the areas defined in WG-FSA2023/36. The Working Group recommended that the location of the sets be redesigned not only by depth strata but also by target species distribution.

4.122 Although this research is designed to be effort limited, the WG-SAM-2023 recommended the calculation of a precautionary catch limit using CPUE obtained from previous research activities, and a CPUE-by-seabed area calculation. This information was not included in the revised proposal presented to WG-FSA.

4.123 WG-SAM-2023 noted that macrourids were likely to be the main by-catch taxa in this region and recommended that there should be some additional analyses undertaken on by-catch rates from previous research activities by Ukraine and the UK. The analysis was not included in the revised analysis presented to the Working Group. The Working Group further recalled previous advice that ten biological specimens per haul were insufficient rates of by-catch sampling (WG-FSA-2019, paragraph 4.166).

4.124 The Working Group noted that CM 41-05, CM 41-11, CM 22-06 and CM 22-07 are not applicable to the research plan outlined in WG-FSA-2023/36.

4.125 The Working Group noted that a representative from Chile was not present to answer questions about the research and recommended that a revised research plan be presented at WG-SAM-2024.

4.126 WG-FSA-2022/42 presented a report of multi-Member research on *D. mawsoni* conducted in Subarea 48.6 between 2012/13 and 2022/23 by Japan, South Africa and Spain, noting the achievement of the milestones detailed in the research objectives. The authors have now successfully transitioned from CASAL to Casal2 for assessing *D. mawsoni* at Subarea 48.6, and thanked NZ colleagues for their support in achieving this.

4.127 WG-SAM-2023/01 Rev. 1 provided an update to the efforts involved in the research plan pertaining to Subarea 48.6 in 2021/22–2023/24 under CM 21-02, paragraph 6 (iii) and evaluated in Table 11. The authors noted that South Africa will be unable to participate in fishing activities in 2023/24 due to vessel availability but would still be contributing to other milestones as planned. As a result of the reduction in the number of vessels from three to two, catch allocations were revised to ensure that the same amount of research would be achieved.

4.128 The Working Group recommended continuing the research fishing at Subarea 48.6 according to the research proposal in WG-SAM-2023/01 Rev. 1.

4.129 The Working Group recommended that the catch limits for Subarea 48.6 be based on the trend analysis as shown in Table 4.

Area 58

Champsocephalus gunnari in Division 58.5.2

4.130 The fishery for *C. gunnari* in Division 58.5.2 operated in accordance with CM 42-02 and associated measures. In 2022/23, the catch limit for *C. gunnari* was 2 616 tonnes. Details of this fishery and the stock assessment of *C. gunnari* are contained in the Fishery Report (https://fisheryreports.ccamlr.org/).

4.131 The results of a random stratified trawl survey in Division 58.5.2 undertaken during March 2023 were summarised in WG-FSA-2023/49. The survey-recorded catch of Patagonian toothfish (*D. eleginoides*) was 66.8 t, and the catch of mackerel icefish (*C. gunnari*) was 16 t.

4.132 The Working Group noted that estimates of assessed by-catch were within the range of abundance observed in previous surveys, and the species composition has not changed. The biomass estimates for *Channichthys rhinoceratus* were at the second-highest reported levels since 2012. Biomass estimates of grey rockcod (*Lepidonotothen squamifrons*) showed an increase in biomass over the 2022 estimate, but the biomass of *Macrourus* spp. remained stable. Murray's skate (*Bathyraja murrayi*) experienced an increase in biomass to the previous years' estimates whilst the estimated biomass for the other *Bathyraja* species was lower than last year.

4.133 WG-FSA-2023/10 presented a preliminary 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-2023/49. Bootstrapped biomass estimates had a mean of 16 127 tonnes, with a one sided lower 95% confidence bound of 10 092 tonnes, mainly comprised fish of age 3+. Projecting forward, the proportion of the one-sided lower 95th confidence bound of fish aged 1+ to 3+ (4 631 tonnes) gave yields of 714 tonnes for 2023/24 and 599 tonnes for 2024/25 that allow for 75% escapement and therefore satisfy the CCAMLR decision rules.

Management advice

4.134 The Working Group recommended that the catch limit for *C. gunnari* in Division 58.5.2 should be set at 714 tonnes for 2023/24 and 599 tonnes for 2024/25 seasons.

Dissostichus eleginoides in Division 58.5.1

4.135 The fishery for *D. eleginoides* in Division 58.5.1 is conducted in the French exclusive economic zone (EEZ) of the Kerguelen Islands. Details of the fishery and the stock assessment are contained in the Fishery Report (https://fisheryreports.ccamlr.org/).

4.136 WG-FSA-2023/67 Rev.1 presented an updated integrated assessment model for the Kerguelen Islands *D. eleginoides* fishery in Division 58.5.1 up to the end of 2021/22. Key additions and updates to the assessment model included the incorporation of data up to 2022, an updated calculation of the depredation rate (sperm whale and lice) and re-estimation of the stock recruitment variability by estimating year class strength using results from a four-year otolith reading program.

4.137 The Working Group supported the ongoing addition of aging data into the stock assessment as well as the proposed survey to be conducted in the coming season.

4.138 The updated assessment model run in CASAL estimated B_0 at 224 760 tonnes (95% CI: 206 390 – 249 520 tonnes). The estimated SSB status in 2022 was 66.3% (95% CI: 63 – 70.3%).

4.139 A comparative model developed in Casal2 demonstrated strong consistency in key results. A Casal2 model including updated historical tag-recapture data showed improved residuals between observed and expected number of tag recaptures (WG-FSA-2023/24 Rev. 1).

4.140 The Working Group welcomed the presentation of a Stock Annex for the Kerguelen Islands EEZ *D. eleginoides* fishery in Division 58.5.1 (WG-FSA-2023/59) and recommended that this be published as a part of the CCAMLR Fishery Report for this area.

4.141 During the meeting, additional sensitivities were run on tag recapture data. The MPDs of the retrospective runs with tagging data excluded year-by-year back to 2016, showed a small amount of change in patterns of SSB and percent SSB and limited changes in most recent recruits and year class strength between the retrospectives from 2016 to 2022 (Figure 5). The authors of WG-FSA-2023/67 Rev. 1 noted that changes observed shall be investigated in the short term in the light of a potential spatial bias in tag-recapture data.

4.142 The Working Group agreed that the catch limit set by France of 5 020 tonnes for 2023/24 that accounts for depredation was consistent with the CCAMLR decision rules for the model runs presented.

Management advice

4.143 No new information was available on the state of fish stocks in Division 58.5.1 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 2023/24.

4.144 WG-FSA-2023/28 explored how different recruitment projections under potential regime shifts in Patagonian toothfish stocks might influence associated SSB calculations. An investigation into whether re-estimation of SSB_0 according to stock productivity (dynamic SSB_0) might impact historical, current and future stock status. For this work, the Patagonian toothfish fishery in Division 58.5.1 was used as a case study.

4.145 Six different recruitment scenarios were considered:

(i) scenario R: lognormal distribution with a mean of 1 (method used in the current Kerguelen stock assessment) and a variance sampled from the range of observed values of recruitment between 2001 and 2017 (lognormal empirical method)

(ii) scenario R1: recruitment sampled from the whole series of recruitment (2000-2017) (empirical sampling method)

(iii) scenario R2: recruitment variations sampled from the 2000-2006 period (empirical sampling method)

(iv) scenario R3: recruitment variations sampled from the 2007-2017 period (empirical sampling method)

(v) scenario R4: recruitment variations sampled from the 2013-2017 period (empirical sampling method)

(vi) scenario R5: constant low recruitment for 2017-2030 and constant medium recruitment for 2031-2057.

4.146 Results from scenarios with the highest recruitment values (R2) were the most optimistic with regard to SSB_0 and stock status. Scenarios R and R1 were ranked behind this and resulted in stock status above 60% of SSB_0 in both cases. Results from scenarios R3 and R4 demonstrated different trajectories with resulting stock status of 28% and 34% of SSB_0 respectively. R5 provides a result which splits these two patterns in line with the differing scenarios that were used.

4.147 Re-estimation of SSB_0 according to stock productivity (dynamic SSB_0) produced a significant impact on past, current and future stock status. In general, scenarios with lower recruitments leading to lower SSB_0* corresponded to higher SSB stock status ratios.

4.148 The Working Group thanked the authors for this interesting and timely paper and strongly encouraged further development, testing and exploration of the themes covered.

Dissostichus eleginoides in Division 58.5.2

4.149 The fishery for *D. eleginoides* in Division 58.5.2 operated in accordance with CM 41-08 and associated measures. In 2022/23, the catch limit for *D. eleginoides* was 3 010 tonnes. Details of the fishery and the stock assessment are contained in the Fishery Report (https://fisheryreports.ccamlr.org/).

4.150 WG-FSA-2023/26 Rev. 1 presented an updated assessment for Patagonian toothfish (*D. eleginoides*) at Heard Island and McDonald Islands in Division 58.5.2. Starting with the 2021 assessment model that was used to provide management advice, this paper presents a bridging analysis and sensitivity analyses, and proposes a new assessment model for 2023. The 2023 assessment included updated catch data to 2023 and observations to the end of 2022, including new ageing data from the Random Stratified Trawl Survey (RSTS) and commercial fishery, re-estimated growth parameters, and an updated annual cycle to reflect the recent timing of the RSTS survey taking place prior to the main fishing season. The base-case model using Casal2 estimated B_0 at 64 520 tonnes (95% CI: 60 419 – 69 241 tonnes) and the current status (B2023) at 39.4% of B_0 (95% CIs 39.1 – 39.5% B_0). Based on the result of this assessment and the application of the CCAMLR decision rules, the paper recommended a catch limit of 2 660 tonnes for the 2023/24 and 2024/25 seasons.

4.151 The Working Group welcomed the updated assessment and noted a concentration in the spatial extent of fishing effort after 2018 and that in addition the spatial spread of releases showed small areas of high tagging concentration in 2018, 2020 and 2021. Since high spatial concentration of tagged and recaptured fish in small areas can strongly influence tag-based abundance estimators if individuals are unlikely to mix within the wider population, 323 individuals which had been subsequently recaptured in the same small areas had been excluded from the base-case assessment.

4.152 The tagging retrospective analysis for this assessment conducted during the meeting indicated that relative to tagging data up to 2018, tagging data after 2018 caused a downward bias on estimates of B_0, a more rapid decline in SSB status over the entire fishery period, and as a consequence a lower SSB status in 2023 (Figure 6). Estimates of spawning stock biomass in 2023 were 40% when using the tagging data up to 2022, 44% when using tagging data up to 2018, and 47% of SSB_0 when using tagging data up to 2014. The Working Group also noted that survey catchability q dropped from 1.21 when using all tagging data to more realistic levels below 1 in the tagging retrospective analysis (e.g., 0.90 when using tagging data up to 2018 and 0.83 when using tagging data up to 2014).

4.153 The Working Group further noted that the recruitment estimated by the stock assessment using tagging data up to 2018 decreased in the 1990s and increased to near average after 2010 compared to those estimated by the assessment with all tagging data (Figure 6). The Working Group noted that this pattern of elevated recruitment in recent years was more consistent with the observations from the trawl surveys.

4.154 The Working Group recalled that tagging data provide information on absolute abundance. It noted that the observed trends in estimated spawning biomass and recruitment by the tagging retrospective analysis could be explained by an increasing spatial concentration of tagging data which would result in much smaller biomass estimates in recent times compared to relatively large biomass estimates from earlier years. To account for this, the stock assessment estimated larger recruitment in the earlier part of the estimated time series and smaller recruitment in the latter part of the time series. This could have also resulted in a conflict between observations from trawl surveys and the tagging data.

4.155 During the meeting, two sensitivities based on the retrospective run with tagging data up to 2018 were also run. The MPD was projected forward with the catch limit of 2 660 t proposed by WG-FSA-2023/26 Rev. 1 and recruitment sampled from either the full estimated recruitment time series (1986 to 2017) or from only the last 10 years of estimated recruitment (2008 to 2017). These runs resulted in SSB status at the end of the 35-year projection period of 60% (1986 to 2017 recruitment) and 43% of SSB_0 (2008 to 2017 recruitment, Figure 7).

4.156 Based on these analyses, the Working Group noted that the stock status in 2023 may not be as pessimistic and the estimated recruitment may not have declined as strongly as that predicted by the stock assessment model presented in WG-FSA-2023/26 Rev. 1.

4.157 The Working Group noted that although the proposed catch limits follow the CCAMLR Decision Rules, catches at the level of the catch limit proposed in WG-FSA-2023/26 Rev. 1 would be expected to reduce the stock status further below the 50% target in the short term, however spatial bias and patterns in recent recruitment make this conclusion uncertain.

Management advice

4.158 The Working Group recommended that the catch limit for *D. eleginoides* in Division 58.5.2 be set at 2 660 tonnes for the 2023/24 season based on the outcome of this assessment.

4.159 The Working Group recommended that Scientific Committee require a revised stock assessment addressing the issues identified in the workplan (paragraphs 4.53-4.59) be provided to WG-FSA in 2024.

4.160 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 2023/24.

Dissostichus eleginoides in Division 58.6

4.161 The fishery for *D. eleginoides* at Crozet Islands is conducted within the French EEZ and includes parts of Subarea 58.6 and Area 51 outside the Convention Area. Details of this fishery and the stock assessment are contained in the Fishery Report (https://fisheryreports.ccamlr.org/).

4.162 WG-FSA-2021/45 presented an updated integrated CASAL assessment model for the Crozet Islands *D. eleginoides* fishery in Subarea 58.6 up to the end of 2021/22. Further model diagnostics were included in WG-FSA-2023/66. The assessment model updated the previous assessment model by (1) updating data to the end of 2021/2022, (2) updating depredation rates, (3) including catch-at-age data for the 2010-2022 period, and (4) estimating year class strength for 2000-2016. The base-case assessment model estimated B_0 at 51 570 t (95% CI: 49 900-56 160 t). The estimate of the current SSB was 69% (95% CI: 66.1-72.4%) and the current catch limit of 930 tonnes satisfied the CCAMLR decision rules.

4.163 The Working Group welcomed the updated assessment and noted that the model now estimates year class strengths that were made possible by a 4-year reading program for otoliths from 2020-2024 which has resulted in 3 694 aged otoliths and has the aim of reading 4 500 otoliths by the end of 2024.

4.164 The Working Group noted that the model accounts for recent catches in waters adjacent to the Crozet EEZ on the Del Cano Rise in the Southern Indian Ocean Fisheries Agreement (SIOFA) Area and assumes that these catches have undergone the same depredation rate as catches inside the Crozet EEZ. These catches ranged from 0 to 40 tonnes per year with an average of less than 24 t between 2003 and 2016. Catches increased to more than 138 t in 2017 and 2018 and then decreased to 50 t in 2019. Since then, SIOFA has approved a catch limit of 55 t on the Del Cano Rise (SIOFA CMM-15 (2023)).

4.165 The Working Group noted the updated Stock Annex for the *D. eleginoides* at Crozet Islands fishery (WG-FSA-2023/58) and recommended that the CCAMLR Fishery Report for this area be updated with this Stock Annex.

4.165 The Working Group agreed that a catch limit of 930 tonnes (which would be total removals of 1 352 tonnes, including depredation and catches on Del Cano Rise in the Southern Indian Ocean Fisheries Agreement (SIOFA) Area) for *D. eleginoides* in Subarea 58.6 for 2023/24 would be consistent with CCAMLR's decision rules for the precautionary yield for this fishery.

Management advice

4.167 No new information was available on the state of fish stocks in Subarea 58.6 outside areas of national jurisdiction. Therefore, the Scientific Committee recommended that the prohibition of directed fishing for *D. eleginoides*, described in CM 32-02, remain in force in 2023/24.

Research plans in area 58 notified under CM 21-02

4.168 WG-FSA-2023/47 presented a report on exploratory fishing activities undertaken by Australia, France, Japan, Republic of Korea, and Spain in Divisions 58.4.1 and 58.4.2 between the 2011/12 and 2022/23 fishing seasons, noting the achievement of the milestones detailed in the research objectives.

4.169 The Working Group welcomed the report and congratulated the Members involved for the large body of work presented. It noted, in particular, the significant amount of age data collected, as well as the continuous progress with the collection of such data.

4.170 WG-SAM-2023/03 presented a multi-Member proposal for continuing research in the *D. mawsoni* exploratory fishery in East Antarctica (Divisions 58.4.1 and 58.4.2) from 2022/23 to 2025/26, including the research objectives, methods, and milestones in accordance with Annex 24-01/A Format 2.

4.171 The Working Group welcomed the paper and commended the clarity of the information presented. It noted that the research plan in WG-SAM-2022/04 for Division 58.4.2 was agreed in 2022 and therefore does not need to be evaluated by WG-FSA-23, and that the research plan for Division 58.4.1 (WG-SAM-2023/03) has been evaluated by WG-FSA-23.

4.172The Working Group noted the importance of testing and updating stock structure hypotheses of toothfish across East Antarctica and links to other areas. It noted the recently updated stock hypothesis for toothfish in Divisions 58.4.1 and 58.4.2 (WG-SAM-2022/09) and that a comprehensive understanding of stock structure and ecology of this species benefits from the incorporation of information pertaining to biological information, migratory patterns, oceanography and genetic data. The Working Group further noted the value of collecting oceanographic data using CTD sensors during fishing operations to inform oceanographical models.

Management advice

4.173 The Working Group recommended the research proposal as detailed in WG-SAM-2023/03 for Division 58.4.1 proceed.

4.174 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 4.

Area 88

4.175 WG-FSA-2023/37 Rev. 1 presented a study on levels of genetic diversity and population structure of the Antarctic toothfish in Areas 58 and 88 by using a combination of the Patagonian toothfish specific (N=7) as well as developed Antarctic toothfish microsatellite markers (N=7). The authors noted the similarity between Areas 58 and 88 for both *D. eleginoides* and *D. mawsoni* markers, with a higher diversity within Subarea 88.1, including genetic variability between samples collected in different years.

4.176 The Working Group noted that the annual variability in genetics may reflect the role of the Ross Sea as an oceanographic sink for a number of larval areas from the Amundsen Sea, Bellingshausen Sea, Banzare bank and Ross Sea depending on annual variability in currents. The Working Group noted that this may also reflect sampling bias or contamination of the samples. The Working Group encouraged further work, noting that analysis including age may provide more detailed information than the current analysis splitting the samples into juvenile and adult.

4.177 The Working Group noted that the widespread connectivity of *D. mawsoni* was consistent with existing hypotheses about the circumpolar connectivity of areas. The Working Group further noted that regional oceanographical features may generate local stocks, and suggested the Members collect further data to test stock structures in the Southern Ocean.

4.178 WG-FSA-2023/25 presented investigations into the diet composition and feeding strategies of *D. mawsoni* in Subareas 88.1 and 88.3, conducted based on stomach content analysis of specimens collected during the 2022/23 fishing season. The authors noted that in Subarea 88.1 there was a transition in the dominant prey items around 100 cm from molluscs to fish, whereas in Subarea 88.3 fish predominated in the diet across all lengths.

4.179 The Working Group noted that accounting for the digestion state of the stomach contents may provide useful information on whether the toothfish had been consuming by-catch species caught on the longline before landing and recommended that future work could include analysis on the stomach contents of by-catch species to provide further information on trophic interactions.

Subarea 88.1 and SSRUs 882AB - *D. mawsoni* in the Ross Sea region

4.180 The exploratory fishery for *D. mawsoni* in Subarea 88.1 operated in accordance with CM 41-09 and associated measures. In 2022/23, the catch limit for *D. mawsoni* was 3 495 tonnes. Details of this fishery and the stock assessment are contained in the Fishery Report (https://fisheryreports.ccamlr.org/).

4.181 SC-CAMLR-42/BG/29 presented a description of a low-cost ocean sensor to capture temperature and depth information trialled in the Ross Sea during the 2022/23 season. These sensors are currently widely deployed throughout New Zealand's EEZ in partnership with the commercial fishing sector to provide temperature and depth information through the water column.

4.182 The Working Group noted the value of data collected by these devices which is particularly relevant in informing regional changes relevant to climate change. Additionally, the benefits of ease of operation and automatic downloading of data and that the two-year battery life and the intervals between calibrations are practical. While there was a current depth limit of 1 000 m, further developments were underway to extend the depth limit. The Working Group noted the importance of coordinating data collection with the standards for data used in oceanography models and that output from these sensors adhered to international data sharing standards, data formatting and metadata collection. The Working Group noted the benefits of such data being collated and available through organisations such as SOOS.

4.183 WG-FSA-2023/09 presented the results from the 2023 Ross Sea shelf survey (RSSS). The estimated relative biomass index of toothfish in 2023 was one of the lowest of the series. Biological data and samples were collected from 1662 toothfish; samples and measurements were also collected on by-catch species and the environment. A total of 155 toothfish were tagged and released with an 92% tag length overlap statistic; no tagged fish were recaptured. The catch limit of 99 t was not exceeded, as catches in all strata were lower than the previous years.

4.184 The Working Group thanked the authors of the paper and noted that this survey was the twelfth in the time series, was an important monitoring tool in the Ross Sea region MPA and provided standardised information on abundance and age structure for use in the stock assessment, as well as for improving understanding of the ecosystem in the area.

4.185 The Working Group noted that the catch rates in the 2023 Survey were around half of the levels seen in the previous survey, but that the catch length distribution was similar to previous years. The Working Group therefore concluded that the low catch rates did not seem to be caused by a failure of recruitment, but instead by a factor affecting catchability such as timing of the survey, or sea lice reducing catchability by removing bait. The Working Group encouraged further work to analyse oceanographic data, such as salinity and temperature, to evaluate whether these may be related to the lower catchability.

4.186 The Working Group recommended that the recruitment index from this survey continues to be monitored and evaluated within the stock assessment model. The Working Group recommended that the standardisation of the annual biomass index should be investigated with additional variables, including time of season, to evaluate if this was a significant effect.

4.187 The Working Group reviewed the continuance research proposal for Ross Sea shelf survey (WG-SAM-2023/02). The Working Group noted that the Ross Sea shelf survey has a catch limit as agreed in SC-CAMLR 41 (SC-CAMLR 41, paragraph 3.138):

(i) 2023/24: 69 tonnes (including the core strata and the McMurdo Sound stratum)

(ii) 2024/25: 99 tonnes (including the core strata and the Terra Nova Bay stratum).

4.188 WG-FSA-2023/19 presented a characterisation of the toothfish fishery in the Ross Sea region. Scaled length distributions showed no decrease in the size of fish caught through time in any of the management areas. There was a small change in the sex ratio of Antarctic toothfish, with a gradual pattern of more males caught in all areas until 2015. The number of Antarctic toothfish recaptured over the last five years of the mark-recapture program was higher than the average annual number of recaptures over the past decade.

4.189 The Working Group noted the value of the fishery characterisation in summarising the activity of the fishery and, in particular, welcomed the information about tag recapture and CPUE, which provide information to validate the harvest rate and trends in abundance estimated by the integrated assessment.

4.190 WG-FSA-2023/51 proposed changes to the Ross Sea region Data Collection Protocol (RSDCP). It includes: (i) a new field that allows noting the additional samples, to be added to the observer biological sample and tag recapture forms and the C2 tag recapture form, and (ii) the reintroduction of the skate injury condition field on both observer and C2 forms.

4.191 The Working Group recommended that the C2 and observer data forms be updated to include these fields for the 2023/24 season (paragraph 2.21).

4.192 WG-FSA-2023/13 presented an update of the Bayesian sex- and age-structured integrated stock assessment model for Antarctic toothfish (*D. mawsoni*) in the Ross Sea region (RSR; Subareas 88.1 and Small-Scale Research Units (SSRUs) 88.2A-B) with Casal2. Further model diagnostics were included in WG-FSA-2023/22. The model estimated B_0 at 77 855 t (95% CIs 71 954–85 115 t) and the current stock status (B_{2023}) at 64.3% B_0 (95% CIs 61.3–67.3% B_0). The recommendation for the catch limit is 3 499 t for RSR Antarctic toothfish in the 2023/24 and 2024/25 fishing seasons.

4.193 The Working Group welcomed the updated stock assessment and noted the model sensitivity runs exploring alternative selectivity assumptions, and that the work so far did not fully explain the catch at age compositions. The Working Group encouraged further work on selectivity assumptions and noted the flexibility within the Casal2 model framework to test these assumptions.

4.194 The Working Group welcomed the inclusion of a retrospective analysis among the model diagnostics, showing the effect of running the assessment on shorter time series of data, while keeping the biological parameters and model structure consistent. The Working Group noted that this analysis was recommended by the 2023 independent review of CCAMLR toothfish assessments, (paragraph 4.47), and may provide information about whether there are trends in processes such as recruitment that are not consistent with the model assumptions.

4.195 WG-FSA-2023/13 proposed that the catch limit for *D. mawsoni* in the Ross Sea be set at 3 499 tonnes for 2023/24 and 2024/25 based on the outcome of the assessment and the application of the decision rule.

4.196 The Working Group noted that a catch limit for the Ross Sea region (Subarea 88.1 and SSRUs 882A–B), set at 3 499 tonnes for 2023/24 and 2024/25 based on the assessment, assuming a catch split of 19% for the area north of 70°S, 66% for south of 70°S, and 15% in the Special Research Zone, would be consistent with the precautionary yield estimated using the CCAMLR decision rules.

4.197 During the meeting, additional sensitivities were run using the tag data retrospectives. The MPDs of the retrospective runs with tagging data excluded year-by-year back to 2013 showed that there was only a small amount of change in the spatial bias from the tag data, with patterns of SSB, percent SSB, recruits, and year class strength showing very similar values between the retrospectives from 2013 to 2023 (Figure 8).

4.198 The Working Group noted that although the effects of spatial bias were not so apparent in the Ross Sea fishery, there was still the potential for spatial bias in the tag data and assumptions about future recruitment in the assessment to impact management advice.

4.199 WG-FSA-2023/55 presented the updated Stock Annex for the Ross Sea region. The Working Group recommended that the CCAMLR Fishery Report for this area be updated with this Stock Annex.

Management advice

4.200 The Working Group recommended that the catch limit for the Ross Sea region (Subarea 88.1 and SSRUs 882A–B) be set at 3 499 tonnes for the 2023/24 season, with 69 tonnes allocated for the Ross Sea shelf survey in 2023/24 based on the outcome of the assessment.

4.201 The WG recommended that SC require a revised stock assessment addressing the issues identified in the workplan (paragraphs 4.52-4.57) be provided to WG-FSA in 2024.

Subarea 88.2

4.202 WG-FSA-2023/62 presented a characterisation of the fishing and tagging programme in the Amundsen Sea Region. It highlighted that there was an improvement in the numbers of recaptures of tagged toothfish within the four research blocks. However, data on recaptured fish was limited due to an uneven distribution of fishing effort on the seamounts in SSRU 88.2H.

4.203 The Working Group noted that although fishing in SSRU 88.2H had extended to an additional seamount in the last year, effort was still concentrated on only two seamounts. The Working Group recommended that further information was needed about whether the requirement in CM 41-10 paragraph 12 to spatially spread effort had been successful, and that the analysis be updated and presented to WG-FSA in 2025 with an additional two seasons of data.

Management advice

4.204 The Working Group recommended that the existing measures in CM 41-10 paragraph 12 to spread effort in SSRU 882H remain in place for a further two seasons to allow for further evaluation of their effectiveness.

4.205 The Working Group recommended that the catch limits for Subarea 88.2 SSRUs 882C-H be based on the trend analysis as shown in Table 4.

Subarea 88.3

4.206 WG-FSA-2023/20 Rev. 1 presented a research plan for Subarea 88.3 which updated the research plan with the recommendation from the Scientific Committee to integrate the Ukrainian research with the Korean and New Zealand research plan. The combined vessel research plan proposed to continue the research on *Dissostichus* spp. in Subarea 88.3, which began in 2021/22, in 2023/24.

4.207 The Working Group noted that the research had made much progress, and that the research plan made no significant changes to that which had previously been endorsed.

Management advice

4.208 The Working Group recommended continuing the research outlined in WG-FSA-2023/20 Rev. 1 for the 2023/24 season.

4.209 The Working Group recommended that the catch limits for Subarea 88.3 be based on the trend analysis as shown in Table 4

By-catch

By-catch management in krill fisheries

5.1 WG-FSA-2023/69 presented the findings of a machine learning approach for otolith shape-based species discrimination. The approach combined a neural network with a triplet loss function which reduced the allometric growth effects on the ability to discriminate species. A total of 14 established machine learning methods of discrimination were tested, with the combination of a neural network and the triplet loss function resulting in a classification accuracy of 96%.

5.2 The Working Group noted the effectiveness of the outlined techniques. The number of samples used in the study was also discussed (159 in total between four species), and the

Working Group suggested that more samples would likely improve the classification accuracy, noting that the technique could potentially be extended to other hard structures found, for example, in diet samples.

5.3 The Working Group recommended excluding the effect of allometric growth in future otolith shape-based species discrimination studies.

5.4 WG-FSA-2023/P01 presented an analysis of fatty acid profiles and energy density of muscle and gonad tissue from *C. gunnari* collected in Subarea 48.2. The findings suggested that ovarian development during spawning in this species utilises energy from feeding, as opposed to energy stored in the tissues, known as an income breeding strategy. The paper highlighted the importance of fish by-catch sample collection from krill fishery operations as an important source of information for developing the understanding of Antarctic fish ecology.

5.5 The Working Group noted the utility of this approach for investigating species ecology, as well as broader food web structure. Several ongoing similar projects were noted on the food web ecology for Patagonian (Subareas 48.3 and 48.4) and Antarctic (Subarea 48.4) toothfish, using the same methods that will be presented to future working groups.

5.6 WG-FSA-2023/04 presented an overview of an ongoing project aiming to improve the identification of fish by-catch in the krill fishery. The three-part project will:

(i) utilise integrative taxonomy to collate and identify fish collected from the krill fishery in all subareas, aiming to cover all available species and life history stages that interact with the fishery

(ii) systematically review the available literature to collate data on reproductive aspects of by-catch species

(iii) develop enhanced field guides for fishery observers, focused on images of key ID features.

5.7 The authors noted that of the 86 species investigated during the systematic review, 15 appeared to be missing key information (e.g., reproductive timings, larval duration). A list of species for which samples are missing in the study was presented, with the aim of requesting engagement with Members to provide samples and imagery if available. Members were encouraged to contact the authors to collaborate.

5.8 The Working Group thanked the authors for presenting the project at an early stage in order to engage with other Members, highlighting the need for this work and the potential for it to produce valuable resources for fisheries observers and the wider community. It further suggested that a compendium of life history characteristics resulting from the systematic review could help to address the lack of risk assessments in the krill fisheries for by-catch populations.

5.9 WG-FSA-2023/73 presented an updated summary of fish by-catch in the krill fishery, which implemented recommendations by WG-FSA-2022, including the estimation of total by-catch weights by species and providing spatial and temporal patterns in by-catch as well as length frequency distributions. After the identification and correction of data quality issues the analysis presented confirmed the localised and sporadic nature of high by-catch events.

5.10 The Working Group noted the comprehensive analysis done by the Secretariat, as well as the changes made since last year, and supported the suggestion for future iterations of the paper to include extrapolated by-catch estimates using methods outlined in WG-IMAF-2023/03. The Working Group requested future iterations of this paper include colourblind-friendly plots as the use of cyan and bright green together on a white background can be difficult to interpret.

5.11 The Working Group noted that these analyses were valuable to the understanding of total removal of fish species, as well as from an ecological perspective. It also noted that the analysis indicated that by-catch rates are relatively similar between fishing methods, and that the by-catch of fish in the krill fishery is characterised by the occurrence of sporadic and localized large by-catch events.

5.12 The Working Group recommended the Secretariat include relevant report figures in the krill fishery report.

5.13 The Working Group noted the cohort progression of *C. gunnari* in Subarea 48.2, and that the short life span of this species may result in periodic pulses of high by-catch rates for this species until the next large recruitment event in this area. It also suggested that the detection of a large cohort of young fish may predict large catches of older fish in subsequent seasons.

5.14 The Working Group also noted the potential for different gear selectivity of by-catch species between vessels depending on gear configuration and that future research towards the correction for the effect of gear selectivity on length frequency distributions would be beneficial.

By-catch management in toothfish fisheries

Macrourus spp.

5.15 WG-FSA-2023/27 reported on three bottom trawl surveys carried out by New Zealand in the Ross Sea region in SSRUs 881HIK and 882A in 2008, 2015, and 2019. Catches from these three surveys contained a mixture of three species: *M. whitsoni*, *M. caml*, and *Cynomacrurus piriei*, and were combined across years and scaled to the slope area to give a composite biomass estimate.

5.16 The Working Group recommended that work on estimating biomass of macrourids using different data sources continues, including additional work to determine appropriate approaches for setting catch limits in the different management areas. The Working Group also noted that the timing of these biomass surveys could provide a good opportunity to assess the impact of the RSRMPA on macrourids.

5.17 Noting the three different methods of biomass estimation outlined in WG-FSA-2023/27, the Working Group recommended using the constant density biomass estimate to develop future management advice.

5.18 The Working Group recalled that the decision rules previously used in 2003 to assess γ for *M. whitsoni* were based on a median spawning stock biomass of 50% B_0 at the end of a 55-year projection, and that the probability of depletion below 20% of B_0 being no greater than 0.1 over the projection period (WG-FSA-2003, paragraph 5.238). The Working Group noted that the probability of depletion below 20% of B_0 was the rule that determined the value of γ selected in 2003 (WG-FSA-2003, paragraph 5.241).

5.19 The Working Group noted that the paper WG-FSA-2023/27 had calculated γ based upon a median escapement of 75%. This resulted in a γ for *M. whitsoni* of 0.0214 and for *M. caml* of 0.021. During the meeting, models were also run to calculate γ based on 50% escapement, and for the probability of depletion below 20% of the median pre-exploitation spawning biomass being 0.1. The 50% escapement resulted in a γ of 0.56 for *M. whitsoni* and 0.59 for *M. caml*, whilst the depletion rule resulted in a γ of 0.14 *M. whitsoni* and 0.08 for *M. caml*.

5.20 The Working Group recommended further work to evaluate the decision rules used for these species to provide guidance on an appropriate level of escapement that should be applied, noting that there were differing views on the appropriate choice of either 50% or 75% escapement for calculating the γ for macrourids.

5.21 The Working Group noted that the current levels of macrourid by-catch in the Ross Sea fishery were substantially lower than the estimated catch limits, and that the revised catch limits using 75% escapement were similar and slightly higher than the current limits.

5.22 The Working Group recommended that the current catch limits for macrourids in Subarea 88.1 remain unchanged.

5.23 SC-CAMLR-42/BG/37 provided a summary from the Secretariat on how by-catch move-on rules are implemented for *Macrourus* spp. by-catch within Paragraph 6 of CM 41-09 and how this interacts with Paragraph 5 and 6 of CM 33-03. Paragraphs 5 and 6 require two move-on rules; a 5 n mile move-on rule for individual catches exceeding 1 t, and a cessation rule that requires cessation of fishing for a vessel where catches within two 10-day periods exceed 1 500 kg and 16% of the catch of toothfish spp. The paper noted an absence of compliance issues with Paragraph 6 of CM 41-09 indicating that the by-catch thresholds in place have been effective in preventing high catches of *Macrourus* spp.

5.24 The Working Group noted that Paragraph 6 of CM 41-09 (2022) specifies the catch limits of by-catch species for Management Areas in Subarea 88.1. While CM 33-03 does not apply to Subarea 88.1, the fishing cessation rule in Paragraph 6 of CM 33-03 is also specified within Paragraph 6 of CM 41-09. However, it is applied at the SSRU level for Subarea 88.1 and at the area to which a catch limit applies in CM 33-03.

5.25 The Working Group noted that the implementation of the fishing cessation rule outlined in CM 41-09 (paragraph 6) was from the decision by the Commission to apply the cessation of fishing at the SSRU level in Subarea 88.1 following the implementation of the RSRMPA. The Working Group recommended maintaining the current fishing cessation rule for Subarea 88.1 at the scale of SSRU, as specified in CM 41-09 Paragraph 6.

5.26 The Working Group further discussed the application of the fishing cessation rule to areas outside of the Ross Sea, noting that toothfish fishing in all new and exploratory fisheries outside of the Ross Sea takes place in research blocks, aside from SSRU 88.2 H. The Working Group noted that the application of the current move-on rule may hinder toothfish research in research blocks (SC-CAMLR-2017, paragraphs 3.143 to 3.146) and that the second 1-tonne move-on rule (CM 33-03, paragraph 5) would provide adequate protection from depletion within a research block and would be consistent with article IX, 2 (h).

5.27 The Working Group recommended the removal of CM 33-03 paragraph 6.

5.28 The Working Group noted that the macrourid biomass estimates presented in WG-FSA-23/27 for the Ross Sea and suggested that catch limits for macrourids in research blocks and other exploratory areas could be calculated using the CPUE-by-seabed area analogy method currently used for toothfish. This approach would allow catch limits to better reflect the density of macrourids in each research block rather than using a constant proportion of the toothfish catch limit. The Working Group requested the Secretariat provide progress on this to WG-SAM-2024 and WG-FSA-2024.

5.29 The Working Group suggested that for the next iteration of research plan proposals in these areas, proponents provide details on how they will generate area-specific gamma values for macrourids.

5.30 WG-FSA-2023/32 Rev. 1 reported on a study of molecular and morphological traits of 338 individual macrourids collected in Subareas 88.1 and 88.3 between 2021 and 2022. The samples were classified as *M. caml* and *M. whitsoni* based on the morphological identification keys. Comparisons between morphological identification and mtDNA COI sequences of 49 individuals suggested that the pelvic fin rays and the rows of lower jaw teeth should be jointly examined for accurate identification of the two species. When samples examined by observers were compared with subsequent morphological identification conducted in the laboratory, there were differences in species identification which may be due to the overwhelming dominance of *M. caml* in the catches in Subarea 88.3, making it challenging for observers to differentiate between the two species. Molecular analysis is still underway to further differentiate between the two species.

5.31 The Working Group thanked the authors for the progress made on the identification of macrourids and looked forward to the outcomes of the molecular analysis. The Working Group recommended that a likelihood or Bayesian approach could be considered to progress the molecular analysis. As there is currently no phylogeny based on nuclear markers for Antarctic macrourids to assist in the analysis of mitochondrial marker datasets, the Working Group recommended that this could be an important avenue for future research. The Working Group noted that variation in the species identifications made aboard and subsequently ashore were possibly due to differences in individual experience and noted that South African colleagues had published a paper in 2021 (Gon et al., 2021) for the four species of *Macrourus* in the CCAMLR area that could be useful in this research. The Working Group also suggested that otolith shape morphology might assist with refining the differentiation between these two species.

5.32 The Working Group welcomed the provision of training materials or identification guides for macrourids such as those in WG-FSA-2023/32 Rev. 1, and the offer to have these initially translated into English for subsequent translation into other CCAMLR languages and being made available by the Secretariat.

5.33 WG-FSA-2023/33 reported progress made since WG-FSA-2022 to estimate the abundance trends of grenadiers caught as by-catch in the longline fisheries in CCAMLR Subarea 48.6. This work used spatio-temporal delta generalised linear mixed models (GLMMs) implemented with R package "VAST". A single model covering all research blocks and all fishing gears (trotlines and Spanish lines) was developed, with gear types incorporated as a catchability covariate, and an index of abundance was estimated separately for each block. The paper recommended more studies to progressively improve the use of VAST modelling to estimate the abundance of by-catch species in Subarea 48.6. Future work could include abundance models for other by-catch species.

5.34 The Working Group recommended that observer data could further assist in species identification when linked to the C2 data. The Working Group welcomed the progression and suggested that further studies contrasting conventional GLMMs with the more complex VAST model might be informative.

Skates and sharks

5.35 WG-FSA-2023/40 reported on a project to inform post-release survival rates of skates using pop-up satellite tags and to investigate capture-related stress through blood biomarkers. The survival and activity patterns of 24 Kerguelen sandpaper skates was evaluated using MiniPat pop-up archival satellite tags.

5.36 The Working Group welcomed the development of the tagging method and encouraged further studies and publication on post-release survival and collaborative research into this topic. The Working Group also noted that future work could include environmental conditions, mortality factors such as depth range, soak time, and skate size with the potential to use recorded injury codes to assist in this evaluation.

5.37 The Working Group noted that the estimation of the post-release survival estimates using pop-up tags would allow for more realistic estimates of stock status from skate assessments.

5.38 WG-FSA-2023/11 described results from an aging study using the centrum of 285 vertebrae for the three skate species caught as by-catch in the Kerguelen and Crozet Patagonian toothfish (*D. eleginoides*) fisheries in Division 58.5.1 and 58.6. While the ages are not yet validated, the results using this method indicated that the three skate species display faster growth compared with the conventional method based on the corpus calcareum, suggesting a relatively productive life-history. However, the paper noted that there was potential to underestimate the ages of older individuals.

5.39 WG-FSA-2023/35 further presented research on maturity of the three species of skates mainly caught as by-catch in the Kerguelen and Crozet Patagonian toothfish fisheries. The paper presented length-at-maturity estimates for *B. eatonii* and *B. irrasa* in Kerguelen and *A. taaf* in Crozet. The length at 50% maturity for *B. irrasa* males and females were both >100 cm TL, while *B. eatonii* and *A. taaf* showed length at 50% maturity near 80 cm TL, except for female *A. taaf* which had a highly uncertain estimate of length of 50% maturity of 98 cm TL.

5.40 The Working Group thanked the authors for both papers and suggested some future work which included investigating the use of additional anatomical structures for aging as well as vertebrae, the potential to use chemical marking in tagged skates, and increasing data collection during the skate spawning seasons to obtain more information on size at maturity.

5.41 WG-FSA-2023/41 examined recent trends in shark by-catch from longline fisheries in the CAMLR Convention Area using information reported by vessels (C2) and scientific observers from 2017 to the start of 2023 fishing seasons. The paper noted substantial gaps in reported shark by-catch and suggests that shark by-catch may have increased during this period. The paper highlighted differences in trends between vessel and scientific observer records relating to shark by-catch in total numbers, and in categories of retained, discarded, and released sharks. The paper highlight instances where observer data indicated retained sharks and the vessel data recorded none.

5.42 The Working Group noted that differences between the amount of line observed and by-catch recorded by observers was generally much less than values reported in the vessel report for the entire line, and that shark catches were generally patchy and unevenly distributed along a longline, which could explain some of the differences. The Working Group also noted that vessels may initially retain by-catch (as required when south of 60°S latitude), but then discard them north of 60°S, which may then explain part of the difference with observer records.

5.43 The Working Group suggested that the methodology on extrapolation in paper WG-IMAF-2023/03 could provide additional guidance in how the shark data might be analysed and noted that there was potential bias between the recording of small commonly caught shark species such as *Etmopterus* spp. and large sharks such as porbeagle sharks (*Lamna nasus*) and sleeper sharks (*Somniosidae*) which are rarely caught but recorded.

5.44 WG-FSA-2023/50 presented updated biomass estimates and exploitation rates consistent with the CCAMLR decision rules for *A. georgiana* in the Ross Sea, providing a range of estimates of biomass and exploitation estimates depending on values chosen for life history parameters. Model uncertainties were presented, particularly concerning survivorship. Biomass and exploitation estimates were highly reliant on mortality and recruitment steepness assumptions. Regardless of assumptions on tagging cohort treatment and assuming plausible extremes of natural mortality, the current exploitation rate was considered sustainable if survivorship was more than 60%. If live skates are not released, then exploitation rates would be higher and would likely be inconsistent with CCAMLR decision rules.

5.45 The Working Group recalled the skate survival tank experiment by Endicott and Agnew (2004) and used the estimates by depth category to estimate discard survival of *A. georgiana* in the Ross Sea region. The weighted average survivorship for all skates released in the Ross Sea region was estimated to average 0.70 ranging between 0.66 and 0.74 between 2003-2023 (Table 12).

5.46 The Working Group noted that sustainability results were dependent on a number of parameters for which there is currently little information, and encouraged more work to better inform these, such as recording of skate injury condition at capture and release (Table 1), research to improve post-release mortality estimates; welcoming the planned skate tagging in the 2027/28 season. The Working Group suggested that the use of PSAT tags may provide an alternative source of information to improve our understanding of the release mortality.

5.47 WG-FSA-2023/65 Rev. 1 recalled the 2-year programme during the 2019/20 and 2020/21 fishing seasons in the Ross Sea region to tag and release skates for abundance estimation and to validate the thorn ageing method for Antarctic starry skate (*A. georgiana*). A total of 10 218 skates have been tagged and released since the 2019/20 fishing season in the Ross Sea, Amundsen Sea, and Bellingshausen Sea region. Recaptures from these initial releases will be used to monitor trends in population size through time with additional tagging occurring periodically. Since the 2019/20 fishing season, a total of 127 skates tagged have been returned to NIWA (New Zealand) for sampling. Results from the age validation experiments are ongoing.

5.48 The Working Group noted that CM 41-01, Annex 41-01/C, paragraph 2 should remain in place to ensure skates are sampled and thorns retained. The Working Group also encouraged Members to collect thorns for analysis, and noted that CM 41-09 would need to be modified in the future to allow tagging and release of skates that are unlikely to survive.

5.49 The Working Group noted that CM 41-09 would need to be modified in the future for the next 'Year of the Skate' to allow for the tagging and release of skates with injuries, as was undertaken in previous 'Year of the Skate' programmes.

5.50 The Working Group recommended that logbook fields to record skate injury codes be reinstated to allow routine recording of injuries for tagged skates and that the form be modified to allow more than one injury type to be recorded for an individual skate (paragraph 2.21).

VME management

5.51 WG-FSA-2023/29 presented an update on the work of WG-EMM-2023 on a potential protection mechanism for notothenioid fish nest areas in the Convention Area. The authors proposed definitions for:

(i) a fish nest with a distinction between active and potential status

(ii) fish nest areas including methods, criteria (e.g., minimum density) and a review process for re-assessing fish nest areas every five years if applicable.

5.52 The Working Group recommended that the *Neopagetopsis ionah* fish nest area in the southern Weddell Sea be protected, and that a five-year review process as defined in WG-FSA-2023/29 is suitable.

5.53 The Working Group noted that the monitoring related to the procedure for five-year review enables the evidence on the continued presence of fish nest areas as defined in WG-FSA-2023/29 to be provided.

5.54 The Working Group noted that other fish species use hard substrates where evidence of a depression delineating a nest would not be apparent. The Working Group also noted that the nest density for other fish species might be lower than for *N. ionah*. Therefore, definitions and indicators developed in the paper WG-FSA-2023/29 may not be applicable to all nesting fish species.

5.55 The Working Group requested that the Scientific Committee develop mechanisms to provide protection for unusual phenomena associated with Antarctic Marine Living Resources that are vulnerable to human activities when they are discovered. It suggested that Conservations Measures such as those used for VMEs, or areas uncovered by icesheet retreat or other fishery regulations, could be developed to ensure immediate protection until such time as their importance is evaluated by the Scientific Committee.

5.56 WG-FSA-2023/70 presented a revised VME Taxa Classification Guide for the toothfish fishery and the authors recommended it replace the existing guide (https://www.ccamlr.org/node/74322) to realign the guide with recent taxonomic changes.

5.57 The Working Group welcomed the paper and noted the revised guide is an important update that will help observers aboard fishing vessels throughout the Convention Area. The Working Group further noted that analytical tools such as artificial intelligence could be developed to aid observers in classifying VME indicator taxa with more precision.

5.58 The Working Group noted that two codes were still to be created when the paper was submitted and recommended that the revised version of the guide provided in Appendix H be used throughout the Convention Area from season 2024/2025 onwards.

5.59 The Working Group noted that the revised guide could be used for season 2023/2024 by vessels operating in the Ross Sea Region and requested the Secretariat to provide observers on these vessels intending to use the revised guide with an updated observer longline form including the revised VME taxon codes.

5.60 The Working Group recommended that the 2009 version of the CCAMLR VME Taxa Classification Guide remain in use outside of the Ross Sea Region until the revised version is made available in 2024.

5.61 The Working Group noted that the 536 taxon codes provided on the forms represent a subset of the 13,615 codes maintained by FAO-ASFIS (http://www.fao.org/fishery/en/collection/asfis). The Working Group noted that all ASFIS codes can be used currently in the forms and that additional codes for taxa for which no ASFIS code exist can be requested. The Working Group requested the Secretariat update the logbook forms to clarify the procedure to report taxa not listed on the forms and add a link to the ASFIS taxon list.

5.62 WG-FSA-2023/75 presented a new interface for the VME registry which will replace the current Excel file approach. The authors further noted differences between the data reported by observers and vessels and requested the Working Group to consider how to integrate VME data reported by observers.

5.63 The Working Group welcomed the paper and noted that the visualisation tool could be used to identify areas of overlap between research plan activities and known areas where VME indicator thresholds have been notified. The Working Group requested the Secretariat continue to develop, document and maintain single sources of spatial data.

5.64 The Working Group noted that VME risk area notifications are a vessel responsibility and noted that discrepancies between vessel and observer data require further investigation as they may be the result of data quality issues.

Scheme of International Scientific Observation

6.1 WG-FSA-2023/01 presented the ‘SAGO Extreme’ fish collection and de-hooking system used onboard the Uruguayan fishing vessel Ocean Azul during November and December 2022 in the Patagonian toothfish fishery in CCAMLR subarea 58.7. The paper reviewed the effectiveness of the SAGO system in reducing depredation by comparing the catch per unit effort for fishing lines retrieved in the presence of marine mammals between sets with and without the system. Out of 165 sets, marine mammals were directly observed on 34 occasions, with the SAGO system being used during 14 hauls. *D. eleginoides* were collected from the SAGO capsules on 11 occasions, which were assessed to be in good condition and therefore tagged and released.

6.2 WG-FSA-2023/02 described a new launching procedure for the 'SAGO Extreme' system to eliminate SAGO capsule contact with the seafloor.

6.3 The Working Group thanked the authors for the papers, noting that more information would be required to better enable CCAMLR Working Groups to assess the effects of the SAGO on items such as toothfish tagging programmes, the potential escapement of small by-catch species and skates, the effects of the de-hooking process on toothfish, potential for bottom impacts, and comparability of VME indicator taxon retention with the SAGO system.

6.4 The Working Group recommended that details on the methodology and sampling protocols for the SAGO system should be submitted to WG-FSA to better inform the Working Groups on the effects of this fishing method on catch, by-catch and the environment.

6.5 The Working Group noted that further research should include underwater video cameras attached to the SAGO capsule to determine the interactions with fish and marine mammals. The Working Group encouraged Uruguay to consider the experimental design and potential for attaching the CTD sensors to the SAGO capsule to collect the oceanographic data.

6.6 The Working Group recalled that a bottom fishing impact assessment, submitted for a vessel fishing in an area, needs to include information for any new fishing gear configuration notified, if that gear could be in contact with the sea floor.

6.7 The Working Group noted that the vessel Ocean Azul has been notified for the Ross Sea (Subarea 88.1 and Subarea 88.2 A and B) (CCAMLR-42/BG/08 Rev 1) and the Amundsen Sea (88.2) and noted that marine mammal depredation is not an issue when fishing in these areas. Therefore, the Working Group recommended the SAGO system should not be used in these areas.

6.8 WG-FSA-2023/07 Rev. 2 provided details of the CCAMLR Scheme of International Scientific Observation (SISO) deployments including deployment information for all observers placed onboard vessels in the CCAMLR Convention Area during the 2022/2023 season. There were 27 longline trips and 18 trawl trips observed up to 9 October 2023. The paper noted small updates to commercial and observer forms and manuals.

6.9 The Working Group welcomed an update to the taxonomic database for species codes and the implementation of minor changes in the krill observer logbook to include warp strike severity fields.

Future work

7.1 SC-CAMLR-42/BG/04 presented an application for GCBF funds to support an in-person training workshop on the development of integrated stock assessments for CCAMLR data-limited toothfish research fisheries, with Subarea 48.6 used as a pilot study. The workshop will provisionally be held in Cape Town, South Africa in 2024, organised by Mr Somhlaba, Dr T. Okuda (Japan) and Mr R. Sarralde (Spain), and supported by Mr A. Dunn (New Zealand). The total funds applied for are A$30 000.

7.2 The Working Group welcomed the initiative and recommended the Scientific Committee endorse it.

7.3 The Working Group noted that Subarea 48.6 was the focus of the training workshop and noted that consideration of sex-specific biological processes in an assessment would be beneficial in this Subarea. It noted that any interested Members were welcome to attend the workshop and that its outcomes, including training materials which could be used as templates for other areas, will be made available to all Members at WG-FSA-2024.

7.4 The Working Group reviewed its workplan (SC-CAMLR-41, Table 8) and adjusted the priority status, timing and contributors associated with the current tasks (Table 13). It also added several new tasks generated from discussions during the meeting such as those pertaining to stock assessments.

Other business

8.1 WG-FSA-2023/52 Rev. 1 presented results from a satellite tagging experiment, where fifty Popup Satellite Archival Tags (PSATs) were deployed off Davis Bank on North Scotia Ridge (FAO Area 41), during the austral summers of 2019 and 2020 on *D. eleginoides* individuals ranging from 97 to 139 cm in total length. For PSATs that reported more than 300 km away from the release site, the authors corrected for the distance that a tag had drifted prior to its first successful satellite link using particle backtracking modelling. The analysis included estimates of least-cost paths between release and recapture locations using a 450 to 2 000 m bathymetric constraint.

8.2 The Working Group welcomed the valuable results generated by this successful collaboration between scientists and the fishing industry. It noted that similar experiments were ongoing in Division 58.5.2 on skates, as well as other areas and species, and recalled past studies (e.g., WG-FSA-14/64). The Working Group noted that PSATs provided information such as indications of swimming speed, site fidelity, possible location in the water column as well as post-release mortality. It discussed the possibility of future PSATs technological advancements which may include additional sensors such as accelerometers and conductivity. Noting the lack of post-release mortality reported in the study, the Working Group noted that this was helpful to confirm that toothfish were tolerant to tagging procedures. It encouraged Members to collaborate on PSAT studies by sharing data and protocols.

8.3 Dr Devine presented work funded by Fisheries New Zealand of relevance to the Working Group on the estimation of release survival for pelagic sharks and fish. Among the objectives of the project, collating available scientific literature on the release mortality of *D. eleginoides* and convening a workshop of relevant experts to estimate the release survival, according to gear type and configuration, handling behaviour, and environmental conditions were tasks highlighted to the Working Group. Dr Devine encouraged meeting participants with expertise in tagging to collaborate on the project.

8.4 The Working Group welcomed the work and noted the importance of the consideration of post-release mortality to its work, and that it could depend on many factors including tag type, fish size and sex, depth, and fish handling procedures. It encouraged all to participate in the project, including observers and scientists not present at the meeting.

8.5 Dr P. Ziegler informed the Working Group that the annual Heard Island random stratified trawl survey was planned for March 2024.

8.6 Dr Devine informed the Working Group that the Italian research vessel Laura Bassi will be conducting a survey in the Ross Sea region in January-February 2024 and will be deploying moored instrumentation and Argo floats along with under-way and vessel-based sampling, sampling to study the hydrography, zooplankton, pelagic, and benthic communities, and for palaeoecological ocean and sea ice reconstruction.

Advice to the Scientific Committee

9.1 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) Fisheries and observer forms updates

 (a) Catch and Effort (CE) for longlines (paragraph 2.11)

 (b) Separate C1 form for krill and finfish (paragraph 2.12)

 (c) Workshop to discuss trawl forms (paragraph 2.13)

 (d) B2 removal, noting proposal to retire CM 23-05 (paragraph 2.15)

 (e) C4 form review (paragraph 2.16)

 (f) Skate injury codes in observer logbook (paragraphs 2.21 and 5.50)

 (g) Marine debris reporting (paragraph 2.37)

 (h) krill observer form, by-catch sampling (paragraph 3.41)

 (i) Additional fields in C2 and observer forms for tagging (paragraph 4.192)

(ii) Geospatial rules (paragraph 3.18)

(iii) Krill fishery management

 (a) Catch limits in Divisions 58.4.1 and 58.4.2 (paragraphs 3.27 and 3.28)

 (b) Priority questions and data requirements (paragraphs 3.49 and 3.50)

 (c) Krill length sampling (paragraphs 3.44 and 3.45)

(iv) Icefish fisheries management

 (a) Catch limits in Subarea 48.3 (paragraph 4.73)

 (b) Catch limits in Division 58.5.2 (paragraph 4.135)

(v) Toothfish fisheries management

(a) Catch limits for data-limited toothfish fisheries (paragraph 4.7)

(b) Age determination (paragraphs 4.18, 4.20, 4.21)

(c) Tag overlap statistic (paragraph 4.34)

(d) Tagging protocols (paragraphs 4.36 and 4.37)

(e) Independent review panel conclusion (paragraph 4.51)

(f) Integrated stock assessments work programme (paragraphs 4.57 and 4.58)

(g) *D. eleginoides* in Subarea 48.3 (paragraphs 4.96 and 4.97)

(h) *D. eleginoides* in Subarea 48.4 (paragraph 4.106)

(i) *D. mawsoni* in Subarea 48.4 (paragraph 4.112)

(j) *D. mawsoni* in Subarea 48.6 (paragraph 4.129 and 4.130)

(k) *D. eleginoides* in Division 58.5.1 outside of EEZ (paragraph 4.144)

(l) *D. eleginoides* in Division 58.5.2 (paragraph 4.159 - 4.161)

(m) *D. eleginoides* in Subarea 58.6 outside of EEZ (p. 4.168)

(n) *D. mawsoni* exploratory fishery in Divisions 58.4.1 and 58.4.2 (paragraphs 4.174 and 4.175)

(o) *D. mawsoni* in Ross Sea region (paragraphs 4.201 and 4.202)

(p) *D. mawsoni* in Subarea 88.2 (paragraphs 4.205 and 4.206)

(q) *D. mawsoni* in Subarea 88.3 (paragraphs 4.210 and 4.206)

(r) by-catch of macrourids in Subarea 88.1 (paragraph 5.22)

(s) by-catch move-on rules (paragraphs 5.25 and 5.27)

(t) GCBF funds application (paragraph 7.2)

(u) Use of SAGO Extreme (paragraph 6.7)

(vi) VMEs

(a) fish nests (paragraph 5.52)
(b) protection for unusual phenomena (paragraph 5.55)

Adoption of the report and close of meeting

10.1 The report of the meeting was adopted requiring 7 h and 50 min of discussion.

10.2 At the close of the meeting, Mr Somhlaba thanked all members of the Working Group for the hard work and positive contributions. He also thanked the Secretariat for their support and coordination in progressing the work of the group.

10.3 On behalf of the Working Group, Dr M. Collins (United Kingdom) thanked Mr Somhlaba for his leadership, skill, patience and tremendous spirit in guiding the discussions of the Working Group.

10.4 On behalf of the Working Group, Mr Dunn (New Zealand) thanked the Secretariat team for their work, responsiveness, and high-quality work in support of the meeting.

10.5 The meeting was closed.

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Table 1. Proposed skate injury codes for skate injury assessment.

Category	Description
0	No visible injuries
J	Jaw cartilage break or significant tearing of tissue around the mouth
G	Gills bleeding on either dorsal or ventral surface
L	Lice damage on/around the peritoneal cavity
I	Intestinal prolapse exceeding 3 cm, including if bleeding
P	Penetrating injury of the peritoneal cavity
E	Eye or spiracle injury
W	Wounds that are minor or superficial skin trauma to any region
B	Bruising on the dorsal or ventral side of disc or tail
S	Scar tissue around mouth/jaw that has healed from previous injury

Table 2. Precautionary catch limits for *Euphausia superba* in Division 58.4.1.

Division	Subregion	Longitude Range	Biomass (million tonnes)[1]	Precautionary Harvest Rate	Catch Limit (t)
58.4.1	West	80-103°E	1.567	0.0847	132 725
58.4.1	Middle	103-123°E	0.643	0.0847	54 462
58.4.1	East	123-150°E	2.114	0.0847	179 056
58.4.1	Total	80-150°E			366 243

[1]Biomass estimates from Abe et al. (2023a, Table 1).

Table 3. Precautionary catch limits for *Euphausia superba* in Division 58.4.2.

Division	Subregion	Longitude Range	Biomass (million tonnes)[1]	Precautionary Harvest Rate	Catch Limit (t)
58.4.2	West	30-55°E			1 448 000*
58.4.2	East	55-80°E	6.480	0.0860	557 280
58.4.2	Total	30-80°E			2 005 280

* Catch limit from Conservation Measure 51-03, paragraph 3.
[1]Biomass estimate from Cox et al. (2022).

Table 4: Research Blocks biomasses (B, tonnes) and catch limits (CL, tonnes) estimated using the trend analysis*. Greyed cells indicate research blocks that require catch advice for the upcoming season. 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 5 Seasons. Recommended catch limits are subject to approval by the Commission.

Area	Subarea or Division	Research Block	Species	PCL	Trend decision	Adequate recaptures	CPUE Trend Decline	B	B×0.04	PCL×0.8	PCL×1.2	Recommended CL for 2024
48	48.1	481_1	*D. mawsoni*	43	-	-	-	-	-	-	-	
		481_2	*D. mawsoni*	43	-	-	-	-	-	-	-	
		481_3	*D. mawsoni*	0	x	x	x	x	x	x	x	
	48.2	482_N	*D. mawsoni*	75	-	-	-	-	-	-	-	
		482_S	*D. mawsoni*	75	-	-	-	-	-	-	-	
	48.6	486_2	*D. mawsoni*	123	ISU	Y	N	3 741	150	98	148	148
		486_3	*D. mawsoni*	37	ISU	N	N	1 045	42	30	44	42
		486_4	*D. mawsoni*	157	D	Y	Y	6 136	245	126	188	126
		486_5	*D. mawsoni*	168	ISU	Y	Y	20 621	825	134	202	202
58	58.4.1	5841_1	*D. mawsoni*	138	x	x	x	x	x	x	x	112*
		5841_2	*D. mawsoni*	139	x	x	x	x	x	x	x	80*
		5841_3	*D. mawsoni*	79	x	x	x	x	x	x	x	79*
		5841_4	*D. mawsoni*	46	x	x	x	x	x	x	x	46*
		5841_5	*D. mawsoni*	60	x	x	x	x	x	x	x	116*
		5841_6	*D. mawsoni*	104	x	x	x	x	x	x	x	50*
	58.4.2	5842_1	*D. mawsoni*	86	ISU	Y	N	13 769	551	69	103	103
		5842_2	*D. mawsoni*	258	ISU	N	Y	5 934	237	206	310	206
	58.4.3	5843a_1	*D. eleginoides*	0	x	x	x	x	x	x	x	
	58.4.4	5844b_1	*D. eleginoides*	18	-	-	-	-	-	-	-	
		5844b_2	*D. eleginoides*	14	-	-	-	-	-	-	-	

(continued)

Table 4 (continued)

Area	Subarea or Division	Research Block	Species	PCL	Trend decision	Adequate recaptures	CPUE Trend Decline	B	B×0.04	PCL×0.8	PCL×1.2	Recommended CL for 2024
88	88.2	882_1	*D. mawsoni*	230	ISU	Y	N	4 356	174	184	276	184
		882_2	*D. mawsoni*	268	ISU	Y	N	28 853	1154	214	322	322
		882_3	*D. mawsoni*	208	ISU	N	N	6 054	242	166	250	242
		882_4	*D. mawsoni*	185	ISU	Y	N	10 302	412	148	222	222
		882H	*D. mawsoni*	122	ISU	Y	N	10 837	433	98	146	146
	88.3	883_1	*D. mawsoni*	16	ISU	N	Y	1 401	56	13	19	13
		883_2	*D. mawsoni*	20	-	-	-	-	-	-	-	20
		883_3	*D. mawsoni*	48	ISU	N	Y	5 371	215	38	58	38
		883_4	*D. mawsoni*	48	ISU	N	Y	2 078	83	38	58	38
		883_5	*D. mawsoni*	8	-	-	-	-	-	-	-	8
		883_6	*D. mawsoni*	36	ISU	N	N	2 065	83	29	43	43
		883_7	*D. mawsoni*	36	ISU	N	N	3 184	127	29	43	43
		883_8	*D. mawsoni*	10	-	-	-	-	-	-	-	10
		883_9	*D. mawsoni*	10	x	x	x	x	x	x	x	x
		883_10	*D. mawsoni*	10	x	x	x	x	x	x	x	x

*Proposed maximum catch is based on the 75th percentile of catch rates and longlines with 5000 hooks (see Table 8 in WG-SAM-2023/03).

Table 5: Preliminary example of a table summarising evidence for changes in stock assessment parameters or processes that could be due to the effects of environmental variability or climate change, based on the available information for the Antarctic toothfish stock assessment for the Ross Sea region.

Parameter or process			Evidence for trends and potential drivers
1a	Recruitment	Mean recruitment	Patterns in recruitment from the assessment model showed no evidence of trends over time (WG-FSA-2023/13).
1b		Recruitment variability (σ_R and autocorrelation)	The time series is currently not long enough to evaluate changes in variability, but the depletion rule was not a constraint in the application of the CCAMLR decision rules in the most recent assessment (WG-FSA-2023/13).
2	Age at maturity		No analyses have investigated potential changes in age or length at maturity (WG-FSA-12/40).
3	Stock-recruit relationship		Recent recruitments are consistent with the stock recruitment assumptions, but the time series of recruitment is not long enough to determine if the stock recruitment relationship was affected by climate change (WG-FSA-2023/13). Long term monitoring of mean recruitment and its relationship to spawning stock biomass may be able to be used to determine if changes in the relationship occur in future years.
4a	Natural mortality	From direct predation	Not known.
4b		Not from direct predation	Not known.
5	Growth rates		Age-length residual patterns across cohorts suggest that there have been small long-term fluctuations in mean size at age, following a roughly decadal cycle (WG-FSA-2019/11).
6	Length-weight		Patterns of length-weight relationship showed no evidence of trends or variability over time (WG-FSA-2019/11).
7	Sex ratio changes		No evidence of changes in sex ratio in the catch or the RSSS that may be explained by climate change (WG-FSA-2023/19).
8	Spatial distribution		No evidence of a change in the spatial distribution for Antarctic toothfish in the Ross Sea region from the analysis of fishing effort data (WG-FSA-2023/19). However, any changes in spatial distribution outside the historical fishing footprint are not known.
9	Stock structure		No evidence to suggest the stock structure hypothesis for Antarctic toothfish in the Ross Sea has altered from current stock structure hypotheses.
10	Locations of spawning and site fidelity		Not known.
11	Depredation mortality		No evidence for any changes in rates or occurrence of depredation from either fisher or observer observations - only rare instances of depredation mortality have been observed in the Ross Sea.

Table 6: Recommendations from the summary of the 2023 Independent Review, and the Working Group response to them including allocation of priority.

2023 Independent review panel recommendation	Priority	Response
1.1 Assessments move to a more contemporary modelling platform/s such as Casal2 as soon as practicable to allow more flexibility and robustness in running models.	High	Casal2 assessments presented and used for advice in 2023.
2.1 Where data allows, toothfish assessments should use sex-specific estimates of biological parameters.	Medium	The Ross Sea assessment is already sex disaggregated. For the other assessments work has been undertaken estimating sex-specific parameters. Sex-specific models should be investigated as a sensitivity run in future work, but importance dependent on the use of length data and sexual dimorphism.
2.2 Future analyses should investigate methods to incorporate environmental and ecosystem parameters in toothfish population models.	Medium	Consider whether assessments and management are robust to ecosystem changes using management strategy evaluations.
2.3 Sensitivity testing should be conducted to investigate the impact of freeing and covarying currently fixed parameters such as natural mortality and steepness in toothfish assessment models.	Low	Very little information is available to estimate these parameters freely, but sensitivity testing is a high priority for future work when evaluating alternative decision rules. An evaluation should be conducted when more recent information on steepness available. Work on the estimates and functional forms of natural mortality should be conducted and uncertainties in these parameters would be useful to consider in an MSE.
2.4 Post release mortality associated with tagging, natural mortality and movement estimates should be regularly reviewed and updated as new methods become available and tagging timeseries grow.	Medium	Vessel-specific relative tagging mortality estimates have been estimated for the Ross Sea, 48.3 and 58.5.2. Natural mortality was estimated in 58.5.2 and the Ross Sea (Candy, 2011; Candy et al. 2011; WG-SAM-06/08) but estimates of M should be updated.
3.1 Methods such as longline surveys and/or spatially structured fishing should continue to be developed to augment fishery-independent data on distribution and abundance of toothfish vulnerable to the fishery.	Medium	Existing survey time series contribute to the assessment in the Ross Sea (longline survey) and in 48.3 and 58.5.2 (trawl surveys). Potential for development of future structured sampling should be evaluated.
3.2 Model-based methods should be investigated to evaluate and, where necessary, adjust for, possible biases introduced by interannual variation in surveys, fishing pattern and stock distribution.	Very high	A workplan has been developed (see paragraph 4.53 to 4.60) to investigate the impact of interannual spatial variability in tag and effort distribution, with respect to the stock.
3.3 Where available, otoliths collected from across the timespan of fishing activity should be aged and included in estimating catch at age, growth.	Ongoing	Ageing programs underway in all the assessments. Ross Sea and 58.5.2 have aged otoliths across all years of the fishery.
3.4 Future analyses should investigate the extent of age, cohort and density-related effects on biological parameters for toothfish stocks.	Low	Could be investigated as part of management strategy evaluations.

(continued)

Table 6: (continued)

2023 Independent review panel recommendation	Priority	Response
4.1 A comprehensive stock annex should be developed for CCAMLR's integrated assessments for toothfish.	High	Stock annexes presented or updated for 48.3 TOP, 48.4 TOP, Ross Sea TOA.
4.2 Retrospective analyses be added to the suite of standard diagnostics for assessment models.	High	Presented for many of the assessments in 2023. The Working Group investigated retrospective trends in tag data. Stock assessors should include retrospective diagnostics in all future assessments.
5.1 CCAMLR continue to develop its suite of assessment diagnostics to include checks for trends in key biological and fishery parameters in space and time.	Medium	Table 5. Developments towards Casal2 has allowed standardised code for diagnostics. Diagnostics with analyses of key biological and fishery parameters in space and time should be developed.
6.1 Management strategy evaluation should be conducted to investigate alternative periodicity of assessments, length of projection period and alternative harvest strategies to achieve CCAMLR's objective.	Very high	A workplan has been developed (paragraph 4.53) to evaluate additional decision rules such as F-based rules and refine the operationalisation of the current decision rules.
6.2 CCAMLR continue to explore alternative methods for robustly estimating recruitment used in projections.	High	Being addressed as part of 6.1. Assumptions about future recruitment need to be evaluated as part of the MSE.
7.1 SC-CAMLR note that the 2021 integrated assessment constituted the best science available to CCAMLR upon which to base its management advice in the subarea 48.3 Patagonian toothfish fishery.	-	An updated integrated assessment was presented to the Working Group for this fishery in 2023 to provide management advice in 48.3.
7.2 SC-CAMLR continue to use assessments that integrate timeseries of fishery, survey and biological data in a statistically robust way, such as that used in 2021, to provide management advice to CCAMLR for the subarea 48.3 Patagonian toothfish fishery.	-	Future assessments for Subarea 48.3 will continue to be developed based on Casal2 integrated assessments that integrates timeseries of fishery, survey and biological data in a statistically robust way.

Table 7: Maximum posterior density (MPD) CASAL B_0 estimates (tonnes) for *D. eleginoides* reported to WG-FSA and comparison with Secretariat estimates.

Assessment/Model Run	Reported B_0	Secretariat B_0	Difference (%)	WG-FSA-2023 paper No
Division 58.5.1				
M2	225 761	225 761	0	67 Rev. 1
Subarea 58.6				
M4	51 387	51 387	0	66

Table 8: Secretariat verification of MPD results and risks for Casal2 assessments submitted to WG-FSA. Risk 1 and risk 2 refer to the CCAMLR decision rules where risk 1 refers to Rule 1 and risk 2 to Rule 2.

Assessment/Model Run	Variable	Reported value	Secretariat value	WG-FSA-2023 paper No
Subarea 48.3	B_0	110 386	110 386	15 Rev. 1
Casal2 final	Objective function	879	879	
	Risk 1	<0.01	<0.01	
	Risk 2	0.49	0.49	
Subarea 48.4	B_0	914	914	17
Run23	Objective function	14 939	14 939	18
	Risk 1		<0.01	
	Risk 2		0.19	
Division 58.5.1	B_0	203 372	203 372	67 Rev. 1
M2	Objective function	1 299	1 299	
	Risk 1		<0.01	
	Risk 2		0.33	
Division 58.5.2	B_0	66 343	66 343	26 Rev. 1
3b	Risk 1	<0.01	<0.01	
	Risk 2		0.50	
Ross Sea region	B_0	78 533	78 533	13
R3	Objective function	2 977	2 977	
	Risk 1	<0.01	<0.01	
	Risk 2	0.50	0.50	

Table 9: Template table to be included in Casal2 stock assessment reports for Secretariat verification purposes. The "Comments" column may contain justifications for expected differences with Secretariat verifications. MPD refers to the median of the posterior distribution.

Variable	Value	Comments
Proposed yield (t)	X	
B_0 (t)		
MPD	X	
MCMC median	X	
Total objective function value	X	
Risk 1	X.xx	
Risk 2	X.xx	

Table 10: Summary review schedule of proposed and ongoing research proposals under CM 21-02 and CM 24-01. New proposals submitted either under CM 21-02 or CM 24-01, paragraph 3 should be submitted 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, CHL – Chile.

CM	Project plan	Description	Member	Area	Fishing seasons	Years since approval	2023	2024	2025
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	2021/2022-2023/2024	2	FSA		
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	2022/2023-2024/2025	1	FSA	FSA	
24-01	WG-FSA-2023/03	New Fishery Research Proposal Plan Under CM 24-01 Paragraph 3 to Continue the Acoustic-Trawl Survey *Champsocephalus gunnari* in the Statistical Subarea 48.2	UKR	48.2	2023/2024-2024/2025	Resubmitting in 2024	SAM FSA	To be determined	
24-01	WG-FSA-2023/36	New Fishery Research Proposal Plan for *Dissostichus* spp. under CM 24-01, paragraph 3, Subarea 48.2 during season 23/24 — 25/26	CHL	48.2	2023/2024-2025/2026	WG-FSA Suggested submit to WG-SAM 2024	SAM FSA	To be determined	To be determined
21-02	WG-SAM-2023/03	Continuing research in the *Dissostichus mawsoni* exploratory fishery in East Antarctica (Divisions 58.4.1 and 58.4.2) from 2022/23 to 2025/26; Research plan under CM21-02, paragraph 6(iii)	AUS, FRA, JPN, KOR, ESP	58.4.1	2022/2023-2025/2026	New	SAM FSA		FSA
21-02	WG-SAM-2023/03	Continuing research in the *Dissostichus mawsoni* exploratory fishery in East Antarctica (Divisions 58.4.1 and 58.4.2) from 2022/23 to 2025/26; Research plan under CM21-02, paragraph 6(iii)	AUS, FRA, JPN, KOR, ESP	58.4.2	2022/2023-2025/2026	1		FSA	
21-02	WG-FSA-2021/38	Revised proposal for continuing research on Antarctic toothfish (*Dissostichus mawsoni*) in Statistical Subarea 48.6 in 2021/22 from a multiyear plan (2021/22–2023/24): Research Plan under CM 21-02, paragraph 6(iii)	JPN, ZAF, ESP	48.6	2021/2022-2023/2024	2	FSA		

Table 11: Summary of the assessment of proposed and ongoing research plans and proposals under 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, TOA – *Dissostichus mawsoni*; n/a – not applicable. Section references refer to sections of the proposal listed in row 1 of the table.

Subarea/division:	48.6	58.4.1	88.1	88.3
Proposal:	WG-SAM-2023/01 Rev. 1	WG-SAM-2023/03 ** The research activity at Division 58.4.2 has been conducted in 2022/23 fishing season. So, this is the second year of an ongoing four-year plan with no significant change proposed for Division 58.4.2. Therefore, it is not required to be reviewed by WG-SAM and WG-FSA in 2023. This review table focuses on only Division 58.4.1.	WG-SAM-22/01 Rev. 1 WG-FSA-2022/41 Rev. 1 WG-SAM-2023/02	WG-SAM-2023/04 WG-FSA-2023/20 Rev. 1
Members:	JPN, ESP, ZAF	AUS, ESP, FRA, JPN, KOR	NZL	KOR, UKR
Conservation measure under which the proposal is submitted:	CM21-02	CM21-02	CM24-01	CM24-01
Time period:	2021/22–2023/24	2022/23–2025/26	2022/23–2024/25	2021/22–2023/24
Main species of interest:	TOA	TOA	TOA	TOA
Main purpose of the research (e.g. abundance, population structure, movement, …)	Abundance, population structure and distribution	Abundance, population structure and distribution	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: section 1.a	Y: Section 1a	Y: sections 1a, 1b	Y: 1. Objective of the research plan (a)
1. Quality of the proposal				
1.1 Is there enough information to evaluate the likelihood of success of the research objectives?	Y: all of this proposal	Y: Sections 3a, 3b & 3c	Y: sections 3a-3d	Y: 1. Objective of the research plan (b)

(continued)

Table 11 (continued)

Subarea/division:	48.6	58.4.1	88.1	88.3
2. Research design				
2.1 Is the proposed catch limit in accordance with research objectives?	Y: section 3.d, 4.a, and 4.b	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: section 3.b	Y: Section 3b (e.g., Report WG-SAM-2019 para. 6.6-6.7 and 6.11-6.13, and Table 1)	Y: section 3a	Y: 3. Survey design, data collection and analysis
2.3 Have the environmental conditions been thoroughly accounted for?	Y: section 3.b	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: section 5	Y	Y WG-SAM-11/16, WG-FSA-12/41, WG-SAM-13/32, WG-SAM-14/25, WG-FSA-14/51, WG-SAM-15/44, WG-SAM-16/14, WG-SAM-17/39, WG-FSA-17/57, WG-SAM-17/01, WG-SAM-18/10, WG-FSA-17/41, WG-SAM-19/03, SC-CAMLR-39/BG/28, WG-FSA-21/23, WGFSA-2022/40	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: section 5	Y: Section 5	Y: section 5, reference in Appendix 1, section 3.1.1	Y: 3. Survey design, data collection and analysis (b)

(continued)

Table 11 (continued)

Subarea/division:	48.6	58.4.1	88.1	88.3
3.2 Do the research platforms have acceptable tag detection and survival rates?	Y: WG-FSA-17/36 and WG-FSA-2019 report (Figure 7). *Shinsei-maru No. 8* is a new vessel, same gear and crew that the withdrawn *Shinsei-maru No.3*.	The vessels *Antarctic Discovery* and *Tronio* have good tagging performance (WG-FSA-17/36). The vessel *Kingstar* had a tag detection of 1 and no tag survival performance estimated (WG-FSA-17/36), however this vessel released 22 recaptures of a total 56 recaptures in Divisions 58.4.1 and 58.4.2 between 2015-2020. The vessel *Antarctic Aurora* has not had their tagging performances calculated but recaptured tagged fish before in this area, and the *Shinsei-Maru No. 8* started fishing in 2021 in Subareas 88.1 and 48.6 with the same crew and fishing gear as the *Shinsei-Maru No.3*. The vessel *Southern Ocean* started toothfish fishing in the Ross Sea in 2021/22 and has not had the tagging performances calculated. The vessels *Cap Kersaint* and *Sainte Rose* have tagging experience from fishing in Division 58.5.1 and not had the tagging performances calculated.	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 do not have their tagging performances calculated but have had tag recaptures before in this area.
3.3 Have the research teams sufficient resources and capacity for:				
3.3.1 Sample processing?	Y: section 1.c	Y: section 3b	Y: section 3b	Y: 3. Survey design, data collection and analysis

(continued)

Table 11 (continued)

Subarea/division:	48.6	58.4.1	88.1	88.3
3.3.2 Data analyses?	Y: section 1.c	Y: table 5	Y: Sections 3c, 3d WG-SAM-11/16, WG-FSA-12/41, WG-SAM-13/32, WG-SAM-14/25, WG-FSA-14/51, WG-SAM-15/44, WG-SAM-16/14, WG-SAM-17/39, WG-FSA-17/57, WG-SAM-17/01, WG-SAM-18/10, WG-FSA-17/41, WG-SAM-19/03, SC-CAMLR-39/BG/28, WG-SAM-2021/23, WG-FSA-2022/40	Y: 3. Survey design, data collection and analysis
4. Data analyses to address the research questions				
4.1 Are the proposed methods appropriate?	Y: section 1.a and 3.c	Y: section 3c	Y: section 3c	Y
5. Impact on ecosystem and harvest species				
5.1 Is the catch limit proposed consistent with Article II of the Convention?	Y: section 3.d, 4.a, and 4.b	Y: section 4a and 4b	Y: sections 4a and 4b	The proposed catch limits are planned to be updated during WG-FSA-23, reflecting the data collected in 2021/22 season.
5.2 Are the impacts on dependent and related species accounted for and consistent with Article II of the Convention?	Requires more analysis on by-catch populations, see WG-SAM-2019/09 (WG-FSA-2019 report Table 8): section 3.b	Y: Figure 1, Section 4c	Y: Sections 4b, 4c, Appendix 3 SC-CAMLR-39-BG- 03, SC-CAMLR-39-BG-28	Y

(continued)

Table 11 (continued)

Subarea/division:	48.6	58.4.1	88.1	88.3
6. Progress towards objectives for ongoing proposals				
6.1 Have the past and current milestones been completed?	Y: Section 1.c, and WG-FSA-2019/23 Rev. 1 Appendix 1	Y: Table 5, Section 1c	Y WG-SAM-11/16, WG-FSA-12/41, WG-SAM-13/32, WG-SAM-14/25, WG-FSA-14/51, WG-SAM-15/44, WG-SAM-16/14, WG-SAM-17/39, WG-FSA-17/57, WG-SAM-17/01, WG-SAM-18/10, WG-FSA-17/41, WG-SAM-19/03, SC-CAMLR-39/BG/28, WG-FSA-21/23, WG-SAM-2022/13, WG-FSA-2022/40, 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: WG-FSA-2019 report, para 4.58	Y: Report WG-FSA-2019 para. 4.91	Y	Y
6.3 Are all the objectives likely to be completed by the end of the research plan?	Y: Table 1	Completion of research objectives is conditional on the continuation of the exploratory fishing activities in Division 58.4.1.	Y	Y
6.4 Are there any other concerns?	N	N	N	N

Table 12. Annual percentage of skates released by depth range (m) in the Ross Sea region, using the survivorship estimates from Endicott & Agnew (2004) shown as bolded percentages for those depths.

Season	< 1300	1300–1500	> 1500	No. released	Estimated survivorship
Survivorship	**75%**	**46%**	**24%**		
2003	81	16	3	966	0.69
2004	92	8		1 852	0.73
2005	78	22		5 057	0.69
2006	74	25	1	14 698	0.67
2007	75	22	3	7 336	0.67
2008	82	17	1	7 190	0.70
2009	87	11	1	7 088	0.71
2010	87	11	2	6 796	0.71
2011	91	9	0	5 440	0.72
2012	80	20		2 238	0.69
2013	86	13	1	5 675	0.71
2014	96	4		5 534	0.74
2015	90	8	2	12 978	0.72
2016	72	26	2	6 016	0.66
2017	81	19	0	3 857	0.69
2018	74	25	1	5 924	0.67
2019	83	16	1	8 870	0.70
2020	86	13	1	15 620	0.71
2021	71	27	2	9 490	0.66
2022	83	16	1	15 654	0.70
2023	91	9	0	8 461	0.72

Table 13: Intersessional work plan for WG-FSA. Items tasked to WG-FSA from the Scientific Committee Strategic Plan (SC-CAMLR-41, Table 8). Numbers refer to the numbering in the original tables. DSAG – Data Services Advisory Group, SISO – Scheme of International Scientific Observation, AUS – Australia, CHN – People's Republic of China, ESP – Spain; FRA – France, JPN – Japan, KOR – Republic of Korea, NZ – New Zealand, ZAF – South Africa, UK – United Kingdom, USA – United States.

Theme	Priority research topic	Priority research topic task	Timeframe	Contributors	Secretariat participation
1. Target species	(a) Develop methods to estimate total fish by-catch for the krill fishery	(iii) Data collection – SISO, vessels Priority: High	2024-2025	Secretariat	Yes
	(b) Develop stock assessments to implement decision rules for krill	(i) Krill management approach (synthesis of krill recruitment, spatial scale, biomass estimates, predator risk) Priority: High (1) Subarea 48.1 (2023) Priority: High (2) Other areas (48.2 and 48.3) Priority: High	2024-2025	WG-ASAM-2024/ WG-EMM-2024	Yes
		(ii) Methods to account for uncertainty in stock status Priority: Low			
		(iii) Develop krill management approach as a multiannual cycle Priority: Medium	Upon completion of (i)		
		(iv) Krill management strategies that are robust to climate change Priority: Low	2027	WG-SAM-2027/ WG-EMM-2027	Yes
	(c) Develop methods to estimate biomass for finfish	(i) Data collection – SISO and vessels Priority: High			
		(1) Conversion factors Priority: mostly done	2024	Secretariat, FRA and NZ	Yes
		(2) Tagging protocols Priority: done	2023	Dr Jones/Mr Arangio	Yes
		(3) Ross Sea data collection program Priority: Medium	2024–2028	All involved Members (NZ Lead)	Yes

(continued)

Table 13 (continued)

Theme	Priority research topic	Priority research topic task	Timeframe	Contributors	Secretariat participation
		(ii) Accounting for potential spatial bias in assessments. Priority: Urgent	2024–2025	WG-SAM 2024 and Members	
	(d) Develop stock assessments to implement decision rules for finfish	(i) Research to develop new assessments Priority: Low		WG-SAM	
		(1) Research plan evaluations Priority: Required	Annual	WG-SAM/WG-FSA	Yes
		(2) Subarea 88.2 fishery structure Priority: Low	2027 2023–2027	(NZ lead) All involved Members	Yes
		(3) Stock structure and connectivity (cross ref modelling of spatial structure, done in Areas 48, 58 and Subareas 88.1 and 88.2) Priority: Low		JPN/NZ/CHN/KOR/USA Members	Yes
		(ii) Develop new assessment tools			
		(1) Casal2 development Priority: done	2023–2025	NZ/All involved Members	
		(2) Casal2 data limited assessment. Priority: high	2024	ZAF, ESP, JPN and other Members	Yes
		(iii) Provide precautionary catch limits Priority: Required	Annual	WG-FSA regular updates	Yes
		(iv) Developing sex disaggregated assessment models for areas with combined sex assessments Priority: Medium	2026	Members	

(continued)

Table 13 (continued)

Theme	Priority research topic	Priority research topic task	Timeframe	Contributors	Secretariat participation
	(e) Management strategy evaluations for target species (Second Performance Review, Recommendation 8 independent review)	(ii) Development and testing of data-limited fishery decision rules Priority: Medium	2024–2025	Interested Members (WG-FSA-2024, paragraph 4.67)	Yes
		(iii) Finfish management strategies that are robust to climate change Priority: Urgent	2024	AUS/NZ/UK Interested Members	Yes
		(iv) Analysis of current and alternative decision rules Priority: High (see also WG-SAM-2023 Table 1, theme 1, task (e)(i))	2024	Members and WG-SAM-2024	Yes
	(f) Refine stock assessment procedures	i) Improve methods for inclusion of ageing data, e.g.: • Determining the CVs on the age compositions and effective sample sizes Priority: Medium • Determining the effect of different target levels of precision for age determination, Priority: Medium	2024-2025	Members	
		ii) Incorporating environmental and ecosystem parameters in toothfish population models Priority: Medium	2024-2025		
		iii) Investigate the impact of covarying productivity parameters. Priority: Medium	2026-2027		

(continued)

Table 13 (continued)

Theme	Priority research topic	Priority research topic task	Timeframe	Contributors	Secretariat participation
		iv) Continuing development of stock assessment diagnostics Priority: ongoing	2026-2027		
		v) Developing methods to validate and pool multimember age data Priority: ongoing	2026-2027		
2. Ecosystem impacts	(a) Ecosystem monitoring (Second Performance Review, Recommendation 5)	(i) Structured ecosystem monitoring programs (CEMP, fishery)			
		(2) Fishery via SISO Priority: Medium		Regular monitoring	Yes
		(3) Research surveys Priority: Low		Members fishing under CM-24-01 Surveys	
		(iii) Invasive species Priority: Low			
	(c) By-catch risk assessment for krill and finfish fisheries	(i) Monitoring status and trends Priority: High	Annual	Secretariat	
		(ii) By-catch species catch limits Priority: High	2026	Members	
		(iii) Review of by-catch decision rules Priority: Medium	2027		
		(iv) By-catch mitigation methods Priority: Low	2026	Members	
	(d) Habitat protection from fishing impacts	(i) Habitat classification, bio-regionalisation and monitoring Priority: Low			
		(ii) VME identification and management Priority: Low	2025	Members	Yes

(continued)

Table 13 (continued)

		(iii) Protection of biodiversity and ecosystems (Second Performance Review, Recommendation 7) (1) Ecosystem impacts from krill and finfish fishing, including analyses whether research and sampling design is able to detect such impacts Priority: Low (2) Physical disturbance of longline fishing on benthic ecosystems Priority: Low (3) Suitability of reference areas for comparison between fished and unfished areas Priority: Medium	2027	Members and WG-EMM	Yes
	(e) Monitoring and adaptation to effects of climate change, including acidification	(i) Develop methods to detect change in ecosystems given variability and uncertainty (Second Performance Review, Recommendation 6) Priority: Medium		Members and WG-EMM	
Administrative topics	(a) Advise on database facilities required through DSAG Priority: ongoing		Annual	DSAG	Yes
	(b) Advise on quality control and assurance processes for data provided to and supplied by the Secretariat Priority: ongoing		Annual	DSAG	Yes

(continued)

Table 13 (continued)

	(c) Refine the scheme of international scientific observation (SISO) for: (1) finfish Priority: Medium (2) krill Priority: High		2027 2024-2025		Yes
	(d) Further develop data management systems Priority: Medium	(1) Quality assurance Priority: ongoing	Annual	DSAG	Yes
		(2) DOI Priority: Low		DSAG	Yes
		(3) Review Data access rules Priority: Low		DSAG	Yes
	(e) Communication of progress, internal and external Priority: ongoing		Annual	Convener	Yes
	(f) Working group terms of reference Priority: Done		2022	SC-CAMLR-41	Yes
	(g) Scientific Committee Symposium in 2027 (Include annual review) Priority: Medium		2027	SC Chair	Yes

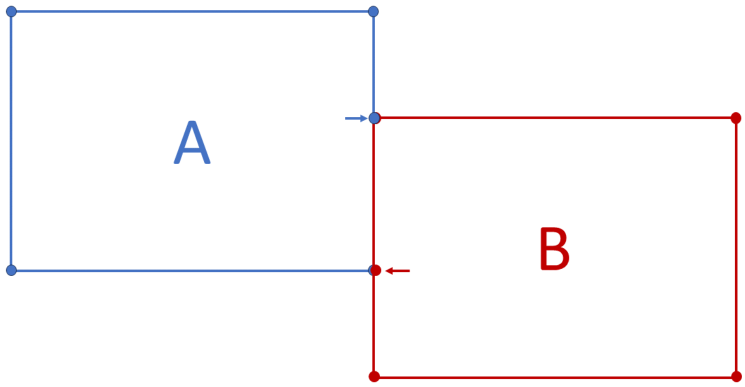

Figure 1. Polygons A and B are each defined by four vertices and an additional vertex at the extremity of their shared edge (arrow).

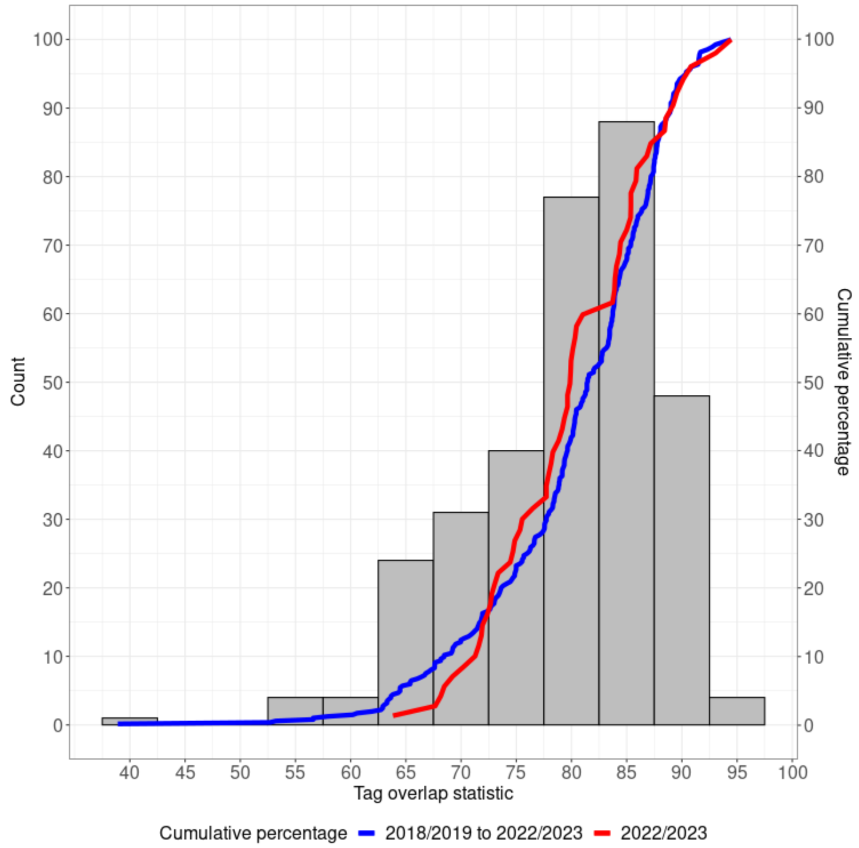

Figure 2: Histogram of the tag overlap statistics calculated as specified in CM 41-01 (2022) for CCAMLR seasons 2018/2019 to 2022/2023. The overlap statistic was calculated when more than 30 TOP or 30 TOA were tagged for all areas for which a catch limit is assigned. An overlap statistic below 60 does not necessarily imply a compliance issue, as the spatial distribution to which the tag overlap should to be applied was modified in CM 41-01 during 2022. The figure also shows cumulative percentage of the fishing trips which achieved a given value for the tag overlap statistic (blue – seasons 2018/2019 to 2022/2023 and red – season 2022/2023 only).

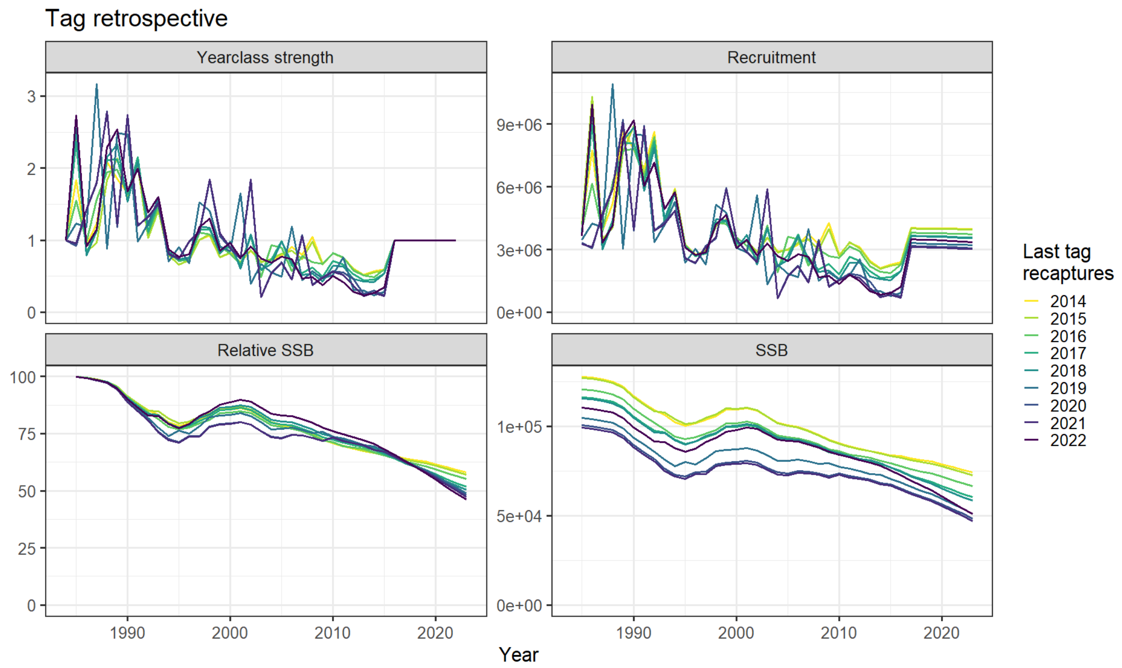

Figure 3: Estimated year class strength, recruitment, relative spawning stock biomass and spawning stock biomass, from the tagging retrospective analysis for the *D. eleginoides* stock assessment in Subarea 48.3 where tagging data were removed year-by-year from the 2023 stock assessment. Note that the 2023 stock assessment used tag recapture data up to 2022.

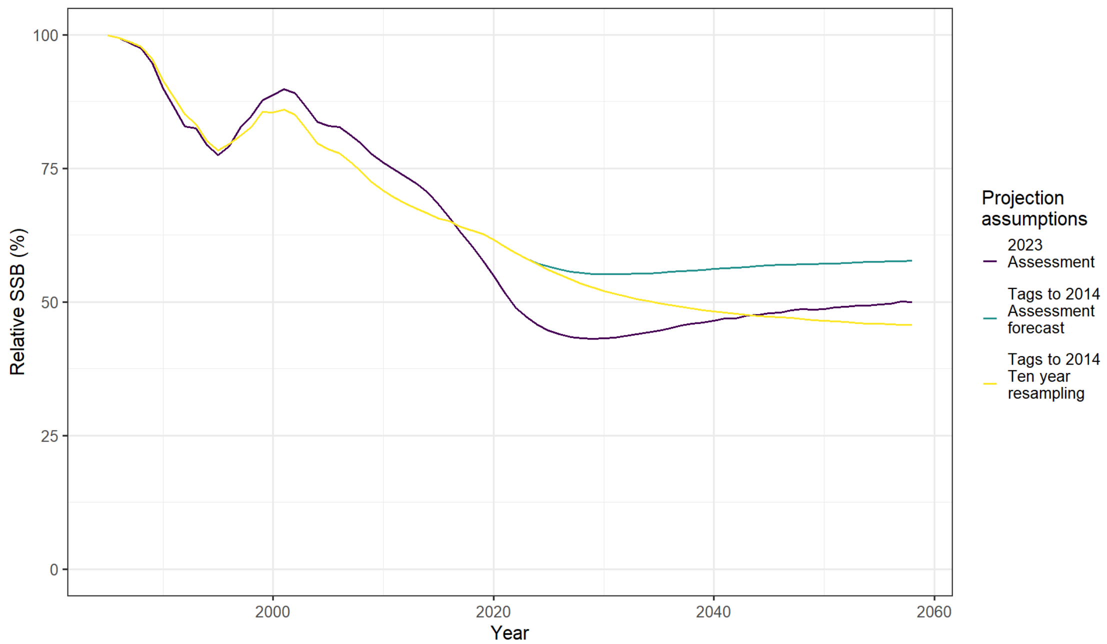

Figure 4: Maximum of the posterior distribution (MPD) from the toothfish stock assessment in WG-FSA-2023/15 Rev. 1 and median projection forward applying a 0.85 multiplier to the lognormal-empirical distribution from 1993-2016 estimated year class strength time series (purple line) for *D. eleginoides* in Subarea 48.3, and the retrospective run with tagging data up to 2014 and median projection forward with the same recruitment assumption as in WG-FSA-2023/15 Rev. 1 (green line) and resampling the last ten years of estimated recruitment (yellow line). All projections assume the proposed catch limit of 2 000 tonnes and 98 tonnes of depredation from WG-FSA-2023/15 Rev.1.

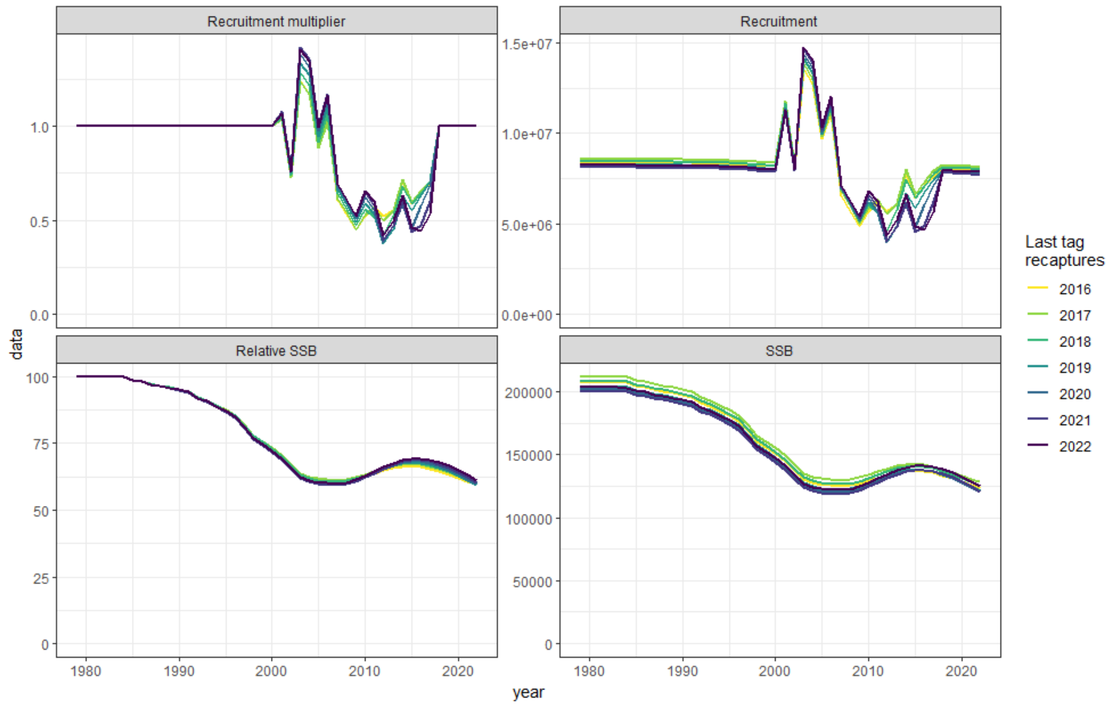

Figure 5: Estimated recruitment multiplier, recruitment, relative spawning stock biomass and spawning stock biomass from the tagging retrospective analysis for *D. eleginoides* in Division 58.5.1 where tagging data were removed year-by-year from the 2023 stock assessment. Note that the 2023 assessment used tag recapture data up to 2022.

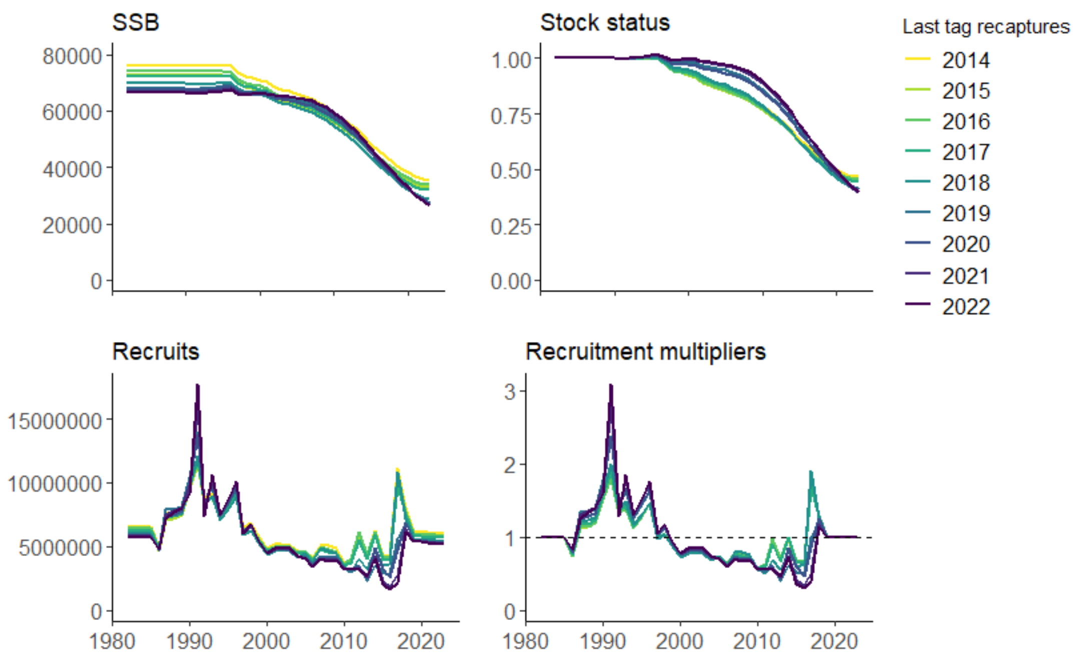

Figure 6: Estimated spawning stock biomass, relative spawning stock biomass (stock status), recruitment and recruitment multipliers from the tagging retrospective analysis for the *D. eleginoides* stock assessment in Division 58.5.2 where tagging data were removed year-by-year from the 2023 stock assessment. Note that the 2023 stock assessment used tag recapture data up to 2022.

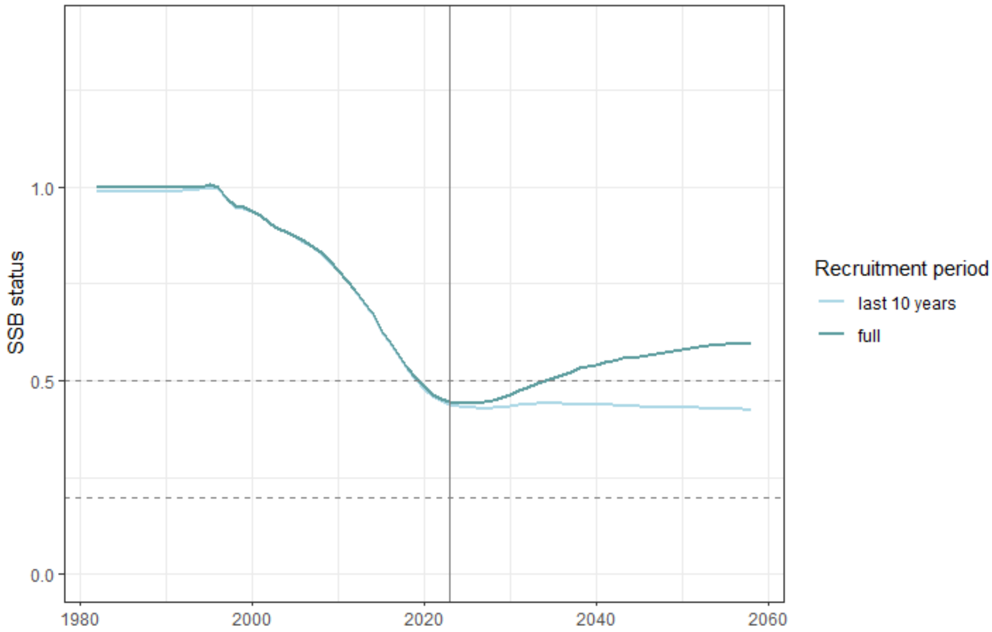

Figure 7: Maximum of the posterior distribution (MPD) of the retrospective run with tagging data up to 2018 and median projection forward with the catch limit of 2 660 tonnes proposed by WG-FSA-2023/26 Rev. 1 and recruitment sampled from either the full estimated recruitment time series (1986-2017) or from only the last 10 years of estimated recruitment (2008-2017) for *D. eleginoides* in Division 58.5.2.

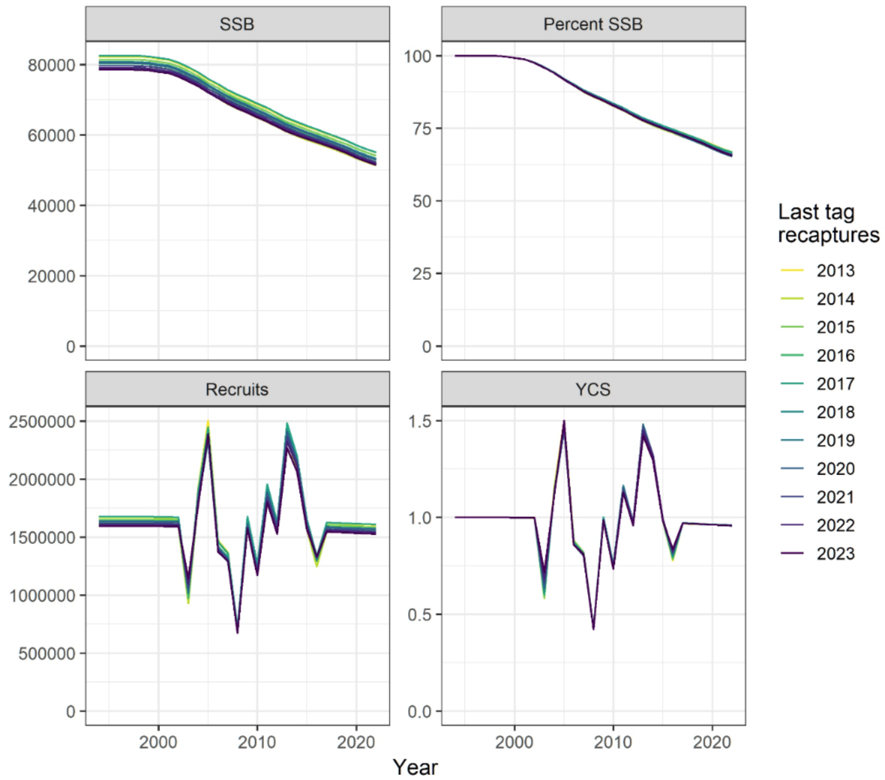

Figure 8: Estimated spawning stock biomass, percent spawning stock biomass, recruitment, and relative year class strength from the tagging retrospective analysis for *D. mawsoni* in Subareas 88.1 and 88.2AB where tagging data were removed year-by-year from the 2023 stock assessment.

Appendix A

List of Participants

Working Group on Fish Stock Assessment
(Hobart, Australia, 1 to 13 October 2023)

Convener	Mr Sobahle Somhlaba Department of Agriculture, Forestry and Fisheries
Argentina	Dr Marco Favero National Research Council (CONICET, Argentina)
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Korea, Republic of	Mr Hyun Joong Choi TNS Industries Inc.
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	Dr Eunjung Kim National Institute of Fisheries Science
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	Professor Hyuk Je Lee Sangji University
	Mr Jeongseok Park National Institute of Fisheries Science
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	Mr Nathan Walker Ministry for Primary Industries
Norway	Mr James Clark MRAG
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South Africa	Mrs Melanie Williamson Capricorn Marine Environmental (CapMarine)
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CCAMLR Secretariat

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Fisheries and Observer Reporting Coordinator

Dr Stéphane Thanassekos
Fisheries and Ecosystem Analyst

Daphnis De Pooter
Science Data Officer

Appendix B

Agenda

Working Group on Fish Stock Assessment
(Hobart, Australia, 1 to 13 October 2023)

1. Opening of the meeting
    - 1.1 Introduction
    - 1.2. Adoption of the agenda
    - 1.3 Review of terms of reference and the work plan
2. Review of CCAMLR fisheries in 2022/2023 and notifications for 2023/2024
3. Krill
4. Fish
    - 4.1 Area 48
        - 4.1.1 *Champsocephalus gunnari* in Subarea 48.3
        - 4.1.2 Icefish research survey proposal in Subarea 48.2
        - 4.1.3 *Dissostichus eleginoides* in Subarea 48.3
        - 4.1.4 *Dissostichus eleginoides* in Subarea 48.4
        - 4.1.5 *Dissostichus mawsoni* in Subarea 48.4
        - 4.1.6 Research plans targeting *D. mawsoni* in area 48 notified under CM 21-02 or CM 24-01
    - 4.2 Area 58
        - 4.2.1 *Champsocephalus gunnari* in Division 58.5.2
        - 4.2.2 *Dissostichus eleginoides* in Division 58.5.1
        - 4.2.3 *Dissostichus eleginoides* in Division 58.5.2
        - 4.2.4 *Dissostichus eleginoides* in Division 58.6
        - 4.2.5 Research plans in area 58 notified under CM 21-02

4.3 Area 88

4.3.1 Subarea 88.1 and SSRUs 882AB - *D. mawsoni* in the Ross Sea region

4.3.2 Subarea 88.2

4.3.3 Subarea 88.3

5. By-catch

5.1 By-catch management in krill fisheries

5.2 By-catch management in toothfish fisheries

5.3 VME management

6. Scheme of International Scientific Observation

7. Future work

8. Other business

9. Advice to the Scientific Committee

10. Adoption of the report and close of meeting

Appendix C

List of Documents

Working Group on Fish Stock Assessment
(Hobart, Australia, 2 to 13 October 2023)

WG-FSA-2023/01	Advances in reducing the interaction with Killer whales and Sperm whales, in the Patagonian Toothfish fishery in CCAMLR subarea 58.7: application of the SAGO Extreme capture system Delegation of Uruguay
WG-FSA-2023/02	Update of the ´SAGO EXTREME` fishing system on the ´Patagonian toothfish` *Dissostichus* eleginoides fishery Delegation of Uruguay
WG-FSA-2023/03	New Fishery Research Proposal Plan Under CM 24-01 Paragraph 3 to Continue the Acoustic-Trawl Survey *Champsocephalus gunnari* in the Statistical Subarea 48.2 Delegation of Ukraine
WG-FSA-2023/04	Improving identification of fish bycatch in the Antarctic krill fishery Delegation of the United Kingdom
WG-FSA-2023/05	2023 trend analysis: Estimates of toothfish biomass in Research Blocks CCAMLR Secretariat
WG-FSA-2023/06	CCAMLR fishery data forms and manuals development status CCAMLR Secretariat
WG-FSA-2023/07 Rev. 2	Implementation of the CCAMLR Scheme of International Scientific Observation during 2022/23 CCAMLR Secretariat
WG-FSA-2023/08	Core processes illustrations in support of the proposed Agent-Based Modelling framework (WG-SAM-2023/17) CCAMLR Secretariat
WG-FSA-2023/09	2023 Ross Sea shelf survey results Devine, J. and C. Péron
WG-FSA-2023/10	A preliminary assessment for mackerel icefish (Champsocephalus gunnari) in Division 58.5.2, based on results from the 2023 random stratified trawl survey Maschette, D.

WG-FSA-2023/11	Age and growth of the subantarctic skates *Bathyraja eatonii* and B. irrasa in Kerguelen and Amblyraja taaf in Crozet through the use of the vertebrae centrum Faure, J. and C. Péron
WG-FSA-2023/12	Antarctic toothfish (*D. Mawsoni*) age determination Misar, N.
WG-FSA-2023/13	Assessment model for Antarctic toothfish (*Dissostichus mawsoni*) in the Ross Sea region to 2022/23 Mormede, S., A. Grüss, A. Dunn and J. Devine
WG-FSA-2023/14	Casal2 Stock Assessment for Antarctic krill in CCAMLR Subarea 48.1 Kinzey, D. and G.M. Watters
WG-FSA-2023/15 Rev. 1	Assessment of Patagonian Toothfish (*Dissostichus eleginoides*) in Subarea 48.3 Earl, T. and L. Readdy
WG-FSA-2023/16	Assessment of Patagonian Toothfish (*Dissostichus eleginoides*) in Subarea 48.3: Assessment Diagnostics Earl, T. and L. Readdy
WG-FSA-2023/17	Assessment of Patagonian Toothfish (*Dissostichus eleginoides*) in Subarea 48.4 Readdy, L. and T Earl
WG-FSA-2023/18	Assessment of Patagonian Toothfish (*Dissostichus eleginoides*) in Subarea 48.4: Assessment Diagnostics Readdy, L. and T. Earl
WG-FSA-2023/19	Characterisation of the toothfish fishery in the Ross Sea region (Subarea 88.1 and SSRUs 882A–B) through 2022/23 Devine, J.A. and S. Mormede
WG-FSA-2023/20	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-2023/21 Rev. 1	Detection by an albatross sentinel of a vessel probably engaged in IUU activity in 2019 over Banzare Bank, subarea 58.4.3b Collet, J., K. Delord, B. Guilloux, A.-S. Bonnet-Lebrun, C. Péron, A. Corbeau, A. Pajot, C. Barbraud and H. Weimerskirch

WG-FSA-2023/22	Diagnostic plots for the 2023 assessment for Ross Sea region Antarctic toothfish (*Dissostichus mawsoni*) Mormede, S., A. Grüss, A. Dunn and J.A. Devine
WG-FSA-2023/23	Diagnostic plots for the 2023 assessment model for the Crozet Islands EEZ Patagonian toothfish (*Dissostichus eleginoides*) fishery in Division 58.6 Massiot-Granier, F., F. Ouzoulias and C. Péron
WG-FSA-2023/24 Rev. 1	Diagnostic plots for the 2023 assessment model for the Kerguelen Island EEZ Patagonian toothfish (*Dissostichus eleginoides*) fishery in Division 58.5.1 Massiot-Granier, F., F. Ouzoulias and C. Péron
WG-FSA-2023/25	Diet composition and feeding strategy of Antarctic toothfish, Dissostichus mawsoni in Subareas 88.1 and 88.3 in the 2022/23 fishing season Baeck, G.W., S. Chung and J. Park
WG-FSA-2023/26 Rev. 1	Draft integrated stock assessment for the Heard Island and McDonald Islands Patagonian toothfish (*Dissostichus eleginoides*) fishery in Division 58.5.2 Masere, C. and P. Ziegler
WG-FSA-2023/27	Estimates of biomass and catch limits for macrourids on the continental slope of the Ross Sea region (Subarea 88.1 and SSRUs 88.2AB) Devine, J., S. Parker, A. Dunn, R. O'Driscoll, and M. Pinkerton
WG-FSA-2023/28	Exploring SSBs responses to different recruitment scenarios and SSB0 calculations in a context of regime shift: a Kerguelen Patagonian toothfish fishery case study Ouzoulias, F., C. Péron and F. Massiot-Granier
WG-FSA-2023/29	Fish nest area in the southern Weddell Sea. Discussions and recommendations from WG-EMM-2023 Teschke, K., R. Konijnenberg, P. Brtnik, L. Ghigliotti and M. Eléaume
WG-FSA-2023/30	Fishery characterisation for Antarctic toothfish (*Dissostichus mawsoni*) and Patagonian toothfish (*D. eleginoides*) around the South Sandwich Islands (Subarea 48.4) Marsh, J., T. Earl, A. Riley and L. Readdy
WG-FSA-2023/31	Fishery characterisation for Patagonian toothfish (*Dissostichus eleginoides*) around South Georgia (Subarea 48.3): 2023 update Marsh, J. and T. Earl

WG-FSA-2023/32 Rev. 1	Identification traits for the grenadiers *Macrourus caml* and *M. whitsoni* for onboard observer's use with preliminary attempt in Subarea 88.3 Chung, S., M-J. Seo and J-K. Kim
WG-FSA-2023/33	Improved VAST (vector autoregressive spatio-temporal) modelling of grenadier relative abundance in Subarea 48.6 Sawada, K. and T. Okuda
WG-FSA-2023/34	Intra- and Inter-annual Variability in Seasonal Sea Ice and Krill Fishery in Subareas 48.1 and 48.2 Shnar V. and S. Kasatkina
WG-FSA-2023/35	Length at maturity of the subantarctic skates *Bathyraja eatonii* and *B. irrasa* in Kerguelen and *Amblyraja taaf* in Crozet Faure, J. and C. Péron
WG-FSA-2023/36	New Fishery Research Proposal Plan for Dissostichus spp. under CM 24-01, paragraph 3, Subarea 48.2 during season 23/24 — 25/26 Delegation of Chile
WG-FSA-2023/37 Rev. 1	Population structure of Antarctic toothfish, *Dissostichus mawsoni* from Areas 58 and 88 in the Antarctic Ocean using microsatellites and genome-wide SNPs Choi, H., H. Park, S. Chung, J. Park, D. Maschette and H.J. Lee
WG-FSA-2023/38	Preliminary assessment of mackerel icefish (*Champsocephalus gunnari*) in Subarea 48.3 based on the 2023 Groundfish Survey Marsh, J. and T. Earl
WG-FSA-2023/39	Preliminary tag-recapture based population assessment of Antarctic toothfish (*Dissostichus mawsoni*) in Subarea 48.4 - 2023 fishing season Marsh, J., L. Readdy, A. Riley and T. Earl
WG-FSA-2023/40	Quantifying post-release survival of skate bycatch in the HIMI Patagonian Toothfish longline fishery Appert, C., S. Tracey, C. Peron, C. Masere, P. Ziegler and J.B. Cleeland
WG-FSA-2023/41	Recent indicative trends in by-catch of sharks in the CAMLR Convention Area C.D. Jones
WG-FSA-2023/42	Report of research fishing operations at Subarea 48.6 between the 2012/13 and 2022/23 fishing seasons Delegations of Japan, Spain, and South Africa

WG-FSA-2023/43 Rev. 1	Report of the co-conveners of the Age Determination Workshop Hollyman, P. and J. Devine
WG-FSA-2023/44	Report of the Groundfish Survey at South Georgias Islands (CCAMLR- Subarea 48.3) in 2023 Delegation of Argentina
WG-FSA-2023/45 Rev. 1	Report of the UK Groundfish Survey at South Georgia (CCAMLR Subarea 48.3) in February 2023 Hollyman, P., S.L. Hill, C. Gunn, P. Keith, B. Rodriguez and M.A. Collins
WG-FSA-2023/46	Report on Argentina´s CCAMLR Subarea 48.3 survey: fish Ruocco, N.L., G. Lukaszewicz, E. Aguilar, B. Fusaro, S. Barbini, D. Figueroa and G.A. Colombo
WG-FSA-2023/47	Report on exploratory fishing in Divisions 58.4.1 and 58.4.2 between the 2011/12 and 2022/23 fishing seasons Cleeland, J., C. Masere, T. Lamb and P. Ziegler
WG-FSA-2023/48	Report on the Acoustic-Trawl Survey of *Champsocephalus gunnari* in Statistical Subarea 48.2 in 2023 Delegation of Ukraine
WG-FSA-2023/49	Results from the 2023 Random Stratified Trawl Survey in the Waters Surrounding Heard Island in Division 58.5.2 Maschette, D., T. Lamb, J. Cleeland, C. Appert, C. Masere and P. Ziegler
WG-FSA-2023/50	Risk assessment for the Antarctic starry skate (*Amblyraja georgiana*) in the Ross Sea Holmes, S.J., B. Finucci, J.A. Devine, and M.H. Pinkerton
WG-FSA-2023/51	Ross Sea region Data Collection Protocols Delegation of New Zealand
WG-FSA-2023/52 Rev. 1	Satellite Tagging of Adult Patagonian Toothfish (*Dissostichus eleginoides*) Provides First Evidence for Unexpected Movement Patterns Kim, E. and C.H. Lam
WG-FSA-2023/53	Searching Spatial-Temporal Changes in Intrinsic Productivity of Antarctic Krill (*Euphausia superba*) in a Climate Change and Fishery Management Context Mardones, M., G. Watters and C. Cárdenas
WG-FSA-2023/54	Spatial Mismatch in Krill Management Approach Warwick-Evans, V., M.A. Collins and S. Hill

WG-FSA-2023/55	Stock Annex for the 2023 assessment of Ross Sea region Antarctic toothfish (*Dissostichus mawsoni*) Mormede, S., J. Devine, A. Grüss and A. Dunn
WG-FSA-2023/56	Stock Annex for the 2023 assessment of Subarea 48.3 (South Georgia) Patagonian toothfish (*Dissostichus eleginoides*) Earl, T., L. Readdy and J. Marsh
WG-FSA-2023/57	Stock Annex for the 2023 assessment of Subarea 48.4 (South Sandwich Islands) Patagonian toothfish (*Dissostichus eleginoides*) Readdy, L., T. Earl and J. Marsh
WG-FSA-2023/58	Stock Annex for the 2023 assessment of the Patagonian toothfish (*Dissostichus eleginoides)* population of the Crozet Islands EEZ in Division 58.6. Massiot-Granier, F., F. Ouzoulias and C. Péron
WG-FSA-2023/59	Stock Annex for the 2023 assessment of the Patagonian toothfish (*Dissostichus eleginoides*) population of the Kerguelen Island EEZ in Division 58.5.1. Massiot-Granier, F., F. Ouzoulias and C. Péron
WG-FSA-2023/60	Stock Annex for the mackerel icefish (*Champsocephalus gunnari*) fishery in Subarea 48.3 Marsh, J. and T. Earl
WG-FSA-2023/61	Study on reproductive potential of *Champsocephalus gunnari, Chaenocephalus aceratus, Pseudochaenichthys georgianus and Notothenia rossii* from South Georgias Islands, March 2023 Militelli, M.I., N. Ruocco and G. Lukaszewicz
WG-FSA-2023/62	Summary of the Toothfish Fishery and Tagging Programme in the Amundsen Sea Region (Small-Scale Research Units 882C-H) to 2021/22 Devine J.A. and S. Mormede
WG-FSA-2023/63	Summary Report from Australia's Heard Island and McDonald Islands Fishery Climate Adaptation Workshop McDonald, A., M. Gold and Philippe Ziegler
WG-FSA-2023/64	The Need to Revise the Approach to Assessing Gear Selectivity in Relation to the Krill Fishery in the Current CCAMLR Topics Sergeev S. and S. Kasatkina
WG-FSA-2023/65 Rev. 1	Update of Skate Tagging Programme in the Ross and Amundsen Sea Regions B. Finucci

WG-FSA-2023/66	Updated Stock Assessment Model for the Crozet Islands EEZ Patagonian Toothfish (*Dissostichus eleginoides*) Fishery in Sub-Area 58.6 Massiot-Granier, F., F. Ouzoulias and C. Péron
WG-FSA-2023/67 Rev. 1	Updated Stock Assessment Model for the Kerguelen Island EEZ Patagonian Toothfish (*Dissostichus eleginoides*) Fishery in Division 58.5.1 for 2023 Massiot-Granier, F., F. Ouzoulias and C. Péron
WG-FSA-2023/68	Updated Stock Assessments for *Euphausia superba* in Divisions 58.4.1 and 58.4.2 Maschette, D., H. Murase, N. Kelly, P. Ziegler and S. Kawaguchi
WG-FSA-2023/69	Using a novel machine learning approach to alleviate the allometric effect in otolith shape-based species discrimination Zhu, G.P. and Y.W. Chen
WG-FSA-2023/70	Revised VME Taxa Classification Guide Ross Sea region – version 2 Devine, J., D. Tracey, S. Mills, D. Macpherson, D. Gordon and E. Mackay
WG-FSA-2023/71	Tag linking - 2023 report CCAMLR Secretariat
WG-FSA-2023/72	Progress on the CCAMLR gear library CCAMLR Secretariat
WG-FSA-2023/73	Fish by-catch in the krill fishery - 2023 update. CCAMLR Secretariat
WG-FSA-2023/74	*Dissostichus* spp. Catch Documentation Scheme (CDS), and monthly fine-scale catch and effort data decision rule review CCAMLR Secretariat
WG-FSA-2023/75 Rev. 1	Vulnerable Marine Ecosystems (VME) in CCAMLR CCAMLR Secretariat

Other documents

WG-FSA-2023/P01	Fatty acid composition and energy allocation in muscle and gonad tissues indicates that the female mackerel icefish *Champsocephalus gunnari* is an income breeder Zhu, G.P. and K. Huang. 2023. *J. Fish Biol.*, 103(3): 460-471, doi: https://doi.org/10.1111/jfb.15461.
WG-EMM-2023/14	CCAMLR Marine Debris Monitoring Program, 2023 CCAMLR Secretariat

Appendix D

Report of the co-conveners of the Ageing Workshop

(Virtual meeting, 9 to 11 May 2023)

Welcome and introductions

1.1 The CCAMLR Ageing Workshop was held online from 9 to 11 May 2023. The Workshop was convened by Dr Philip Hollyman (United Kingdom) and Dr Jennifer Devine (New Zealand) and supported by the CCAMLR Secretariat. Scientists and technical experts from 12 Member nations attended the Workshop.

1.2 At the start of the workshop, Drs Hollyman and Devine welcomed the 36 participants (Attachment I) and thanked those that had uploaded information to the e-Group on practices and procedures in their ageing laboratories. The Workshop was noted as being an informal meeting with the aim to bring together technical experts involved with age estimation of toothfish, skates, macrourids, and other species and those who analyse age data to discuss specific aspects of the age estimation process. The goal was to develop documentation and guidelines on ageing, provide recommendations on the structure and implementation of an age reading database to be maintained by the Secretariat for toothfish, and recommend standard guidelines to improve and validate ages between readers and Members.

1.3 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 requests and recommendations outlined below will be reported to WG-SAM-2023 and WG-FSA-2023 for further discussion and agreed at SC-CAMLR-42 according to the Scientific Committee Rules of Procedure.

1.4 The names of participants are in Attachment I, the terms of reference for the Workshop are given in Attachment II, and the agenda in Attachment III.

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

ToR 1(a)

2.1 Participants from Australia, China, New Zealand, Japan, Korea, Spain, the United Kingdom, and the United States presented on the preparation and protocols used for production ageing within their labs, and some of the issues encountered while preparing and reading otoliths. Information for ToR 1a(i-v) from each Member can be found in Table 1.

2.3 Participants from Australia noted some difficulties with newer versions of the imaging software (Leica K2C/LAS), but that the imaging clarity was vastly improved.

2.2 Participants from China presented a comparison of baked and unbaked otoliths, noting that the primordium and first 5 zones can be identified using unbaked otoliths, and that accurate ageing can be done without baking otoliths, allowing for alternate uses after ageing, such as stable isotope or otolith microchemistry. No systematic differences were found in the ages between the baked and unbaked otoliths, but it was noted that a comparison of grinding versus thin section is still needed.

2.3 New Zealand presented some preliminary comparisons of thin sections versus bake and embed methods, noting that some differences were also because an inexperienced reader was being trained and that more work was needed to determine if systematic differences existed between the two preparation methods. New Zealand also noted issues with cracking when preparing thin sections and advice from other participants included creating slightly thicker sections that are fixed to slides and polished thinner or by using two blades separated by a spacer for stabilisation.

2.4 Participants from Spain noted that they have worked with other Members on ageing, and that direct counting using a microscope tended to have better results, but that images were easier to exchange, compare, and discuss.

2.5 The UK presented on a large resampling project being conducted to add ages to the historical data for Patagonian toothfish and on new studies with geochemical analyses. Images were noted as being difficult to age from static images and that older fish sometimes had crystalised edges with no banding or structure. Several labs discussed that they had encountered this, if not in toothfish, in other species, and that it might be related to a metabolic shift occurring in older fish, possibly with senescence.

2.6 The UK presented on their ageing of Antarctic toothfish and the progress they have made with practical issues and data cleaning but noted that they have limited material and were interested if other Members might share otoliths if fishing in the same areas.

2.7 Participants from the US presented on their connectivity work using, in part, otolith microchemistry to determine pathways and movement and how this might be impacted by the environment or climate change, and on developments using artificial intelligence to age toothfish.

2.7.1 Participants from Australia, China, and New Zealand also discussed developments in their labs for various species for ageing and morphological studies. Other methods, such as genomic approaches and use of methylation for ageing were also discussed.

2.8 The possibility of using otoliths as a source of DNA for other studies was discussed, but it was noted that biosecurity protocols for some Members may prevent this and otoliths with adhered dried tissue creates problems during preparation for ageing. Participants agreed that dedicated tissue collection programs may be better for this data collection and that this information could be part of the metadata that is stored within the otolith library.

2.9 Workshop participants discussed different types of resin or epoxy used for otolith preparation and if environmentally-friendly options were available. Some labs had success with less environmentally-bad epoxies (e.g., exopoxy), while others mentioned several plant-based brands that should be avoided because of poor quality.

2.10 Other species were discussed briefly by the Workshop participants, but many experts could not take part in the Workshop.

2.10.1 The use of skate caudal thorns versus vertebrae was discussed and it was noted that caudal thorns had promise for species in cold water environments, freezing and thawing did not seem to affect the thorns, and there may be sexual dimorphism for some species, where the caudal thorns are more robust for males because they use them when competing; this may affect the reading. Vertebra were discussed as not having the same calcification in deep, cold water as in shallower/warmer-living skate species and that they are likely not a suitable structure for ageing in the Southern Ocean. Workshop participants discussed age validation for skates and that only one individual was needed to validate ages from the pulsed strontium/OTC chemical marking of skates in the Ross Sea region.

2.10.2 Many Member laboratories are ageing other species and were happy to share protocols and comparing age readings.

2.11 Participants noted that several labs are restricted to one reader because of budgetary constraints and that this was not an ideal situation.

2.12 Readability scores were discussed as being useful when comparing between readers (or multiple reads with one reader) to determine where discrepancies in ageing might occur, to determine which otoliths should be used for imaging, and for creating an ageing matrix as described in WG-FSA-2014/46. Each lab tended to have its own set of scores for readability (Appendix IV) and it was discussed that should information be stored at the Secretariat or nations pool their ages for an assessment, a common scale may be needed.

2.12.1 The workshop requested WG-SAM or WG-FSA to determine if the assessments are affected by the number of unreadable otoliths and how that effect is spread across the age classes.

2.12.2 Participants discussed that protocols for pooling ageing data between different laboratories will need to be developed as well as the process for determining when data becomes valid for use in stock assessments.

2.12.3 The workshop requested WG-SAM to develop a mechanism for interlaboratory comparison of ages when pooling data (e.g., CV, IAPE, readability scores).

2.12.4 Participants suggested that if ageing data is used in a stock assessment, then the distribution of readability scores should be included in the report to determine if pooling created issues and where biases may occur.

2.12.5 The workshop requested WG-FSA to recommend to Scientific Committee that all papers that use production ageing data include the distribution of the readability scores, add readability scores to inter-reader comparison plots to indicate where potential biases may arise, and standardise reporting methods, such as by creating common scripts to be added to the CCAMLR github or to the eGroup for the Workshop on Age Determination.

2.12.6 Participants agreed a mechanism or protocol for interlaboratory comparison of age compositions are needed when pooling age data and that this information would need to be included in the ageing database. The Workshop noted that early reports from the CCAMLR Otolith Network (CON) included interlaboratory comparisons in a report to WG-FSA (WG-FSA-02/51) and that this should be considered.

2.13 Participants agreed that otolith reference sets for the two preparation methods: bake and embed and thin sectioning, will need to be developed, that sister otoliths will need to be used for the two methods, and that criteria for developing the reference set need to be defined. It was agreed that pooling resources and otoliths could be less onerous than each lab building its own reference sets, and that sharing of images would be easier and cheaper. Participants also agreed that switching preparation or ageing methods will be difficult for labs to do because it may require extra tools and equipment, which might not be possible.

2.13.1 Concerns were raised that there may be differences between counts from images and via a microscope, therefore the working group participants recommended that Members with the capability to use both methods investigate this further.

2.13.2 The Workshop discussed that the size of the reference set may differ between species because of differences in longevity, but that this may not be problematic because reference sets should continuously evolve (e.g., should be updated with otoliths from more recent seasons), and may need to be larger for species that are aged for assessments. The Workshop discussed that using the age distribution might resolve how large the sample size should be for the reference set. It would need multiple fish in each age category to estimate a variance, may need to be area-specific, and would need to be stratified by sex, readability, or other metadata.

2.13.3 The Workshop discussed the potential use of different types of reference sets. With some (potentially larger sets) being used to train new readers and others for returning readers to read before resuming ageing after an extended break, or to recalibrate their reading at certain intervals to check for drift.

2.13.4 A workshop with ageing experts from each lab would be needed to ensure everyone agreed on interpretation and to generate a single count for each otolith in the reference set. Cassandra Brooks (University of Colorado) offered to host the workshop in the intersessional period (early 2024).

2.13.4.1 The Workshop drafted ToRs (Attachment IV) for the proposed workshop and recommended that SC endorse the proposal for the workshop and ToRs. requested WG-FSA recommend to the Scientific Committee to recommend the draft ToRs for this workshop

2.13.5 The workshop requested WG-FSA to recommend that Scientific Committee recommend an in-person (or online) meeting before 2024 mid-year meetings for the different laboratories to generate a single count for each otolith in the reference set.

2.14 Participants discussed the need for comparative studies on ageing using the two preparation methods and comparing direct counting using microscopes versus images. The US discussed current work their lab is conducting, comparing counts using direct microscope reading versus images and offered to share their results, when available, while experts from Spain discussed discrepancies they found when comparing preparation methods.

2.15 The Workshop discussed what a reasonable sample size should be for inter-reader comparison and that guidance on the optimal amount of coverage is needed. Some labs read 20-30% of the samples, while others have found that 120 otoliths were enough to allow for variance among all the ages.

2.15.1 The workshop requested that WG-SAM help determine the reasonable amount of coverage needed when a second reader ages a subset of the otoliths for production ageing.

2.16 Workshop discussed whether the current thresholds for CV and Index of Average Percent Error (IAPE, 10% and 5%) were adequate and whether thresholds should be different if using only one reader. If the CV is too high, the age-length matrix would become highly variable, and the assessment would not be able to track cohorts well. Participants agreed that including the standard set of precision and bias checks should be added to characterisations or assessment reports, where these data were used.

2.16.1 The workshop requested that WG-SAM and WG-FSA determine the effect of a range of CVs on the age-length matrix and assessments.

2.16.2 The workshop requested that WG-SAM and WG-FSA develop target levels of precision (CV, IAPE) for age determination among readers or counts between a single reader and for reference sets to monitor and maintain consistency in age interpretation.

2.17 The Workshop discussed that a network, such as the CCAMLR Otolith Network (CON) or joining an existing one that meets (online or in-person) to exchange knowledge on new methods and technology, for interlaboratory training, would be beneficial.

2.17.1 The Workshop requested WG-FSA to recommend to Scientific Committee to recommend the resurrection of the CCAMLR Otolith Network for Members to exchange knowledge and work together for ageing purposes, and that the Age Determination eGroup might form the basis for the reinstated network

ToR 1(b)

3.1 Participants discussed lead-radium (Brooks et al. 2011), strontium-chloride, and oxytetracycline marking (Horn et al. 2003) were validation methods used previously for toothfish, and strontium and oxytetracycline were used for skates, but that ethics rules for many Members have changed since these studies which may prevent the use of strontium and tetracycline in the future. Toothfish may be a good candidate for genomic methods, and magnesium mapping, magnesium trace elemental methods, Fourier transform near-infrared spectroscopy (FT-NIRS; Passerotti et al., 2022), or otolith microchemistry approaches may be possibilities.

3.1.1 The workshop requested that WG-FSA recommend Scientific Committee recommend that members work should continue on age validation methods, particularly on non-toothfish species.

3.1.2 Cassandra Brooks offered to make available a dataset that had been age validated.

ToR 1(c)

4.1 The Workshop noted that time and money constraints seemed to dictate what can be accomplished among labs when developing age compositions and catch-age structure, but that if Members pooled ages, less otoliths may need to be read by each lab in the future.

4.1.1 The workshop requested guidance on ToR 1c from WG-SAM to determine the minimum number of samples required and methods to estimate age compositions and catch age structure.

ToR 1(d)

5.1 The Workshop participants noted that there were large differences in the preparation of otoliths and processing of samples between the different laboratories and that a document library, hosted on the Secretariat's website, might be the best approach. Members that may want to contribute can then do so.

5.1.1 The workshop participants recommend Members submit documentation on their ageing protocols and manuals to a document library held by the Secretariat.

ToR 1(e)

6.1 Participants discussed whether the metadata within the otolith reference library should be allowed to link to observer or C2 data and agreed some fields could be useful, but that not all would be needed. The Secretariat noted that linking data to new samples (more recent data) would be possible, but that data quality issues mean linking to historical data could be problematic and require manual confirmation of links.

6.1.1 The workshop recommend Members consider submitting data for inclusion in the age database and otolith library.

6.1.2 The workshop recommended that the Secretariat include a data field indicating whether otolith is part of the reference collection (in both individual member and CCAMLR otolith databases).

6.1.3 The Workshop further recommended that the database would need to include when a change occurred to the database, otolith preparation, ageing approach or readability scoring.

6.2 The Workshop discussed that some suggested database fields were only collected as standard by very few members due to time constraints (e.g., otolith length and weight) but that this data is useful in morphometric studies when available.

6.2.1 The workshop recommended that Members record lengths and weights of otoliths to aid morphometric and AI studies, where possible, but with a particular focus on non-toothfish species as these data are quite sparse.

ToR 1(f)

7.1 The workshop concluded that more images are needed in the CCAMLR otolith reference library before a comparison of age estimates can take place. The workshop discussed a range of variables that would ideally be covered with new imagery, including images from: both toothfish species, a range of geographical areas, both sexes, and a range of lengths and readabilities.

7.1.1 The workshop requested WG-FSA to recommended to Scientific Committee to recommend Members submit a set of up to 60 high quality images, including notations (where currently available), for each species they age, beginning with toothfish, which will then be used to build the reference otolith set.

7.1.2 The workshop requested FSA to recommend to Scientific Committee that Members submit otolith images for Antarctic and Patagonian toothfish by March 1st 2024.

7.1.3 The workshop recommended that those interested in participating in the potential in-person workshop in 2024 should read 150 of the available otolith images before the workshop.

ToR 1(g)

8.1 The workshop had several discussions regarding the use and building of otolith reference collections (2.13 – 2.13.3) but no decisions were reached on a minimum number of otoliths for a reference collection, or how the samples for a reference collection should be chosen. Members currently use reference sets of differing size ranging from 100 – 240 (Attachment 1).

8.2 Recommendations are needed for several aspects on the construction and use of reference sets. The discussion of which should be continued via the eGroup and / or the proposed in-person workshop in 2024.

8.2.1 The workshop requested the assistance of WG-SAM to determine the total number and the selection of specific variables (e.g., sex, area, lengths, years, season, readability score) needed when building the reference set.

8.2.2 The workshop requested Members to work together in the eGroup to determine the number of otoliths to age when reading the reference set for training or for experienced readers prior to production ageing.

8.2.3 The workshop requested Members work together in the eGroup to determine how often readers should use the reference set once qualified, to check for drift.

References

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Appendix D Table 1. Summary of Member ageing programs, including the species aged, method of selection, preparation method, measures of quality control, whether a reference set is used and how it is constructed, and the age arbitration method.

Member	Species	Method of selection	Otolith preparation	Quality control	Use of a reference set	Age arbitration method
Australia	TOP and TOA (also Macrourids, grey rockcod and unicorn Icefish)	2 fish per 1 cm length bin. 1:1 sex ratio	thin section method	Independent readings by 2 different readers. Otoliths for which discrepancies are large are re-read by both readers and the reconciled ages are used. Readers are tested using reference collections for each species prior to production readings.	TOP reference set of 200 otoliths and TOA reference set of 200 otoliths	
China	TOA and TOP (also Icefish, Myctophids, and other several species from Nototheniidae)	Left and right otoliths are randomly selected	bake and embed method / unbaked and embed method (for comparison)	Independent readings by different readers. Precision is assessed by calculating the APE and CV.	No reference set available yet.	
Japan	TOP and TOA	10 random per set and additional fish to ensure 10 males and 10 females for each 5cm length bin	thin section method	A second reading by either different readers or by the same reader at least 2 weeks after the original reading. Precision is assessed by calculating the APE and CV. Annotated images with annuli are created during each reading.	Uses CCAMLR reference dataset	
New Zealand	TOA (also Skates, Macrourids)	all recaptured fish 10 fish per set per species 10 fish per sex per 5cm length bin	bake and embed intent to move to thin section method	Only 1 reader experienced with bake and embed method. Use reference set to test the reader if longer than 4 weeks have passed since the reader had aged the species. Precision is assessed by calculating the APE and CV of the reference set readings.	TOA reference set of 240 otoliths make up, subset in 4 discrete sets of 60 otoliths. These reference sets have been made available to CCAMLR	
Korea	TOA	5 fish per 1 cm length bin in 883. 10 fish per set in other area's	bake and embed method	Only 1 reader whose estimations have been previously demonstrated to be comparable to expert readers.	No reference set available yet.	

(continued)

Appendix D Table 1. (continued)

Spain	TOA	10 random per set and additional fish to ensure 10 males and 10 females for each 5cm length bin	bake and embed method	Consensus by 2 readers is needed.	Uses CCAMLR reference set	
UK	TOP	4 fish per 1cm size class for M and F. also juvenile TOP for groundfish survey	thin section method	The main reader will re-read a random selection of otoliths to assess within-reader variation. A second reader will read between 10 and 20% of the subset. Precision is assessed by calculating the APE and CV.	Two reference sets of 100 otoliths exists and a new reference set is being created using more recent samples.	
USA	TOP and TOA	Random selection of otoliths	bake and grind method	Independent readings by different readers. Precision is assessed by age bias plots and calculating the APE and CV.	Reference set of sectioned otoliths which have been read repeatedly.	

Appendix D Table 2. Otolith clarity rankings used by different members.

Rank	Australia	Japan	Republic of Korea
1	Sections where the opaque and translucent zones are extremely unclear or discontinuous and/or the section does not go through the primordium, where the count is not possible or would be highly unreliable, should be marked unreadable.	very easy to see	Otolith very easy to read; excellent contrast between successive opaque and translucent zones.
2	The section is through the primordium, but the opaque zones are unclear and not continuous for very long sections, or there are large areas where opaque banding is not distinguishable (often in the centre), leaving the count with a high degree of uncertainty.	easy to see	Otolith easy to read; excellent contrast between successive opaque and translucent zones.
3	Opaque zones are visible around most of the section and fairly distinguishable, but some uncertainty still exists in differentiation and interpretation of the banding.	normal	Otolith readable; less contrast between successive opaque and translucent zones than in 2, but alternating zones still apparent; potential error 2 opaque zones.
4	Opaque zones are clear over almost all of the otolith section, but there is perhaps one area that has some ambiguity e.g., towards the outer edge.	hard to see	Otolith readable with difficulty; poor contrast between successive opaque and translucent zones; potential error 3 opaque zones.
5	Opaque zones are clearly visible around the proximal half of the otolith enabling an accurate count of the bands and confidence in repeatability of the count.	unreadable	Otolith unreadable.

(continued)

Table 2. (continued).

Rank	New Zealand	Spain	UK
1	Otolith very easy to read; excellent contrast between successive opaque and translucent zones.	Otolith unreadable	Otolith is very clear and easily readable. Contrast between growth zones is very good.
2	Otolith very easy to read; excellent contrast between successive opaque and translucent zones.	Otolith readable with difficulty; poor contrast between successive opaque and translucent zones	Otolith is clear and readable. Contrast between growth zones is good. One growth zone may be unclear.
3	Otolith readable; less contrast between successive opaque and translucent zones than in 2, but alternating zones still apparent; potential error 2 opaque zones.	Otolith readable; less contrast between successive opaque and translucent zones than in 2, but alternating zones still apparent	Otolith is readable but contrast between zones is lower than 1 & 2. Two growth zones may be unclear.
4	Otolith readable with difficulty; poor contrast between successive opaque and translucent zones; potential error 3 opaque zones.	Otolith very easy to read; excellent contrast between successive opaque and translucent zones	Otolith is difficult to read. Contrast between zones is poor and three growth zones may be unclear.
5	Otolith unreadable		Otolith unreadable

Appendix D Table 3. Requests and recommendations from the Age Determination Workshop.

No.	Request/Recommendation	To whom	Report paragraph	Priority	If actioned and where
1	Submit documentation on their ageing protocols and manuals to a document library held by the Secretariat	Members' ageing laboratories	5.1.1	High	
2	Submit data for inclusion in the age database and otolith library	Members	6.1.1	High	
3	Submit a set of up to 60 high quality images, including notations, to the reference set library before the next Ageing Workshop (March 2024)	Members	7.1.1–7.1.2	High	
4	Read 150 of the available otolith images in the reference set held by the Secretariat before the next Ageing Workshop.	Members / technical experts on toothfish ageing	7.13	High	
5	To work together in the eGroup to determine how often qualified readers should use the reference collection to check for drift, and to determine how many otoliths to age from the reference set for training or for experienced readers prior to production ageing.	Members / technical ageing experts	8.2.2–8.2.3	High	
6	Recommend those with capability to investigate the potential differences in counts from images and from a microscope.	Members' ageing laboratories	2.13.1	Medium	
7	Record lengths and weights of otoliths to aid morphometric and AI studies, where possible, but with a particular focus on non-toothfish species as these data are quite sparse.	Members	6.2.1	Low	
8	Include in the age database a field indicating whether otolith is part of the reference collection (in both individual member and CCAMLR otolith databases).	Secretariat	6.1.2	Medium	
9	Include a field in the age database to indicate when a change occurred to the database, otolith preparation, ageing approach or readability scoring.	Secretariat	6.1.3	Medium	
10	Recommend that all papers that use production ageing data include the distribution of the readability scores, add readability scores to the 1:1 plot to indicate where potential biases may arise, and standardise reporting methods, such as by creating common scripts to be added to the CCAMLR github or to the eGroup for the Workshop on Age Determination.	Scientific Committee	2.12.5	High	

(continued)

Appendix D Table 3. (continued)

11	Develop a mechanism for inter-laboratory comparison of ages when pooling data (e.g., CV, IAPE, readability scores).	WG-SAM	2.12.3	High	
12	Determine the effect of a range of CVs on the age-length matrix and on the stock assessments for toothfish.	WG-SAM, WG-FSA	2.16.2	High	
13	Recommend ToRs for the 2nd Ageing Workshop, to be held before the 2024 mid-year meetings.	WG-FSA, Scientific Committee	Draft ToRs are included in Attachment IV	High	
14	Resurrect the CCAMLR Otolith Network for Members to exchange knowledge and work together for ageing purposes.	Scientific Committee	2.17.1	Medium	
15	Work should continue on age validation methods, particularly on non-toothfish species.	Scientific Committee	3.1.1	Medium	
16	Determine the minimum level of double reading necessary to ensure consistency in age readings	WG-SAM	2.15	High	SAM workplan – Theme 1, Task 11
17	Develop target levels of precision for age determination among readers or compared to reference sets (e.g., mean weighted coefficient of variation (CV)) to monitor and maintain consistency in age interpretation.	WG-SAM, WG-FSA	2.16.1	High	SAM workplan – Theme 1, Task 10
18	Determine the minimum number of samples required and methods to estimate age compositions and catch age structure.	WG-SAM	4.1.1(a)	High	SAM workplan – Theme 1, Task 12
19	Recommend the building of an otolith reference collection	WG-SAM, Secretariat	7.1.1	High	SAM workplan – Theme 1, Task 13
20	Determine the total number and the selection of specific variables (e.g., sex, area, lengths, years, season, readability score) needed for the reference otolith collection	WG-SAM	8.2.1	Medium	SAM workplan – Theme 1, Task 13

Attachment I. List of Participants

Tom Barnes
Avumile Bawuli
Cassandra brooks
Jilda Caccavo
Kevin Caoimhgin
Sangdeok Chung
Daphnis De Pooter
Jennifer Devine
Brit Finucci
Clare Gallagher
Laura Ghigliotti
Alan Hart
Philip Hollyman
Kai Huang
Christopher Jones
Sibusisile Kheswa
Evan Leonard
Alfonsina Macias
Jessica Marsh
Dale Maschette
Andy Nichols
Takehiro Okuda
Kenichiro Omote
Steve Parker
Yuli Rivadeneira
Georgia Robson
Roberto Sarralde
Sanggyu Shin
Sobahle Somhlaba
Colin Sutton
Mio Tanaka
Marino Vacchi
Jose Velez Tacuri
Melanie Williams
Zhen Zhao
Guoping Zhu
Mpumalanga

Attachment II. Workshop TORs

Virtual Workshop on Age Determination Methods – Terms of Reference

1) 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:
      i) Collect otoliths at sea;
      ii) Select otoliths for ageing;
      iii) Prepare and read otoliths;
      iv) Conduct quality control and readability measurement methods, including reader agreement metrics and thresholds for using the read ages in analyses; and
      v) 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 practise 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 WG-FSA-2022 Report – Preliminary version.
   g) Recommend standard guidelines for ageing and future work needed to improve and validate ages between readers and Members.

Attachment III. Workshop Agenda

Virtual Workshop on Age Determination Methods, 9–11 May 2023

Dear Colleagues,

We are looking forward to welcoming all interested parties to the virtual workshop on age determination, taking place on the 9th – 11th of May (SC CIRC 23/19).
The aim of the workshop is to bring together technical experts involved with age estimation of toothfish, skates, macrourids, and other species and those who analyse age data to discuss specific aspects of the age estimation process. The goal is to develop documentation and guidelines on ageing, provide recommendations on the structure and implementation of an age reading database to be maintained by the Secretariat for toothfish, and recommend standard guidelines to improve and validate ages between readers and Members. We would like encourage all delegations with interests in age determination to join the workshop and sign up to the e-group as soon as possible (Workshop on age determination).

The workshop will run from 19:00 UTC until 23:15 UTC each day, be broken into two 2-hour sessions each day with a short break between sessions, and will cover the following topics:

9th of May: Antarctic Toothfish & Patagonian toothfish ageing
10th of May: Toothfish ageing (continued) & Skate ageing
11th of May: All other species (e.g. Macrourids) & wrap up

We are seeking input from members on the following aspects of their ageing programs, no later than the 3rd of May 2023, to be submitted to the CCAMLR e-group (Workshop on age determination**).**

1) Which species are aged;
2) How the ageing structures are
    a. collected at sea,
    b. selected for ageing,
    c. prepared for reading,
    d. read;
3) What methods are used for quality control;
4) What readability measurements are used; and
5) Are references sets used – if so, please provide details on how they are constructed and used.

We would also encourage members to prepare short presentations on their ageing programs to cover the following:

1) An overview of their ageing program (methods, species, current and future work)
2) Any queries or issues they would like to raise or discuss during the workshop

We will share all materials on an e-group prior to the workshop and a summary of the workshop outcomes will be presented to WG-FSA.

Kind regards,
Dr Philip Hollyman & Dr Jennifer Devine, Co-conveners
Material can also be emailed to:
Philip Heath Philip.Heath@mpi.govt.nz; Jennifer Devine Jennifer.Devine@niwa.co.nz

Attachment IV. 2nd Age Determination Workshop Terms of Reference

1) Develop otolith reference sets for both Patagonian and Antarctic toothfish for each stock that is currently production aged, where reference sets will be housed at the Secretariat, including
    a. Annotate images
    b. Agree upon ages
    c. Agree upon metadata to be included in the reference set database, held by the Secretariat
2) Document the standard practices for ageing depending on the preparation method
3) Conduct a comparison of age reading from static images and physical samples to determine if there are any differences in age readings and/or biases from a particular method.

Proposal for a second CCAMLR workshop on age determination methods

Title: 2nd CCAMLR Age Determination Workshop (WS-ADM2-2024)
Host: University of Colorado, Boulder
Objectives:

1. To develop reference sets with agreed ages for both species of toothfish.
    a. Use the CCAMLR otolith image library to create production ageing reference sets.
    b. Outline how members should approach building their own otolith reference sets as a training tool for new readers.
2. To develop best practice standards based on the age preparation methods including diagnostic procedures and age database structure and use.

Terms of Reference:

1. Develop otolith reference sets for both Patagonian and Antarctic toothfish for each stock that is currently aged for stock assessments, where reference sets images and associated ageing data will be held by the Secretariat. Reference sets will be developed using annotated images submitted by members in advance of the workshop (WG-FSA-2023/43 rev 1, Table 3).
2. Document the best practise standards for ageing depending on the age preparation method including:
    a. Annotate images.
    b. Agree upon reference set ages.
    c. Agree upon metadata to be included in the reference set database, held by the Secretariat.
3. Conduct comparisons of age reading from static images and physical samples to determine if there are any differences in age readings and/or biases from a particular method.
4. Develop protocols, diagnostics, and procedures for 'blind' reads of otoliths to be used in future inter-reader and inter-lab comparisons

Convener(s): Dr J. Devine (New Zealand), Dr. C. Brooks (SCAR), Dr. P. Hollyman (United Kingdom)
Venue: University of Colorado, Boulder
Date: 22–26 April 2024
Duration: 5 days
Invited experts: TBA
Observers or external organisations: None
Funding required by CCAMLR: A$50 000 to cover invited experts travel related costs.
Secretariat Support required: Yes – Data Officer and Science Manager
Ability to submit papers: Not required
Outputs: Conveners report to WG-SAM-2024 and WG-FSA-2024 summarising the data, outcomes, and recommendations from the ToRs of the workshop.
Reported to: WG-SAM-2024 and WG-FSA-2024

Appendix F

Skate Tagging Poster

Tag deployment

1. Use handling procedures outlined in the training manual, minimise time out of water

2. Use more than one person for large skates, transport skate using a transport aide.

3. Carefully remove the hook. Assess suitability for tagging. Do not tag the skate if any of the 'retain' conditions listed below are present.

4. Double tag the skate using tags with sequential numbers if possible.

5. Confirm that tags are anchored with a gentle tug.

6. Record data as required in the observer longline logbook and the C2 logbook. Make sure to include all leading characters, tag type, colour and inscription.

7. Check that tag numbers are recorded correctly.

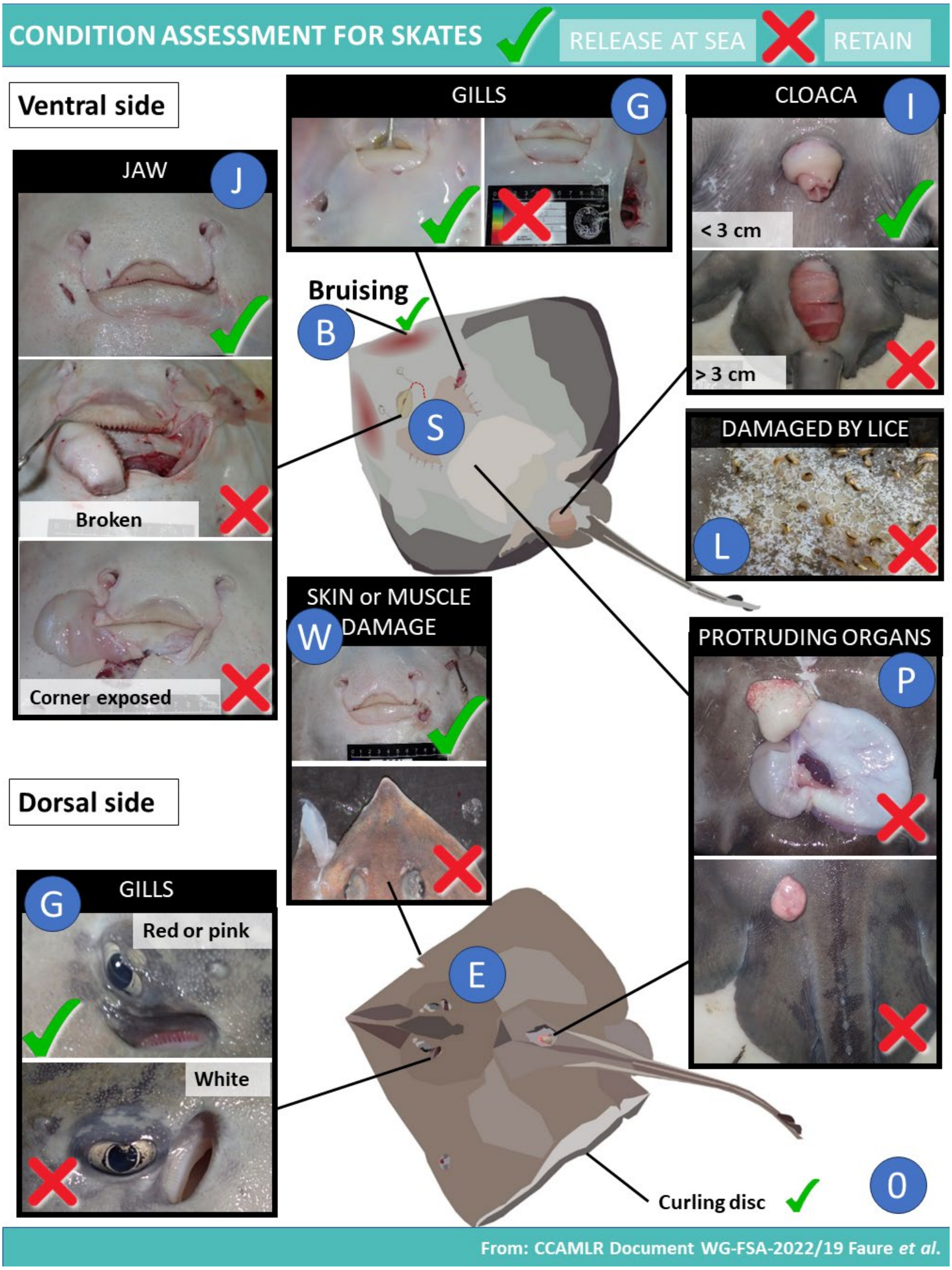
8. Release skate dorsal side up into water where release conditions are appropriate.

9. Observe and record fate of the skate in the logbook.

If a tagged skate is recaptured, retain it for the observer.

Suitability assessment injury codes to use for skates.

Category	Description
0	No visible injuries
J	Jaw cartilage break or significant tearing of tissue around the mouth.
G	Gills bleeding on either dorsal or ventral surface
L	Lice damage around the peritoneal cavity
I	Intestinal prolapse exceeding 3 cm, including if bleeding
P	Penetrating injury of the peritoneal cavity
E	Eye or spiracle injury
W	Wounds that are minor or superficial skin trauma to any region
B	Bruising on the dorsal or ventral side of disc or tail
S	Scar tissue around mouth/jaw that has healed from previous injury



CONDITION ASSESSMENT FOR SKATES
RELEASE AT SEA
RETAIN
Ventral side
JAW
J
Broken
Corner exposed
GILLS
G
Bruising
B
S
CLOACA
I
< 3 cm
> 3 cm
DAMAGED BY LICE
L
SKIN or MUSCLE DAMAGE
W
PROTRUDING ORGANS
P
Dorsal side
GILLS
G
Red or pink
White
E
Curling disc
O
From: CCAMLR Document WG-FSA-2022/19 Faure et al.

Best Practice Tagging Protocol

1. All tagging procedures and provision of equipment, including the sourcing of tags for vessels, is the responsibility of the Flag State of the vessel.

2. Observers and crew should work together in an efficient and effective way to achieve the best possible survival of the tagged fish.

3. Use a lifting aide such as a cradle, stretcher, dip net, or sling to support the weight of large fish selected for tagging from underneath to avoid injury.

4. Don’t lift fish to be tagged using a gaff or any other method that may injure the fish.

5. Only select fish that are in good condition for tagging using the condition assessment criteria.

6. Keep the distance between the hauling bay, the tagging station, and the release point as short as practicable and minimise obstacles that may increase time onboard and the potential for injury to the fish.

7. Use a tagging station which is protected from the weather, both for the safety of the fish handlers and the health of the fish.

8. Minimise the total time fish to be tagged are out of any water, aim for less than three minutes.

9. Minimise the time fish are held in holding tanks, if used.

10. Don’t overcrowd holding tanks or have both skates and toothfish in the tank at the same time. Recommendations on holding tank design can be found in the Commercial Data Collection Manual – Longline Fisheries. The percentage of fish volume relative to volume of water in the holding tank should not exceed 10%.

11. Release tagged toothfish headfirst into the sea and keep the distance between the release point and the sea surface as short as practicable.

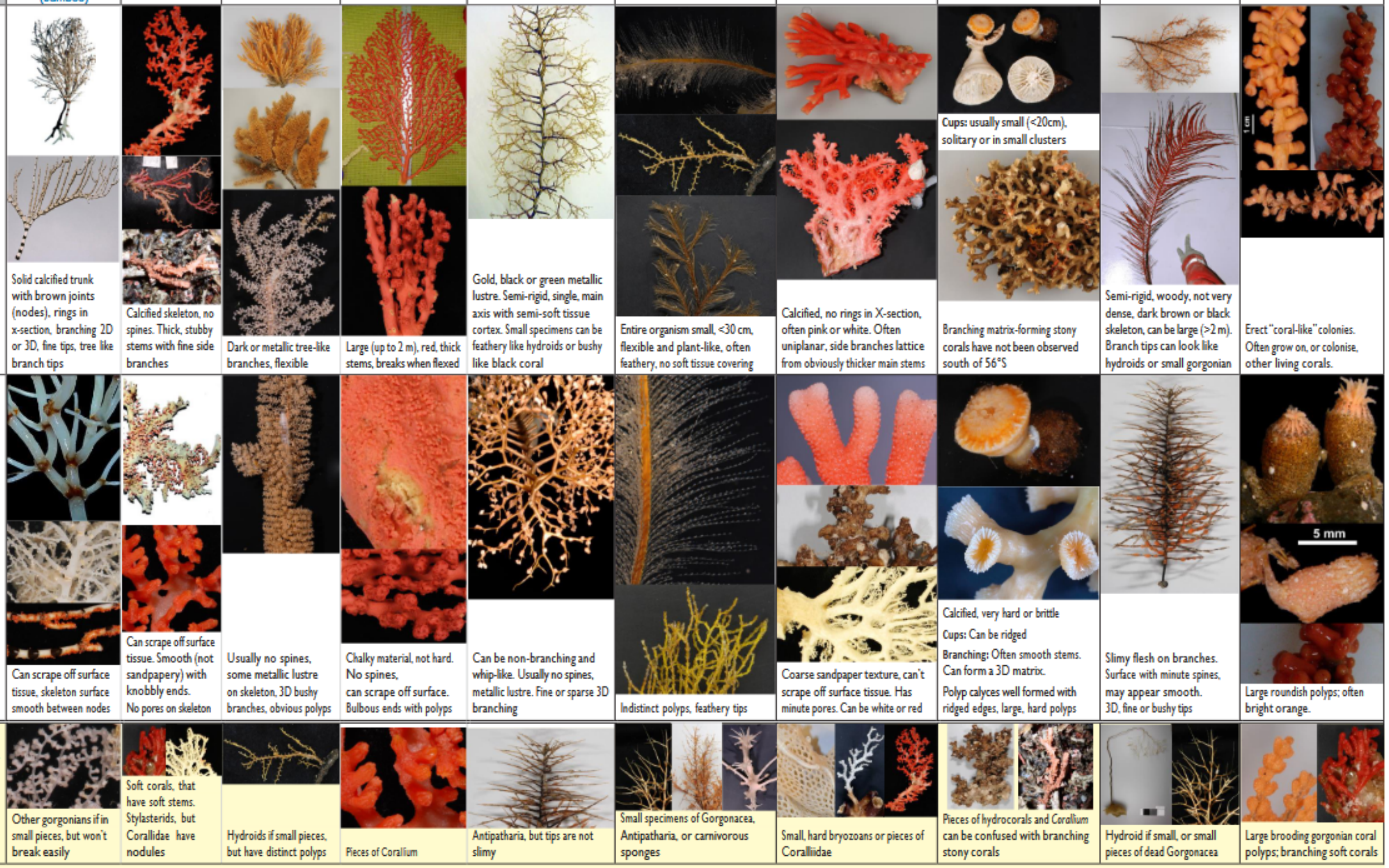
12. Release tagged skates dorsal side up and keep the distance between the release point and the sea surface as short as practicable.

**Additional information is listed in the Commercial Data Collection Manual – Longline Fisheries.*

Note that FAO codes = CCAMLR codes

CCAMLR VME Taxa Classification Guide 2023 Version 2

These groups are not included: Snails, Starfish, Crabs



Phylum	Cnidaria (CNI)									
Code	DWR					HQZ		CSS	AQZ	ZOT
Level	Gorgonian octocorals: Scleralcyonacea (Order)					Leptothecata ZUD (Order)	Anthoathecata AZN (Order)	Scleractinia (Order)	Antipatharia (Order)	Zoantharia (Order)
Taxon	Keratoisididae and Mopseidae (Bamboo)	Coralliidae (Red / precious)	Primnoidae (Bottle brush, sea fans)	*Paragorgia* (Genus) (Bubblegum)	Chrysogorgiidae (Golden)	Hydroids	Stylasteridae AXT (Hydrocorals)	Stony corals	Black corals	Zoanthids
Form, size	Solid calcified trunk with brown joints (nodes), rings in x-section, branching 2D or 3D, fine tips, tree like branch tips	Calcified skeleton, no spines. Thick, stubby stems with fine side branches	Dark or metallic tree-like branches, flexible	Large (up to 2 m), red, thick stems, breaks when flexed	Gold, black or green metallic lustre. Semi-rigid, single, main axis with semi-soft tissue cortex. Small specimens can be feathery like hydroids or bushy like black coral	Entire organism small, <30 cm, flexible and plant-like, often feathery, no soft tissue covering	Calcified, no rings in X-section, often pink or white. Often uniplanar, side branches lattice from obviously thicker main stems	Cups: usually small (<20cm), solitary or in small clusters Branching matrix-forming stony corals have not been observed south of 56°S	Semi-rigid, woody, not very dense, dark brown or black skeleton, can be large (>2 m). Branch tips can look like hydroids or small gorgonian	Erect "coral-like" colonies. Often grow on, or colonise, other living corals.
Detail (texture, colour, polyps)	Can scrape off surface tissue, skeleton surface smooth between nodes	Can scrape off surface tissue. Smooth (not sandpapery) with knobbly ends. No pores on skeleton	Usually no spines, some metallic lustre on skeleton, 3D bushy branches, obvious polyps	Chalky material, not hard. No spines, can scrape off surface. Bulbous ends with polyps	Can be non-branching and whip-like. Usually no spines, metallic lustre. Fine or sparse 3D branching	Indistinct polyps, feathery tips	Coarse sandpaper texture, can't scrape off surface tissue. Has minute pores. Can be white or red	Calcified, very hard or brittle Cups: Can be ridged Branching: Often smooth stems. Can form a 3D matrix. Polyp calyces well formed with ridged edges, large, hard polyps	Slimy flesh on branches. Surface with minute spines, may appear smooth. 3D, fine or bushy tips	5 mm Large roundish polyps; often bright orange.
Commonly mistaken for other groups, such as:	Other gorgonians if in small pieces, but won't break easily	Soft corals, that have soft stems. Stylasterids, but Corallidae have nodules	Hydroids if small pieces, but have distinct polyps	Pieces of Coralium	Antipatharia, but tips are not slimy	Small specimens of Gorgonacea, Antipatharia, or carnivorous sponges	Small, hard bryozoans or pieces of Coralliidae	Pieces of hydrocorals and *Corallium* can be confused with branching stony corals	Hydroid if small, or small pieces of dead Gorgonacea	Large brooding gorgonian coral polyps; branching soft corals

CCAMLR VME Taxa Classification Guide 2023. Commission for the Conservation of Antarctic Marine Living Resources, Hobart, Tasmania, 4p.

Note that FAO codes = CCAMLR codes

CCAMLR VME Taxa Classification Guide 2023 Version 2

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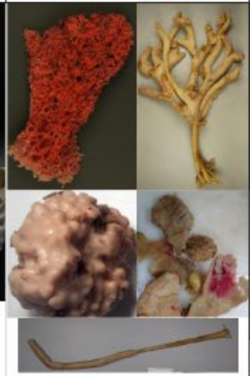
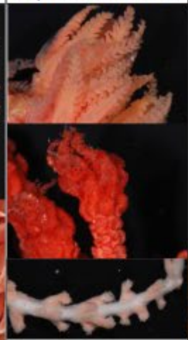
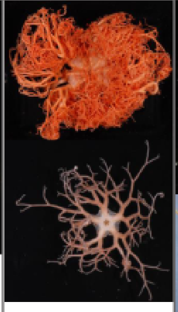
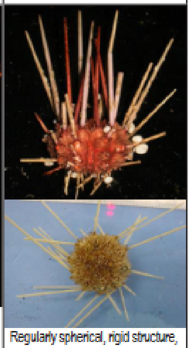
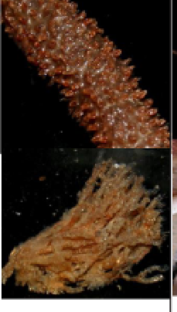
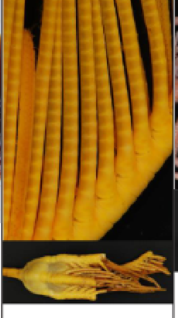
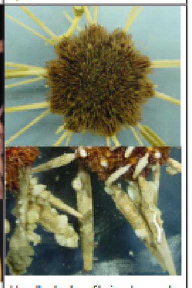
Phylum	Porifera (PFR)		Cnidaria (CNI)			Chordata (CZ1)	Bryozoa	Chemosynthetic
Code	HXY	DMO	ATX	DWQ	NTW	SSX	BZN	CX1
Level	Hexactinellida (Class)	Demospongiae (Class)	Actiniaria (Order)	Malacalcyonacea (Order)	Pennatuloidea (Superfamily)	Ascidiacea (Class)	Bryozoa (Phylum)	Various groups
Taxon	Glass sponges	Siliceous sponges	Anemones	True soft corals	Sea pens	Sea squirts	Lacy bryozoans	Chemosynthetic communities
Form, size	 Diverse shapes: hollow central chamber spiky & vase-like, egg-shaped with hairy mass at base, honeycombed tubular crystalline forms	 Much variety: fans, spheres, solid masses, tubes, and encrusting	 Rubbery bottom with single polyp with lots of tentacles. Usually in retracted hardened cylinder form when captured	 Can be mushroom shaped. Floppy or soft, leather-like surface texture. Usually multiple large polyps, body not symmetrical, no foot or stalk	 Feather-shaped with fleshy polyps. Non-branching to whip-like cartilaginous stalk. Fleshy foot or anchor present, body symmetrical. Can be tall, >1 m	 No tentacles or polyps. Stalked solitary or colonial. No skeleton, stalk-like or encrusting over substrate	 Typically small, (<30 cm). Variable forms. Can be hard or soft (most commonly hard) branching, lace-like, or cornflake shaped, calcified, and brittle, surface cannot be scraped off	Chemosynthetic habitat sites, including cold seeps, vents, whale falls and sunken wood include some of the following associated biota: 
Detail (texture, colour, polyps)	 Surface frequently spiny, always very siliceous or like fibre-glass, ice-like, delicate, crunchy	 Varied textures: fleshy, rubbery, fibrous, woody, flexible, elastic, stony, hairy	 Tentacles sometimes look like worms when detached	 Similar polyps to seapens, but soft corals are not stalked	 Fleshy polyps. Flower or feather like polyp mass	 Regularly spaced surface pores.  Zooids visible in transluscent bodies. Gelatinous, soft and fleshy, leathery, flexible	 No polyps	 Sediment or organisms may smell of rotten eggs - sulphurous
Commonly mistaken for other indicator groups, such as:	 Bryozoans or scleractinians that are small and of a hard matrix	 Some Alcyonaceans, Ascidians, which are not spongy but fleshy and have polyps or siphons, and Bryozoans.	 Alcyonaceans, which usually have several polyps	 Small pieces of Corallidae or some sea pens	 Alcyonaceans or some gorgonians due to large polyps and size	 Spherical demosponges or piece of sea pen	 Stylasterids if hard, hydroids if soft, carnivorous demosponge	Species belonging to the same taxa – to date only the white squat lobsters have been recorded in the Antarctic region. Because these communities are little known, **retain samples to be identified by experts**

CCAMLR VME Taxa Classification Guide 2023. Commission for the Conservation of Antarctic Marine Living Resources, Hobart, Tasmania, Australia, 4p.

Note that FAO codes = CCAMLR codes

CCAMLR VME Taxa Classification Guide 2023 Version 2

These groups are not included: Snails, Starfish, Crabs

Phylum	Brachiopoda	Hemichordata	Annelida (NHE)	Xenophyophoroidea within order Astrorhizida	Arthropoda	Mollusca (MOL)	Echinodermata (ECH)		
Code	BVH	PBQ	SZS	XEF	AX1	DMK	CWD	OEQ	DWL
Level	Brachiopoda (Phylum)	Pterobranchia (Class)	Serpulidae (Family)	Xenophyophoroidea (Suborder)	Cirripedia (Subclass) Bathylasmatidae BWY (Family) Scalpellomorpha DWI (Order)	*Adamussium colbecki* (Species)	Crinoidea (Class)	Euryalida (Order)	Cidaroida (Order)
Taxon	Lamp shells	Pterobranchs *Cephalodiscus* (genus)	Serpulid tube worms	Xenophyophores	Acorn & goose/stalked barnacles	Antarctic scallop	Stalked crinoids (Sea lilies)	Basket stars and snake stars	Pencil spine urchins
Form, size	 Valves enclose the body dorsally and ventrally rather than laterally. Ventral valve typically larger than the dorsal. Attached species have a short stalk emerging from the hinge area of the valves	 Tubes conjoined into colonies. Usually gelatinous, often semi-transparent	 Tube dwelling marine worms. Each tube flange is about 3.5 mm diameter. Forms large clumps, somewhat coral-like, typically Subantarctic distribution	 A specialised group, is among the largest single-celled protozoans. Colony size can be 10-20 cm in diameter	 These are stalked (goose barnacles)  and non-stalked (acorn barnacles)	 Scallop shaped bivalve. Laterally compressed with two shells, hinged dorsally, that completely enclose the body in most species	 Stalked. Small tulip-like body. Arms usually branched. Crinoids are generally fragile, often only fragments. A long stalk, some bearing whorls of hooklike cirri. Body length up to 20 cm	 *Gorgonocephalus* spp (QCX) Gorgons head basket-stars. Large disc with 5 arms splitting at the disc into many coiled branches	 Regularly spherical, rigid structure, typically 2–10 cm in diameter. Covered with small spines and 10 distinct columns of large pencil-like spines
Detail (texture, colour, polyps)	 Delicate shell; clam like. Each valve is bilaterally symmetrical and may be ornamented with concentric growth lines and a fluted or spiny surface	 Red-orange to brown. Tubes closely or loosely bound	 Serpulid worms in hard calcareous tubes	Varied appearance ranging from spherical to flat. Many species have a rounded, lumpy form and irregular netlike surface structure. Most are fragile but one group is felt-like & robust. Found >500 m	 The mantle surface of any barnacle bears at least 5 major plates, which are pulled together for protection. Heavily armoured	 Ribbed scallop-like shell	 Fragile, not flexible. Brittle and segmented	 Distinguished from other brittle stars by branched or highly coiled arms and from sea stars by lack of ventral groove on underside of arms	 Usually shades of beige, burgundy or purple. Spines paler, they can be a substrate for other organisms. Large spines can be cylindrical or flattened
Commonly mistaken for other indicator groups, such as:	Resemble bivalve molluscs but one valve is much larger, and overhangs the smaller valve	 Algae, marine tube worms, tunicates or demosponges	 Other worm like forms in sediment tubes	 Fragments of demosponges sponges (see image), colonial ascidians, bryozoans, or 'inorganic concretions'	 Cup corals or clusters of tube worm casings	 Other bivalves or lamp shells	 Arm fragments can look like other animals such as basketstars, or feather stars if stalk not present	 Seastars with multiple non-coiled arms, and more common sea and brittle stars (in other Orders) with non-branching arms.	 Urchins that lack the large pencil-like spines

CCAMLR VME Taxa Classification Guide 2023. Commission for the Conservation of Antarctic Marine Living Resources, Hobart, Tasmania, Australia, 4p.

CCAMLR VME Taxa Classification Guide

Conservation Measure 22-07 requires vessels to monitor bycatch for the presence of vulnerable marine ecosystem (VME) taxa as defined by the Commission.
The level of classification required is relatively coarse for most taxa, where phylum, class or order is sufficient. However, some groups may require classification to family or even species. In addition, several groups can be confused at first sight. Therefore, a classification guide is needed to assist in the rapid and efficient classification of VME taxa.

Instructions

This CCAMLR VME Taxa Classification Guide provides observers, fishers, and biologists at sea with a taxon-specific, quick, on-deck guide to aid in the classification of macroscopic marine invertebrate bycatch into the required VME groupings. VME taxa are a subset of the total invertebrate taxa encountered as fishery bycatch, and therefore additional processes are still required to collect information on non-VME taxonomic groups. Typically, invertebrate identification is not done at sea because it requires specialised tools. The format of the VME guide is a "compare and contrast table", using photographs and key characteristics to correctly assign VME taxa to the appropriate grouping. It also highlights commonly confused groups. Symbols representing non-VME groups are listed in the top right-hand margin.

The guide is organised into columns, each describing a taxonomic group and colour coded by phylum. Those groups that appear similar have been placed next to each other where possible. The top row for each column is a parent column that identifies the phylum for the vulnerable groups below. The FAO 3-letter taxonomic code for each group is provided at the top of each column and for the parent group. Below the codes are the scientific and common names for each group. The first row contains photographs and brief descriptions of the overall size and shape of specimens for each group. The next row then provides details of the specimen's appearance, such as texture, colour, or polyp characteristics, and also includes close-up images as examples. A final row (with a yellow background) has images and descriptions of specimens representing other phyla. This row shows how these specimens can be commonly mistaken for other taxa and flags details on what to look out for during classification. Text in this row should be read beginning with the phrase in the row heading to aid in clarity.

Photographs of Antarctic specimens have been used where possible to aid in the identification of VME groups. The guide has been linked through colour coding to phyla in the "Guide to common deepsea invertebrates in New Zealand waters" (Tracey et al. 2011), the SPRFMO VME taxa guide (Tracey et al. 2008), and the Field identification guide to Heard Island and McDonald Island (HIMI) benthic invertebrates (Hibberd and Moore 2009). Invertebrate specimens that cannot be identified with confidence need to be identified to the lowest taxonomic level possible, retained on board, and returned frozen as biological specimens for formal identification.

Acknowledgments

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Report of the COLTO–CCAMLR Tagging Workshop 2023 (WS-TAG-2023)

(Hobart, Australia, 14 to 17 March 2023)

Contents

Report of the COLTO–CCAMLR Tagging Workshop 2023 (WS-TAG-2023)

(Hobart, Australia, 14 to 17 March 2023)

Welcome and introductions

1.1 The COLTO–CCAMLR Tagging Workshop was held at the CCAMLR Secretariat in Hobart, Australia, from 14 to 17 March 2023 as an in-person meeting. The Workshop included both meeting room plenary discussions and a hands-on wet-lab component at the University of Tasmania biological sciences laboratory.

1.2 The Workshop was co-convened by Mr R. Arangio (Coalition of Legal Toothfish Operators (COLTO)) and Dr C. Jones (USA), who welcomed participants (Appendix A) to Hobart and encouraged open engagement to stimulate discussion on the best practices for CCAMLR's tagging program and provide recommendations to be reviewed by the Scientific Committee and its working groups.

1.3 Dr D. Agnew (CCAMLR Executive Secretary) welcomed Workshop participants and thanked COLTO for the opening icebreaker evening and for supporting the Workshop. He noted that the CCAMLR tagging program is a critical component of stock assessments for toothfish and used as a reference for skate abundance, and therefore supports successful precautionary management of multiple stocks by the Commission.

1.4 The Workshop welcomed the participation of two invited experts, Mr D. Snodgrass (NOAA) and Mr D. Evans (Hallprint).

1.5 The Workshop agenda was adopted (Appendix B).

1.6 Documents submitted to the Workshop are listed in Appendix C. The Workshop thanked all the participants and authors for their contributions to the meeting.

1.7 The workshop report was prepared by R. Arangio (COLTO), D. De Pooter (Secretariat), J. Fenaughty (New Zealand), I. Forster (Secretariat), C. Jones (USA), S.V. Ngcongo (South Africa), S. Parker (Secretariat), B. Plum (New Zealand), M. Williamson (South Africa) and P. Ziegler (Australia).

Workshop overview

1.8 WS-TAG-2023/02 presented a brief history of toothfish tagging in the CAMLR Convention Area and discussions leading up to WS-TAG-2023. Toothfish have been tagged in CCAMLR fisheries since the late 1990s, and information from the mark-recapture program has been used to estimate movement, growth and mortality rates, and abundance. Tagging of toothfish from fishing vessels in new and exploratory fisheries started in 2000/01 and has become mandatory since 2003/04. The paper included a summary of trends in toothfish tag releases, recaptures and tagging rates, tagging requirements, tag types, improvements to the tagging program, a case-control study of tagging performance, and a summary of discussions on tagging practices and issues identified leading to WS-TAG-2023. The paper also identified outstanding recommendations that would improve the tagging program and challenges for best-practice protocols.

1.9 The Workshop thanked the author for the paper and noted that overall more than 380 000 toothfish and over 69 000 skates have been tagged in the Convention Area. The Workshop recognised that the tagging program for toothfish in CCAMLR is one of the most expansive tagging programs in the world, and it provides important and high-quality data for estimates of biological parameters and toothfish stock biomass, which underpin the stock assessments that provide catch limit advice.

1.10 The Workshop noted the economic impact of the tagging program. Mr A. Smith (New Zealand) estimated that the total costs of the CCAMLR tagging program in fish returned at current market value would equate to in excess of US$150 million based on releasing 380 704 tagged toothfish from 1997 to 2023.

Tagging program presentations

1.11 The Workshop received presentations from nine Members (Australia, Chile, France, Republic of Korea, New Zealand, South Africa, Spain, United Kingdom, with Ms Williamson presenting information on behalf of Ukraine) describing the current practices of tagging toothfish and skates on their vessels, including the processes used for (i) choosing which fish to tag, (ii) landing, handling and transporting fish onboard the vessel, (iii) tagging, and (iv) releasing.

1.12 Considerable variation was reported between Members and vessels in the types and designs of fish landing aides, the role of the observer in tagging procedures, factory configurations and the use of holding tanks. However, the vessels all had developed mechanisms to implement the CCAMLR tagging program, including the need to monitor tag-overlap statistics, move fish around the vessel and handle large fish. The participants noted that one of the valuable aspects of the Workshop was to allow the best practices to be shared among vessels with the goal of improving performance of all vessels in the program.

1.13 Additional information presented by Ukraine (delivered by Ms Williamson) recommended that future work should consider the potential influence of colossal squid (*Mesonychoteuthis hamiltoni*) and seabird depredation, as both tend to target the part of the fish body where tags are attached and may therefore influence recapture results.

1.14 WS-TAG-2023/01 presented a summary of the tagging procedures survey conducted by the Secretariat in 2019 and 2020. The results reflected information provided by Workshop participants in paragraph 1.11, that considerable variation in tagging procedures exists among vessels which may impact tagging program performance, and also that new vessels may influence the level of experience and diversity in vessel configurations used as part of the tagging program. The survey indicated that several fish landing and handling procedures could be improved through updated training materials targeting both vessel crew and observers.

1.15 The Workshop noted that the information gained by the survey was based on a subset of vessels in exploratory fisheries, and recommended that collecting information from all toothfish fishing vessels as part of the fishery notification process would aid in documenting and better understanding tagging performance among vessels. Table 1 provides the vessel-specific information that could be collected to inform on tagging practices.

1.16 Mr Snodgrass presented WS-TAG-2023/03, which summarised the Cooperative Tagging Program on Highly Migratory Species in the Atlantic, operating since 1954. The paper summarised lessons learned and the types of information able to be developed from this tagging program, including practices for handling and tagging large fish.

1.17 The Workshop noted that similar practices are used with toothfish and skates, such as cutting hooks for easy removal, and using materials that minimise removal of the mucus layer on fish skin, which can improve the condition of fish at release.

1.18 The Workshop noted a presentation by Mr Ngcongo summarising observer suggestions for the tagging training manual, including reducing repetition of information, separating release and recapture guidance, and developing sections for different stages of the procedure for easy indexing. In addition, the observers recommended that the overall goals for fish handling should be to minimise the time fish are out of water, avoid the use of holding tanks where possible, use a net to land all fish selected for tagging where possible, and develop better incentives for vessel crew such as recognition for good performance, to improve good performance.

1.19 The Workshop thanked the observers and the presenters for best-practice suggestions and agreed that providing information back to vessels on tagging performance statistics would be useful feedback for Members and vessel operators to maintain and improve tagging performance. In addition, development of innovative landing aides, and continuous improvement and use of best practices should be incentivised through mechanisms such as the COLTO tag lottery.

Best practice discussions

2.1 The Workshop reviewed the existing tagging training module as specified in Conservation Measure (CM) 41-01, Annex 41-01/C (www.ccamlr.org/node/85702) that was developed during WG-SAM-2012 in order to assist in developing best practices for the CCAMLR tagging program.

2.2 Aspects of the review included retrieving fish from the line, minimising handling and transport to tagging stations, time out of water, optimising tag placement, fish health and data quality. It was agreed that toothfish and skates be treated separately, and that best practice should be underpinned by the desired outcome of each element of the program.

Toothfish and skate landing

Tagging responsibility

2.3 The Workshop noted that fish tagging is a Flag State responsibility. Generally the vessel would advise when the next fish should be tagged, with the responsibilities of each part of the tagging process clearly defined collaboratively between crew and observer at the start of each voyage.

2.4 The individual responsible for tagging the fish, whether it is a member of the vessel crew or an observer, should have familiarity with the tagging procedure and have undergone tagging training.

2.5 The Workshop agreed that ideally multiple people on board should be trained to tag fish and that the observer can assist in this role.

Tag-overlap statistic

2.6 The Workshop recommended that the method used in selecting a fish to be tagged, whether it be the 'every nth fish' approach, or a batch tagging approach, be recorded in the observer's cruise report.

2.7 The Workshop discussed the requirement of achieving the >60% tag-overlap statistic, and noted that several tools have been developed to determine whether the overlap statistic is being met, including individual Members' different tag-overlap statistic calculators that can be used in real time to monitor performance and inform decisions on which fish to tag.

2.8 The Workshop noted that a 60% tag-size overlap still leads to potential bias in biomass estimates from stock assessments (WG-SAM-12/24). The Workshop recommended that WG-SAM and WG-FSA review an increase in the minimum tag-size overlap statistic.

Handling different size fish

2.9 The Workshop agreed on the importance of using nets or cradles to retrieve fish intended for tagging, particularly for large fish. It was noted that scoop nets used to retrieve fish by vessels are comprised of various materials, as are slings used to transport fish on board, and that some of these materials can be abrasive to the surface of the fish, such as trawl mesh. The Workshop recommended that vessels use materials that ensure that the fish is released in the best condition possible, such as vinyl, knotless netting, etc.

2.10 The Workshop noted the different approaches to handling small fish versus large fish. Above a certain size/weight, a lifting aide such as a cradle will be necessary, and the need for this will be dependent on a number of factors, such as the height to be lifted or weather conditions.

Effects of weather and time out of water on tagging

2.11 The Workshop noted that there were some unique attributes for different toothfish fisheries, such as sea-ice cover and rough seas, that can make the use of cradles difficult and unsafe. In some cases, more damage could be done to a fish by attempting to get it into a net. The Workshop recommended future work that examines the effect of different methods of landing on fish condition that incorporates factors such as size of fish, sea conditions and height of lift.

2.12 The Workshop recommended that there could be benefits to improved cradle designs, and that a prize could be awarded to an improved design as an incentive. Mr Arangio suggested that COLTO would further explore this concept. The Working Group recommended that WG-FSA consider tasking observers to record details on tagging equipment, including cradle designs, which could be helpful in designing improvements (paragraph 2.17).

2.13 The Workshop noted that weather can be an important factor when fish are brought aboard the vessel. Extreme cold and wind can result in the surface of the fish's eyes freezing, with unknown consequences. One method of preventing corneal damage and reducing the effects of light could be to place a wet towel over the fish's eyes. This would be particularly beneficial where tagging is done in an exposed open deck environment.

2.14 The Workshop agreed that minimising the amount of time that the fish is out of any water is essential, and that different conditions will dictate what practices are achievable.

2.15 The Workshop considered a targeted maximum time that the fish could be out of any water, and agreed that any more than three minutes could make the fish less viable for tag and release, however, this must be balanced so that the quality of the tagging event is not compromised. The Workshop recommended that best practice would target the fish being out any water for no longer than three minutes, while noting some fisheries utilise pre- and post-tagging holding tank time to assess that fish condition is not compromised.

2.16 The Workshop agreed that there may be some benefit in stopping hauling in order to land fish for tagging when possible, allowing more crew to focus on a tagging event. However, it was noted that this could significantly slow down fishing operations if done for every fish, particularly for a fishery where there is a high required tagging rate. Further, there could be problems related to increased cetacean depredation of fish on the line if hauling is stopped frequently. The Workshop agreed that decisions in relation to stopping hauling, while beneficial to the tagging process, should be a vessel decision based on conditions.

Toothfish and skate handling, station and equipment

2.17 The Workshop recommended that holding tanks should only be used if necessary. Best practice is to release the fish immediately after being tagged. However, if holding tanks are used, then the time fish should remain in the tanks should be minimised. During periods when large predators (e.g. killer whales) are in the area, fish should be kept in the holding tank until it is safe to release them. Where possible, toothfish and skate should be kept separately to reduce potential injury to each other.

2.18 The Workshop noted that specifications of the holding tanks from the current tagging training document could be included in the *Commercial Data Collection Manual – Longline Fisheries* to assist vessels in the design and operation of holding tanks, including considerations of container size, cleanliness, required maintenance, as well as water flow rate and water temperature. It was agreed that holding tanks should not be overcrowded and that water levels should be sufficient to allow complete submersion of the animal.

2.19 The Workshop considered the existing training materials and recommended that a viability assessment of the fish in the holding tank should be included. For example, if a fish is tilting sideways or is belly-up, then these fish should not be tagged and released. The viability assessment guidance should also include the phrase 'Do not tag and release fish if any of the listed conditions are present'.

2.20 The Workshop recommended that the diagram instruction for tagging small and large fish should be the same and that only the figure of the fish showing the location of the tag should remain in the figure.

2.21 The Workshop proposed that the tagging training manual be updated to reflect the categories for fish fate matching those in the electronic logbooks.

Toothfish and skate release operations

2.22 The Workshop noted that most of the material contained in the existing tagging training manual regarding the release of toothfish is still considered to be best practice.

2.23 The Workshop recommended that fish should be gently released headfirst into the water with the minimum vertical distance possible. Depending on the fish size, this should be carried out either manually by the person assigned to tag or by using a sling or stretcher. The Workshop further recommended that vessel operators employ other modifications to assist with fish releases, such as a chute if the height of the release point on the vessel is excessive.

2.24 The Workshop discussed the use of appropriate mitigation devices to prevent predation of tagged fish, and recommended that for fisheries with seabird predation issues, tagged fish should be released within the area protected by a bird exclusion device (see CM 25-02), or water spray from a fire hose be used to deter birds.

2.25 The Workshop noted that release operations on vessels with a moon pool were not well understood. The Workshop recommended that the practice of releasing a tagged fish out of a chute or hatch on the side of these vessels was appropriate, as this allowed for observation of the fate of a tagged fish, and reduced the potential of interaction with a vessel's propellor.

2.26 The Workshop discussed the best practice for releasing skates. The Workshop agreed that the best practice was bringing the animal to the roller, cutting the snood and thoroughly inspecting it for damage on board the vessel before determining if the skate was suitable for release.

2.27 The Workshop considered a video presented from WG-FSA-2022/19, which provided precise and clear instructions for assessing and releasing skates. The Workshop recommended the inclusion of the video on the CCAMLR website as a resource for instructing crews on the correct handling and release of skates.

2.28 The Workshop noted that very large skates were rare and that specific handling practices for these individuals would be determined by the environmental and operating conditions at the time.

Tagging equipment

2.29 The Workshop discussed the issue of tag storage on vessels, noting the recommendation that tags should be stored in a dark, cool environment. The Workshop further noted that tags are often stored on the bridge of a vessel, and despite the tags being UV stabilised, they can become brittle in such dry conditions with time. The Workshop recommended that tag packaging be developed to prevent UV exposure during storage, and noted the advice from Mr Evans that brittle tags can be remoisturised by placing them for some time in a wet environment.

2.30 The Workshop recommended using tagging guns with stainless steel internal components to apply the tags, as these better resist the corrosive effects of salt water. The Workshop further noted that the tagging guns provided by the Secretariat meet this standard.

2.31 The Workshop considered tagging skates and large toothfish with heavy-duty T-bar tags and noted that compared to standard T-bar tags, such tags may be less prone to loss and be more easily detected when fish are recaptured. However, the Workshop noted that such tags are more expensive, need to be applied using different guns and will inflict larger wounds to the tagged fish. The Workshop further considered that having two sets of similar looking tagging equipment on board may cause confusion.

2.32 The Workshop noted the potential use of a three-digit alpha numeric code (a checksum) to verify the sequential tag number, and that this option has recently become available from the current CCAMLR tag manufacturer.

Toothfish and skate release operations

2.33 The Workshop discussed the development of three items which would be important outcomes of this Workshop:

(i) a tagging protocol (Appendix D) to summarise the tagging requirements

(ii) a revised training manual for crew and observers

(iii) posters for reference (Appendices E and F) while on board of vessels.

2.34 The Workshop recommended that the Scientific Committee consider the protocol provided in Appendix D be referenced by CM 41-01, Annex 41-01/C, as the tagging protocol.

2.35 The Workshop noted that fish tagging and recovering and processing of recaptured tagged fish are separate processes, and handled by different people. The Workshop noted that training materials should separate fish tagging guidelines and fish recapture guidelines into different sections.

2.36 The Workshop recommended that the toothfish tagging poster provided in Appendix E and the skate tagging poster provided in Appendix F are translated into the different languages used by crew on board CCAMLR longline vessels. The Workshop recommended that the posters be made available on the vessels so they can be referenced by trained fish handlers at the tagging station. The Workshop welcomed the offer by COLTO to coordinate the translation and distribution of the posters.

2.37 The Workshop further noted that the *Commercial Data Collection Manual – Longline Fisheries* should be updated to include guidance for holding tank design subject to vessel configurational constraints.

2.38 The Workshop noted that the *Commercial Data Collection Manual – Longline Fisheries* and the observer longline manual should be updated to specify the conditions which exclude fish from being tagged and released and to specify the following guidelines regarding the recapture of tagged fish:

(i) record data as required in the observer longline logbook and the C2 logbook. Make sure to include all leading characters, tag type, colour and inscription

(ii) the CCAMLR tagging program requires photographs of all attached tags on fish in situ as well as all tags using the tag photo template, making sure tag numbers can be read; take multiple photos if needed

(iii) store otoliths and recaptured tags using the methods requested by the Flag State, ensuring associated data are recorded.

2.39 The Workshop noted that training materials should include best-practice videos as well as videos showing practices which should be avoided.

2.40 The Workshop thanked COLTO for providing the fish for the hands-on wet-lab component of WS-TAG-2023. The Workshop recognised the usefulness of the hands-on session during which it was shown that in large fish the T-bar tags may not be anchored behind the pterygiophore but can be anchored intramuscularly. The Workshop further noted that incorrectly applied tags can be pulled out easily.

2.41 The Workshop recommended that, where possible, hands-on training be included in tag training programs. The Workshop further recommended that fish handlers practice tagging on board of vessels using damaged fish with low commercial value.

2.42 The Workshop recommended that Members consider further developing the training manual incorporating recommendations from WS-TAG-2023 for vessel crew and observers for consideration by WG-FSA-2023, with the assistance of the Secretariat.

2.43 The Workshop requested that, upon completion, the Secretariat update all relevant documents on the website and ensure that they are well organised and easily accessible.

2.44 The Workshop recalled that tagged and released toothfish which were caught using trotlines were reported to have a lower survival rate compared to those released by autoline and Spanish longline vessels (WG-FSA-2017, paragraph 3.71). The Workshop noted that during 2018, fish handlers on board of some trotline vessels received additional training and that if fish condition criteria were met, there should be no difference in survival rate between fish caught by different gear types.

2.45 The Workshop recommended that tagging performance statistics be calculated which differentiate between data collected prior to 2018 and post 2018. Future analyses should further differentiate between data prior to 2023 and post 2023 to assess the impact of WS-TAG-2023.

2.46 The Workshop noted that colossal squids have been reported to feed on fish during hauling. The Workshop discussed additional data collection by observers on squid markings on caught toothfish and recalled the intention of Ukraine (paragraph 1.13) to present a study to WG-FSA-2023 on potential predation by colossal squids on tagged toothfish and non-tagged toothfish during hauling.

2.47 The Workshop discussed new technologies, including electronic monitoring, which could increase the efficiency of the tagging program and encouraged Members to develop, test and share new technologies as they become available.

2.48 The Workshop recalled that several recommendations by WG-SAM and WG-FSA to improve the tagging program are still outstanding (see paragraph 2.49) and discussed the progress made.

2.49 The Workshop recommended that WG-FSA and WG-SAM consider incorporating the following tasks, which remain outstanding from previous working group meetings, in their workplans to improve the tagging program:

(i) developing spatial overlap diagnostics to index the representativeness of the mark-recapture data in providing an absolute abundance estimate

(ii) develop spatially explicit models for each area to account for lack of complete mixing

(iii) estimate and incorporate depredation effect on tag releases

(iv) develop fishery- and vessel-specific tag shedding rates to identify vessels which can benefit from additional training

(v) experimentally estimate initial tagging mortality rate and variability

(vi) estimate fishery- and vessel-specific survival and detection rates.

Data

3.1 The Secretariat presented a summary of data checks undertaken to improve data quality on tagging and tag recapture data. Data checks were undertaken at several stages, including within-logbook error checks, during data processing, and during analysis procedures such as when producing the Fishery Reports.

3.2 Several Members presented their tag data quality checks that were undertaken on board vessels. In many cases the procedures were very similar to those of the Secretariat, although the use of real-time data checks was present in areas where non-CCAMLR tagging programs are undertaken.

3.3 The Workshop noted that the provision of information on tag recaptures to observers and crews in real time is very informative and encouraged engagement and interest in the CCAMLR tagging program. The Workshop further noted that the Secretariat cannot release detailed tagging information directly to vessels as this would contravene CCAMLR data confidentiality rules.

3.4 The Workshop recommended that the Scientific Committee consider a mechanism to enable the reporting of a subset of information on tag recaptures directly to vessels upon request, to further engagement in the CCAMLR tagging program. Such information could be limited to the statistical area, time at liberty, distance travelled and length of the fish when tagged, which would prevent the disclosure of sensitive information regarding the deployment or recapture vessel.

3.5 The Workshop encouraged Members to share tag data quality procedures to improve the accuracy of tagging and recapture information. The Workshop noted that the Secretariat's data quality rules are available to Members upon request, and that some Members provided tag data checking rules to the Secretariat.

3.6 The Workshop noted the practice of the Australian tagging program, where tagged fish were re-released provided they were in good condition, and further noted that this was not a standard practice in other CCAMLR fisheries. It was also noted that these re-released tagged fish are given a unique release ID each time, to accompany the tag numbers, which is then used to track the fish.

3.7 The Workshop requested the Secretariat consider developing a list of common tag release and recapture data errors to be included as part of the tag training manual, as this would assist those collecting tagging data in identifying part of the process that were error prone.

Monitoring tagging operations and program administration

3.8 The Workshop discussed ways that the supply of tagging equipment to Members and companies, as well as overall program operations and efficiency, could be improved.

3.9 The Workshop noted that some numeric sequences on CCAMLR tags overlapped with those used in some Members programs. The Workshop further noted that CCAMLR tags have a single-letter prefix before the serial number which is not present in tags of those Members' programs, and that tag inscriptions were different between all tagging programs.

3.10 The Workshop encouraged that the CCAMLR and Members' tagging programs be combined, as this would remove the issue of duplicate numeric sequences on the tags and may improve tag data quality. Alternatively, the Workshop encouraged direct coordination between Members and the Secretariat to develop mechanisms to avoid duplication of tag number sequences.

3.11 The Workshop noted that the most common errors encountered by the Secretariat when trying to match tag recoveries with releases were transcription errors because of base 10-digit changes to the tag number sequences, likely occurring when a new series of tags are used. The Workshop encouraged investigating the use of shortened alpha-numeric sequences on future tags as this could potentially reduce transcription errors.

3.12 The Secretariat noted that most of the unlinked tag recaptures that were remaining in the CCAMLR database were from Members' tagging programs (generally pre-2005). The Workshop noted that investigating links for these tags is a time-intensive process which involves tasks such as re-matching tags that may have been recorded without an alpha-prefix, cross referencing tags with supplied photographs, or investigating tag numbers individually. The Workshop agreed that improving historic data would be beneficial and encouraged the Secretariat and the Scientific Committee to explore options to achieve this, such as an internship.

Looking forward

4.1 The Workshop reflected that progress made both at this Workshop and historically was due to the excellent relationship between CCAMLR and the fishing industry, and encouraged the collaboration between Members, the Secretariat and industry to continue.

Workplan for future improvement

4.2 The Workshop discussed potential improvements to tag design and automated tag reading devices to increase tag detection rates, and reduce tag data errors. The Workshop noted that that the development of emerging technologies such as radio-frequency identification (RFID) fish tags, and close kin mark recapture (CKMR), should be monitored by Members, and promising techniques be introduced through papers to working groups of the Scientific Committee.

4.3 The Workshop noted that several presentations of tagging operations by Members included electronic tag data entry tablets and applications, and encouraged Members and the Secretariat to investigate options to reduce pencil and paper recording of data by crew and observers, as this would streamline workloads, allow automation of effort checking during the tagging process and reduce transcription errors.

4.4 The Workshop encouraged Members to engage with the Secretariat to enable direct training sessions with observers, vessel officers and crew to introduce CCAMLR's tagging and data collection requirements and best practices, and requested that the Scientific Committee consider a mechanism to efficiently organise and fund such training events.

Pop-up satellite archival tags

4.5 The Workshop noted that CM 91-05, which covers the Ross Sea region marine protected area (RSRMPA), specifies in paragraph 8(iii) that within the special research zone (SRZ) of the Ross Sea, 'Tags shall include pop-up or implanted archival tags that shall be deployed based on advice from the Scientific Committee'.

4.6 The Workshop noted that many configurations of pop-up satellite archival tags (PSATs) were available and that the appropriate configuration was dependent on the specific question being asked. The Workshop further noted that the environmental conditions in the Southern Ocean, and especially related to toothfish and skate deployments were typically outside the operational specifications of currently available archival tags, especially for questions relating to movement patterns. The Workshop encouraged Members to test the performance of PSATs as the technology develops under realistic conditions before large-scale deployments.

4.7 The Workshop reflected that the Scientific Committee had not provided direct advice on the deployment of pop-up or implanted archival tags in the SRZ of the RSRMPA, and that the successful deployment rate of pop-up or implanted archival tags throughout CCAMLR fisheries was currently very low. The Workshop requested that the relevant working groups and the Scientific Committee consider advice relative to archival tagging in the SRZ.

Future work

5.1 The Workshop identified the following topics as potential future tasks:

(i) increase engagement of vessel crew in the tagging program by:

  (a) providing tagging performance statistics to vessels (paragraph 1.19)

  (b) encouraging vessels to develop innovative handling aides (paragraph 2.12)

  (c) considering a mechanism for vessels to obtain information about the tagged fish they recapture (paragraph 3.4)

(ii) examine effects of different hauling methods on fish condition (paragraph 2.11)

(iii) develop a tagging training manual (paragraph 2.42), which includes best-practice videos (paragraph 2.39)

(iv) consider mechanisms to efficiently organise and fund tagging training sessions for vessel crew and observers (paragraph 4.4)

(v) investigate options to reduce pencil and paper recording of data by crew and observers (paragraph 4.3)

(vi) explore options to improve historic tagging data (paragraph 3.12)

(vii) develop, test and share emerging technologies as they become available (paragraph 2.47), including

(a) RFID fish tags (paragraph 4.2)

(b) CKMR (paragraph 4.2)

(c) PSATs (paragraph 4.6).

Outputs and report

6.1 The report of the Workshop was adopted.

6.2 At the close of the meeting, Dr Jones and Mr Arangio thanked all participants for their contributions of ideas to the Workshop and considered that significant progress was made in developing best-practices guidance, documentation and directions for future work to support CCAMLR’s tagging program for both toothfish and skates.

6.3 The Co-conveners noted that the Workshop was unprecedented in having a hands-on practical session for tagging fish in a laboratory. They encouraged the participants to discuss options with their delegations to further develop the tagging training manual.

6.4 Mr Fenaughty and Dr Ziegler, on behalf of the Workshop, thanked the Co-conveners for their guidance, COLTO for funding the meeting venue, support and logistics, and the Secretariat team for their support in conducting the Workshop.

Table 1: Details of vessel configurations and procedures associated with toothfish landing, handling, tagging and release that could be collected in fishery notifications.

Category	Definition
Landing	
Lifting aide used	Is a lifting aide used to support fish that are chosen for tagging?
Type of aide	Cradle/scoop net/basket. Provide diagram with specifications
Fish size for lifting aide (cm)	What is the minimum size of fish that require use of lifting aide?
Vertical lift (m)	Height from water surface to landing
Tagging responsibility	Does the observer or vessel crew typically conduct the tagging procedure?
Tag overlap monitoring tool	Is tag overlap statistic monitored using a tool?
Distance to tag station (m; range)	How far is the transport between landing and tagging station?
Aide material	What material used in transport aides touches the fish?
Holding tank used	Is a holding tank used?
Size (L)	How many litres of water are maintained in the holding tank?
Flow rate	What is the flow-through rate (litres per minute) of water supplied?
Temperature (°C)	How is tank temperature monitored and controlled?
Tank cleaned (days)	How often is the tank drained and cleaned?
Recuperation	Are fish held for a recuperation period after tagging?
Tagging operation	
Number of people	How many people tag the fish (including recording data)?
Weight recorded	Is weight recorded?
Equipment maintenance	
Needle cleaned (days)	How often is the tagging gun needle cleaned?
Tagging needle replaced (days)	How is needle condition monitored and maintained?
Station cleaned (days)	How often is the tagging station cleaned?
Release method	How are fish released from the vessel?
Release height (m)	From what height are fish released to the sea?
Tagging time monitoring	Does someone periodically measure the time out of water used for the tagging operation?
Time out of water	What is the typical measured time (minutes) out of water required for the tagging operation?

Appendix A

List of Registered Participants

COLTO–CCAMLR Tagging Workshop
(Hobart, Australia, 14 to 17 March 2023)

Co-conveners	Mr Rhys Arangio Coalition of Legal Toothfish Operators
	Dr Christopher Jones National Oceanographic and Atmospheric Administration (NOAA)
Invited Experts	Mr Darren Evans Hallprint Pty Ltd
	Mr Derke Snodgrass NOAA / NMFS / SEFSC / PEM
Australia	Dr Philippe Ziegler Australian Antarctic Division, Department of Climate Change, Energy, the Environment and Water
	Mr James Devenport Australian Fisheries Management Authority
	Mr Martijn Johnson Australian Longline PL
	Ms Justine Johnston Australian Fisheries Management Authority
	Mr Tim Lamb Australian Antarctic Division, Department of Agriculture, Water and the Environment
	Mr Dale Maschette Institute for Marine and Antarctic Studies (IMAS), University of Tasmania
Chile	Dr Juan Carlos Quiroz Espinosa AOBAC – Asociación Gremial de Operadores de Bacalao de Profundidad de Magallanes
	Mr Leonardo Danilo Caballero González Instituto de Fomento Pesquero – IFOP

France	Mr Nicolas Gasco Muséum national d'Histoire naturelle Ms Charlotte Chazeau Muséum national d'Histoire naturelle
Korea, Republic of	Mr Hyun Joong Choi TNS Industries Inc. Mr Taebin Jung TNS Industries
New Zealand	Mr Kazuto Senga Sanford Mr Jack Fenaughty Silvifish Resources Ltd Ms Brodie Plum Talley's Ltd Mr Andy Smith Smith Fishing Consultancy Mr Hamish Tijsen Talley's Ltd
South Africa	Mrs Melanie Williamson Capricorn Marine Environmental (CapMarine) Mr Sihle Victor Ngcongo Imvelo Blue Environment Consultancy (Pty) LTD
Spain	Mr Joost Pompert Pesquerias Georgia, S.L
United Kingdom	Dr Deborah Davidson Argos Ltd
CCAMLR Secretariat	Daphnis De Pooter Science Data Officer Isaac Forster Fisheries and Observer Reporting Coordinator Dr Steve Parker Science Manager

Appendix B

Agenda

COLTO–CCAMLR Tagging Workshop
(Hobart, Australia, 14 to 17 March 2023)

1 Welcome and introductions

- 1.1 Workshop overview
- 1.2 Tagging programs presentations

2 Best practice discussions (including wet lab work)

- 2.1 Toothfish and skate landing
- 2.2 Toothfish and skate handling, station, and equipment
- 2.3 Toothfish and skate release operations
- 2.4 Review of current tagging protocol

3 Data

- 3.1 Tag release data
- 3.2 Tag recapture data and recording
- 3.3 Monitoring tagging operations and program administration

4 Looking forward

- 4.1 Workplan for future improvement
- 4.2 PSAT tags

5 Outputs and report

- 5.1 Agreement on what approaches and outputs will be best suited
- 5.2 Summary/Report adoption.

Appendix C

List of Documents

COLTO–CCAMLR Tagging Workshop
(Hobart, Australia, 14 to 17 March 2023)

WS-TAG-2023/01	Summary of tagging procedures survey data received by the Secretariat from 2019 and 2020 Secretariat
WS-TAG-2023/02	A brief history of toothfish tagging in the CAMLR Convention Area and discussions leading up to WS-TAG-2023 C.D. Jones
WS-TAG-2023/03	Overview of the conventional tagging program of the Cooperative Tagging Center, Atlantic Highly Migratory Species (1954–2021) D. Snodgrass and E. Orbesen

Other Documents

WG-FSA-13/54	Further review of CCAMLR tagging programmes S. Parker and J. Fenaughty (New Zealand)
WG-FSA-2022/11	Tag linking – 2022 report CCAMLR Secretariat
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-SAM-12/23	Measures to avoid bias in abundance estimates of Dissostichus spp. based on tag-recapture data D.C. Welsford and P.E. Ziegler (Australia)
WG-SAM-12/24	Influence of tag numbers, size of tagged fish, duration of the tagging program, and auxiliary data on bias and precision of an integrated stock assessment P.E. Ziegler (Australia)
WG-SAM-12/26	Drawing on international experience to improve performance of CCAMLR tagging programs S. Parker and S. Mormede (New Zealand)

WG-SAM-12/27	Viability criteria for tagging toothfish S. Parker (New Zealand)
WG-SAM-12/31	Recommendations for CCAMLR tagging procedures S. Parker, J. Fenaughty (New Zealand), E. Appleyard (Secretariat) and C. Heinecken (South Africa)
WG-SAM-13/25 Rev. 1	An overview of tagging skates (Rajiformes) and CCAMLR skate tagging data S.R. McCully, D. Goldsmith, G. Burt, R. Scott and J.R. Ellis (United Kingdom)
WG-SAM-2019/10	Chemical marking protocols for Antarctic starry skate age validation M. Francis and S. Parker

Appendix D

Tagging Protocol

1. The Flag State of the vessel is responsible for all tagging procedures and tagging equipment, including sourcing of tags for vessels.

2. Vessels are encouraged to work with observers to ensure that tagging and sampling procedures, specified in the *Scientific Observer's Manual – Finfish Fisheries* and the *Commercial Data Collection Manual – Longline Fisheries* are conducted in an efficient manner.

3. Fish that are selected for tagging should be landed on the vessel using a lifting aide that supports the weight of the fish from underneath (e.g. cradle, stretcher, dip net, or sling) to minimise potential injury.

4. Fish that are selected for tagging shall not be lifted using a gaff.

5. Fish that are selected for tagging must be assessed to be in good condition and free from injuries as specified in the Scientific *Observer's Manual – Finfish Fisheries* and the *Commercial Data Collection Manual – Longline Fisheries*.

6. Vessels are encouraged to configure the distance between the hauling bay, the tagging station and the release point to be as short as practicable, and to minimise obstacles that may hinder fish transportation.

7. Fish handling between the hauling bay, tagging station and release point should follow the methods recommended in the *Scientific Observer's Manual – Finfish Fisheries* and the *Commercial Data Collection Manual – Longline Fisheries*.

8. The tagging station should be protected from the weather, and ensure the safety of the fish handlers and the health of the fish.

9. Fish handling time, from landing to release, is encouraged to be as short as possible.

10. The total time fish are out of any water should be less than three minutes.

11. The time fish are held in a holding tank should be minimised.

12. Recommendations on holding tank design are specified in the *Commercial Data Collection Manual – Longline Fisheries*. The percentage of fish volume to volume of water in the holding tank should not exceed 10%. Toothfish and skates should be held separately.

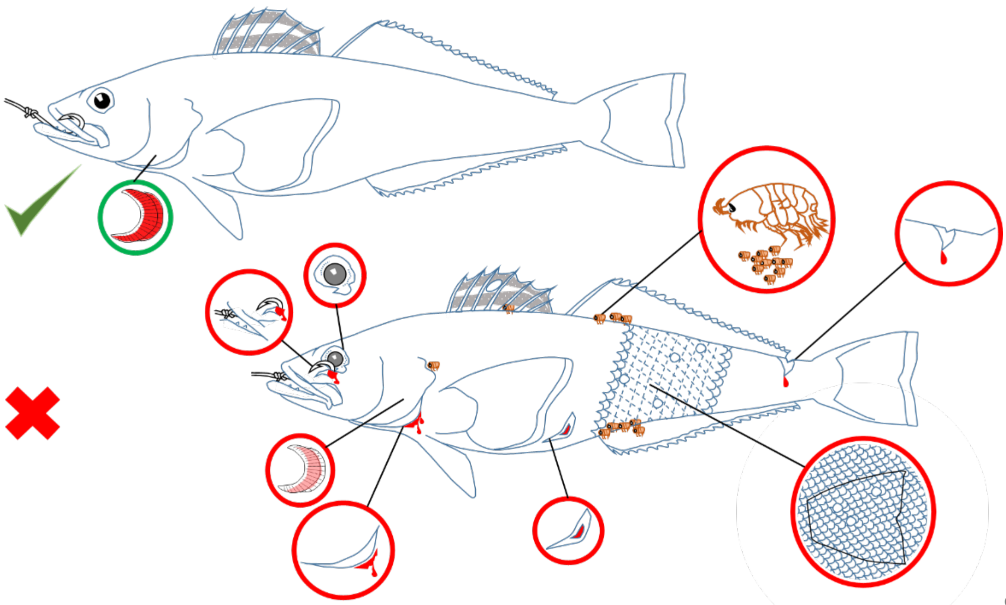
13. Tagged toothfish should be released headfirst, ensuring that the distance between the release point and the sea surface is as short as practicable.

14. Tagged skates should be released dorsal side up, ensuring that the distance between the release point and the sea surface is as short as practicable.

Toothfish Tagging Poster

Tag deployment

1. Use handling procedures outlined in the training manual, minimise time out of water.
2. Use more than one person for large fish, transport fish using a transport aide.
3. Carefully remove the hook. Assess suitability for tagging. Do not tag fish if any of the conditions listed below are present.



credit:
Alan Hart, NIWA

Suitability assessment

Assessment category	Do not tag
Hook injuries	Hook injury outside the mouth area (outside the lips, jaw, or cheek), or in the back of the mouth.
Gills	Gills pink or white
Bleeding	Any visible bleeding from gills, or excessive bleeding elsewhere
Body	Visible damage to fish body with open wounds
Organs	Visible damage to eye or penetration of body cavity, including by crustaceans (amphipods/lice)
Scales	Abrasions or single area of recent scale loss equal to or exceeding the area equivalent to the fish tail

4. Double-tag fish using tags with sequential numbers if possible.

5. Confirm tag is anchored with a gentle tug.

6. Record data as required in the observer longline logbook and the C2 logbook. Make sure to include all leading characters, tag type, colour and inscription).

7. Check that tag numbers are recorded correctly.

8. Release fish headfirst into water where release conditions are appropriate.

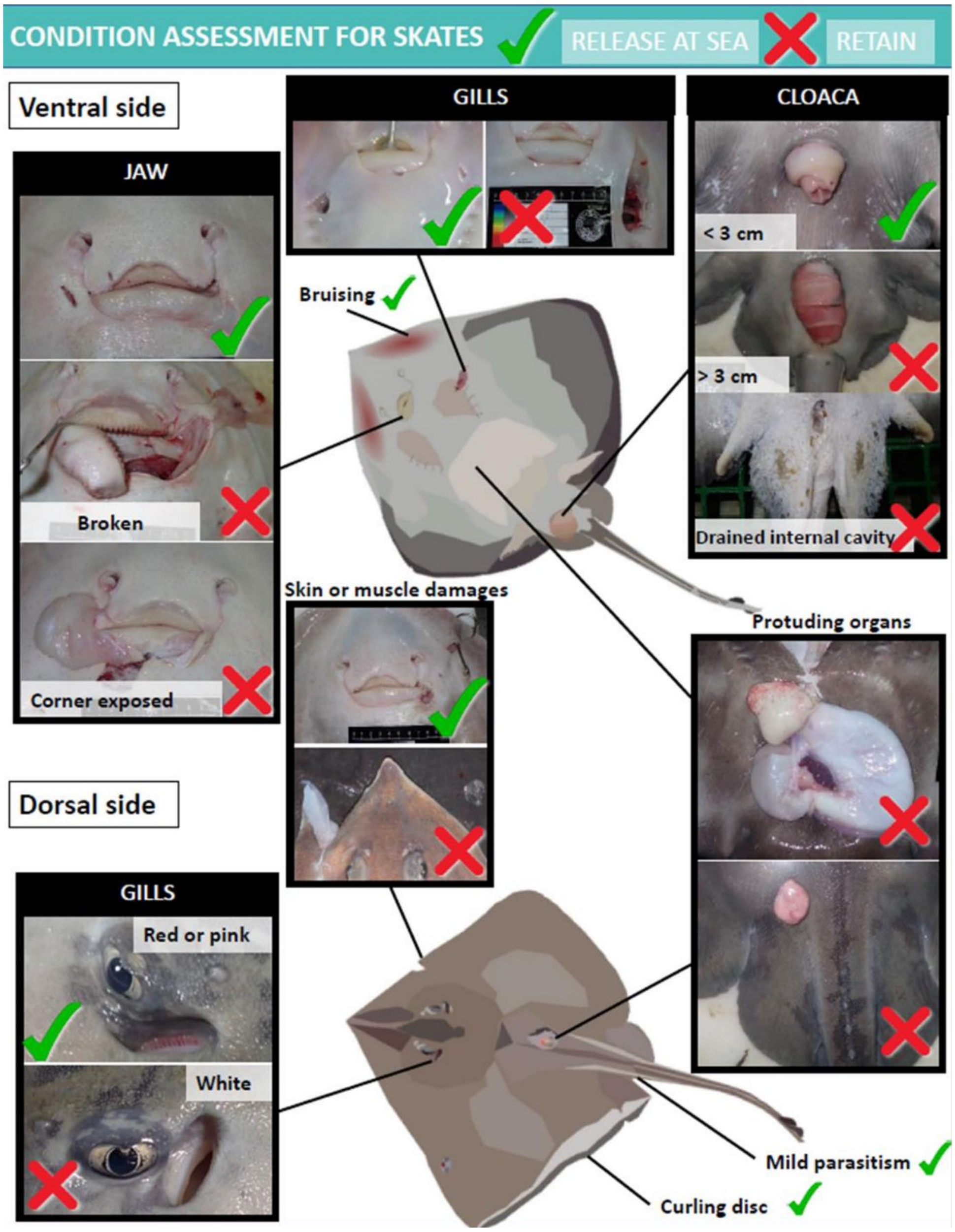
9. Observe and record fate of fish in the logbook.

Appendix F

Skate Tagging Poster

Tag deployment

1. Use handling procedures outlined in the training manual, minimise time out of water
2. Use more than one person for large skates, transport skate using a transport aide.
3. Carefully remove the hook. Assess suitability for tagging. Do not tag the skate if any of the 'retain' conditions listed below are present.



4. Double-tag the skate using tags with sequential numbers if possible.

5. Confirm that tags are anchored with a gentle tug.

6. Record data as required in the observer longline logbook and the C2 logbook. Make sure to include all leading characters, tag type, colour and inscription.

7. Check that tag numbers are recorded correctly.

8. Release skate dorsal side up into water where release conditions are appropriate.

9. Observe and record fate of the skate in the logbook.

If a tagged skate is recaptured, retain it for the observer.

Report of the Krill Fishery Observer Workshop 2023 (WS-KFO-2023)
(Shanghai, People's Republic of China, 19 to 21 July 2023)

Contents

Report of the Krill Fishery Observer Workshop 2023 (WS-KFO-2023)
(Shanghai, People's Republic of China, 19 to 21 July 2023)

Opening of the meeting

1.1 The CCAMLR Krill Fishery Observer Workshop (WS-KFO-2023) was held on the campus of Shanghai Ocean University in Shanghai, People's Republic of China from 19 to 21 July 2023.

1.2 The Workshop co-conveners, Professor G. Zhu (China) and Dr S. Kawaguchi (Australia), opened the Workshop, welcoming participants (Appendix A) to the Shanghai Ocean University campus and noting the long delay of three years in holding the Workshop due to the Covid-19 pandemic. They recalled the importance of this Workshop to the development of the krill management framework and looked forward to an enjoyable and productive Workshop.

1.3 Participants were welcomed by the vice president of Shanghai Ocean University, Professor Jiang Min, who noted the longstanding history of Shanghai Ocean University in krill research, the strong connections with the Secretariat and collaborations with many Members on krill biology. She also noted that the University supports the krill observer programme and welcomed overseas experts coming to China to discuss the important topic of observer tasks in supporting the management of the Antarctic krill fishery.

Adoption of the agenda

1.4 The agenda was adopted.

1.5 Documents submitted to the Workshop are listed in Appendix B. The Workshop thanked all authors of papers for their valuable contributions to the work presented to the Workshop. A glossary of acronyms and abbreviations used in CCAMLR reports is available online.

1.6 In this report, paragraphs that provide advice to the Scientific Committee and its working groups have been indicated in grey. A summary of these paragraphs and additional advice are provided under 'Advice to the Scientific Committee and its working groups'.

1.7 The report was prepared by J. Arata (Invited expert), I. Forster (Secretariat), S. Parker (Secretariat), G. Robson (UK), and Y. Ying (China).

Review of the development of data sampling protocols by the Scientific Committee and its working groups

2.1 WS-KFO-2023/02 reviewed the history of the Scheme for International Scientific Observation (SISO) program, established in 1992. Data collected by SISO helps to identify the effects of fishing on target and dependent species, understanding krill population dynamics and conducting stock assessments. It noted that the development of the new krill management approach for krill fishery will demand more high-quality data, which requires existing protocols to be standardized while being easily applicable. The terms of reference for the WS-KFO-2023 included reviewing the tasks undertaken by the CCAMLR SISO observers (hereby referred to as observers) and improving data collection. The paper identifies three main tasks undertaken by observers:

(i) krill biological sampling,

(ii) fish by-catch sampling, and

(iii) warp observation for bird strikes.

These tasks sometimes implied competing efforts and require a revision of the observer workload and a review of its prioritisation.

2.2 The Workshop welcomed the paper and highlighted the important role that observers have within CCAMLR approach to managing fisheries and appreciated their continuous efforts and efforts of their national coordinators.

2.3 The Workshop noted that along with reviewing sampling protocols to help them understand the purpose of the sampling, it would be beneficial for observer coordinators and scientific observers to be provided with background information on how the data will be used.

2.4 The Workshop noted that the tasks requested of observers have changed over the years due to changing priorities, thus the importance of reviewing the current needs to fulfill the new krill management strategy. The Workshop also noted the need to discuss sampling priorities when more than one observer is onboard.

2.5 The Workshop noted that traditional trawlers target large, dense swarms, while continuous trawlers target large and less dense swarms as they do not stop pumping in between swarms, therefore the krill they catch may have different characteristics.

2.6 The Workshop noted the need to consider training requirements for observers along with the development of new sampling protocols. The Workshop further noted the importance of the specifications of the equipment needed for sampling krill properly, in order to achieve a high level of sampling standardization.

2.7 The Workshop noted that the only current requirement specified under Conservation Measure (CM) 51-06 is krill biological sampling. Fish bycatch, warp strike observations, and observations of incidental mortality associated with fishing are tasked to observers, but the frequency of those tasks is not specified under any Conservation Measure (with the exception of continuous trawl vessel requirements under CM 25-03). As result, each observer program applies different sampling priorities.

2.8 The co-conveners of the Workshop provided a summary on the status of krill fishery management and the importance of observer data. In 2022 the Scientific Committee agreed that the revised catch limit for Subarea 48.1 was based on the best available science but noted that its implementation will require a commensurate increase in data collection and monitoring on krill population, as well as measures to mitigate potential impacts on other components of the ecosystem, including interactions with seabird and marine mammals (SC-CAMLR-41, paragraphs 3.51 and 3.63). During WG-EMM-2023, the SCAR Krill Expert Group (SKEG) presented a first draft on a krill stock hypothesis (WG-EMM-2023, paragraphs 4.28 and 4.29). The Workshop noted that krill fishing vessels could provide almost year-round data that would aid in testing the krill stock hypothesis.

2.9 WG-EMM-2023 proposed a combination of biological, genomics and physical oceanography sampling to achieve a greater understanding of krill stock structure and dynamics (WG-EMM-2023, paragraph 4.32, Table 1). To implement this plan, observers could contribute with biological and environmental information. These data would help to identify spatial-temporal distribution of krill and aid in identifying high-density areas.

2.10 The co-conveners reflected on the recommendations from WG-EMM-2023 and implications regarding this Workshop:

(i) the observer protocols should be modified to include a random selection of individual krill to measure,

(ii) measurements should be taken at a similar time of day, the entire sample should be measured,

(iii) observers should have appropriate equipment (e.g., a stereomicroscope),

(iv) regular krill observer training workshops should be held,

(v) the impact on observer workload needs to be considered when making the recommendations on sampling frequency,

(vi) the requirements of the data collection have changed from historic needs, and current requirements should also be considered if tasking the observers with additional measurements.

2.11 Based on the above, the Workshop developed advice on the following topics:

(i) length frequency sampling protocol,

(ii) equipment requirements to execute the protocol,

(iii) training requirements,

(iv) actual time budget of observer tasks on each type of vessel to understand potential conflicts in scheduling,

(v) improvements needed and challenges for future data collection.

Management of appropriate workload

3.1 WG-EMM-2023/23 presented an analysis of observer sampling rates in the krill fishery for each vessel that fished for krill from 2018 to 2022, including krill biological sampling, fish by-catch sampling, and warp observations following a request by WG-FSA-2022 (paragraphs 8.25 and 8.26). Current sampling rate requirements were given to aid in the interpretation of results. Results indicated that the majority of krill biological sampling rates were above the required minimum rate, by-catch sampling rates were generally high despite the absence of a required minimum rate, and warp observations rates did not always reach the suggested rate (one sample per day).

3.2 The Workshop welcomed this analysis and noted the higher krill biological observation rates for traditional trawlers than for vessels using the continuous trawling system, as well as the potential need for higher sampling rates in particular geographical areas or when krill catches are large.

3.3 The Workshop noted that other factors could be influencing the sampling rates achieved in the krill fishery, including gear type (continuous and traditional trawl), the number of observers on board, other competing sampling tasks, and the type of sampling.

3.4 The Workshop noted that the seasonal change in krill length sampling frequency, every three days during summer and every five days in winter, began voluntarily in 2010 and became a requirement in 2012 (SC-CAMLR-XXXI, paragraph 7.16 and Annex 6, paragraph 2.40). This was implemented to capture the rapid growth period of krill in the summer but may need to be revised to effectively detect this now that the fishery moves around more (paragraph 6.7).

3.5 WS-KFO-2023/03 investigated the variability in krill length and duration of observation by observers involved in krill biological data collection in the Antarctic krill fishery. The results of the analysis showed larger krill were caught during the daytime compared to that at night, and krill size, colour and period affected workload of observers. The authors therefore recommended that a minimum sample size of 100 krill is enough for determining representative krill length frequency distribution of catch, the priorities of observers' tasks need to be redefined, and the sampling design of current biological data collection needs to be reconsidered along with the consideration of workload.

3.6 The Workshop welcomed the paper and noted the conditions of workload dedicated to krill biological data collection could be considered for revision of biological data collection requirements in the Scientific Observer Manual – Krill Fisheries. The Workshop further noted the importance that any changes to observer sampling requirements provide a clear rationale for the data to be collected to promote their use in management of the fishery. The Workshop supported the ongoing improvement of data quality, and the need to give consideration to observer workload in revising requirements.

3.7 The Workshop noted that WG-ASAM-2023 discussed how and when to collect a krill sample along a nominated acoustic transect from a fishing vessel and the appropriate sample size needed to obtain a representative length frequency for krill (WG-ASAM-2023, paragraphs 4.16 to 4.18), and noted that this was dependent on the intended use of these data and the spatial resolution needed.

3.8 WS-KFO-2023/06 summarised the current observer tasks in the krill fishery and responses to the observer survey questionnaire (included in the paper). There were 30 responses to the observer questionnaire survey: from China (17), United Kingdom (7), Korea (3), Chile (2) and Ukraine (1). Twenty-one of the observers had experience on traditional trawlers only, four had experience on continuous trawlers only and five had experience on both trawler types.

3.9 The results of the questionnaire showed variability in how tasks are conducted by different Member programmes. Krill and bycatch sampling were identified as priority tasks while bycatch and IMAF observations for net monitor cable trials were reported to create conflict on time demands, and the time and location of sampling was not necessarily random.

3.10 The Workshop noted the variability among responses and noted the importance of clearly defined sampling specifications for observers that are scientifically supported and practical to implement. The Workshop also noted the value of including feedback from experienced observers with direct experience in the krill fishery in addition to krill fishery managers, observer coordinators and scientists.

3.11 The Workshop noted that historically, observer deployments on the Chinese krill vessels averaged about two months in duration, whereas current deployments can last for close to one year in duration. The Workshop thanked all of the observers for their ongoing commitment and hard work in collecting this valuable information and considered that a prize could be awarded based on length of service or other metrics in recognition of these efforts.

3.12 The Workshop considered the tasks conducted by observers on board krill fishing vessels and developed a table to summarise the amount of time each type of sampling event and task typically entailed (Annex 1, Text of the SISO), with a time range indicated when conditions created variability in the time required (Table 1). The Workshop noted that Table 1 provides a summary of many averages of times required, which may vary the total time required from day to day. Noting that those on the vessel work consecutive days throughout their deployment, the Workshop requested the Scientific Committee provide priorities for the tasks to guide the observer in time allocation among tasks.

3.13 The Workshop noted that only Krill biological sampling and net cable trial monitoring on continuous trawl vessels were specified in Conservation Measures 51-06 and 25-03 respectively, but that other tasks are needed in accordance with the text of the CCAMLR SISO. The Workshop noted that most of the tasks were defined in the Scientific Observer's Manual – Krill Fisheries, but that some ancillary tasks were detailed in Table 1 to account for the time observers spend conducting their duties. The Workshop further estimated the actual average time per day from 2022 data on sampling rates from WG-EMM-2023/23.

3.14 The Workshop noted that identified sampling and supporting activities, that if conducted all in one day, would require an observer to spend almost 12 hours on average across the fishing fleet, and that with large sampling tasks spread over multiple days, the actual average amount of time spent in 2022 was over 9 hours per day on traditional trawl vessels, and over 11 hours per day on continuous trawl vessels due to the net monitoring cable trial requirements. The Workshop further noted that because only two tasks were specified by Conservation Measures while other tasks are outlined in the text of SISO, Annex 1, the specified duties, including ancillary activities would require between 4.2 and 4.7 hours on traditional trawl vessels, and 6.5 to 7.0 hours on continuous trawl vessels depending on the season (Table 1).

3.15 The Workshop noted that time estimates for all tasks were based on the tasks being undertaken by experienced observers. The Workshop further noted that this was the first occasion that estimated observer time allocation for tasking in the krill fishery had been summarised and welcomed the information to support planning within the Scientific Committee and its working groups.

Refinement of sampling and reporting protocols

4.1 WG-EMM-2023/05 presented a comparison of length frequency sampling between krill researchers and scientific observers on board a commercial krill fishing vessel over several seasons. Observers are required to sample 200 individuals every 3 or 5 days, depending on season and other requirements according to CM 51-06, whereas researchers sampled every day at the same time and analysed krill from one or two subsamples. Observers tended to use a monocular microscope that had lower magnification, and there were differences in how the two groups defined maturity stages. There were significant differences in the length frequency distributions for most of the compared samples. The paper concluded that current observer protocols tended to under-sample small krill, the juvenile component of the catch, and the different staging protocols resulted in different life-stage compositions. The bias, as a result, will have effects on estimating the spawning component of the catch and determining the amount of sub-adult stages that will develop into mature krill the following season.

4.2 The Workshop noted that the paper clearly demonstrated the differences in measurements between krill researchers and observers and agreed that there was a need to improve accuracy when measuring and determining sex of krill, particularly for the juveniles.

4.3 The Workshop considered that taking measurements of krill at randomized periods throughout a 24-h cycle would potentially reduce systematic measurement bias as studies have shown that vertical migration of krill can result in different length frequency distributions between day and night periods paragraph 3.5).

4.4 The Workshop further noted the recommendation in the paper that krill sampling be performed daily and reflected that this would require consideration of observer workloads, as a daily sampling frequency would be a significant increase on the current krill sampling requirements (Table 1).

4.5 The Workshop noted the recommendation from WG-EMM-2023 (paragraph 4.3) to consider the draft length frequency sampling protocol developed by WG-EMM-2023 Appendix D for better application on traditional trawling vessels. The Workshop undertook a revision of this protocol, detailed in Appendix D.

4.6 The Workshop noted that the revised krill sampling protocol (Appendix D) may in some cases result in a significant increase in the workload of the observer. The Workshop requested that the Scientific Committee consider the appropriate Working Group to assess whether any krill sampling protocol requires a minimum number of individuals to be measured and sexed, or whether the sampling can be volume based (paragraph 6.7).

4.7 The Workshop suggested that the Scientific Committee consider the frequency of krill biological sampling according to the purpose of the data collection.

4. 8 WS-KFO-2023/01 presented a guide to determining sex and maturity stage of Antarctic krill and provided detailed explanations and high-resolution images of sexual organs to assist observers' krill sampling tasks onboard fishing vessels.

4.9 The Workshop welcomed the guide and the commitment by Dr Kawaguchi to share the materials with the Secretariat for inclusion in the Scientific Observer Manual – Krill Fisheries.

4.10 The Workshop recommended the use of a stereoscopic microscope for aiding sex determination of krill, and thus requested the inclusion of a minimum set of standards of an appropriate quality stereoscopic microscope with upward looking or flexible light source to be added to the observer manual, to assist observer programmes and vessels when they are sourcing equipment.

4.11 WS-KFO-2023/04 presented the results of a study that addressed data quality issues in the CCAMLR krill fishery database, particularly relating to data consistency and accuracy. Historical data links (2000 – 2012) between observer data and C1 vessel data were examined which resulted in 5 660 newly created links and 4 253 updated historical links of the 11 907 records with issues, making a significant improvement. Data accuracy issues were also identified, including unit errors and missing values, which affected the analysis of fish by-catch in the krill fishery. To improve data quality suggestions included enhancing the types of data checks, conducting regular diagnostics, and providing diagnostic tools for observers.

4.12 The Workshop welcomed the results of the study and supported the recommendations to develop better observer advice relative to data checking procedures, as well as the provision of improved diagnostic tools for observers and vessels.

4.13 The Workshop noted that data from CCAMLR krill fisheries has improved in quality since 2012.

4.14 The Workshop noted that the project was undertaken through the CCAMLR international internship programme with support provided by China Fund, the China Scholarship Council and Shanghai Ocean University. The Workshop noted the historic success of the CCAMLR internship programme, and that many graduates had moved on to roles within Members' delegations. The Workshop encouraged Members to engage and continue their support of the CCAMLR internship programme given the increased capacity benefits that had been achieved.

4.15 The Workshop received a summary from Ms Robson on progress with an analysis to determine a krill length frequency sample size that would best reflect the overall length distribution of the catch in a Subarea. The analysis used bootstrapping to develop a power analysis of existing samples. The Working Group noted this progress report was also presented to WG-SAM-2023 (paragraphs 3.4 and 3.5)

4.16 The Workshop noted that the analysis would provide useful information about the estimation of size distribution of the catch and recommended that a paper be prepared and submitted to WG-SAM-2024 for review.

4.17 WS-KFO-2023/05 presented a draft data collection template and accompanying instructions for krill trawling vessels to report standardised data in the event of a whale mortality event. The draft data collection form was provided to WS-KFO-2023 to support any potential discussions around priorities for observers, observer workload and safety and for suggested refinements prior to the template being presented to WG-IMAF-2023.

4.18 The Workshop noted that basic metadata fields regarding the haul position, date and time and fishing depth should be placed first and recommended the addition of a field for haul number to link the data in the cetacean mortality form with fishing vessel data for verification purposes.

4.19 The Workshop recommended that detail on how to distinguish between fresh, decomposed, or very decomposed categories for whale condition, and additional classifications of floating, tangled in net but in the water, and on board be developed to ensure that observers recorded accurate and comparable data in these fields. The Workshop further noted that data such as blubber thickness may be difficult to obtain and should only be performed when safe to do so.

Training materials for krill sex determination and length measurement

5.1 The Workshop noted many Members conducted their current observer training programmes regularly every year immediately following the annual meetings of the Scientific Committee and the Commission.

5.2 The Workshop encouraged Members to contribute their training materials, experiences and multimedia records for developing training materials for scientific observations to the Secretariat.

5.3 The Workshop noted the cooperation among Members or between Members and the Secretariat on observer training that has been implemented and encouraged such collaborative efforts.

5.4 The Workshop encouraged the Secretariat to develop a poster or workstation summary instructions translating the observation tasks from the detailed Scientific Observer Manual – Krill Fisheries into specific items which can be easily followed and directly implemented by the observers. This should be translated into the native languages of the observers.

5.5 The Workshop noted the need to distribute the most updated observation tasks and Conservation Measures to observers in a timely manner, and ensure that fishing vessels and technical coordinators of Members are promptly informed with any updates.

5.6 The Workshop suggested that the Secretariat develop a summary of scientific observation efforts to be included in the krill fishery reports as feedback for observers, and seek confirmation from the observer designating nations before releasing such information.

Advice to the Scientific Committee and its working groups

6.1 The Workshop included a discussion on challenges and opportunities for future developments to improve the krill fishery observer program. These suggestions spanned improvements to the Scientific Observer Manual – Krill Fisheries to clarify sampling priorities and future development recommendations as detailed below.

6.2 The Workshop noted that the draft cetacean sampling form developed in collaboration with the International Whaling Commission (WS-KFO-2023/05) would require specific training and instructions for observers. The Workshop sought clarification on the conditions required for sampling to occur, as it was unclear what data should be collected if a cetacean could not be brought on board versus if it could.

6.3 The Workshop requested that the Scientific Committee consider procedures to follow for the sampling and measurement of bycatch when large numbers of larvae or other small taxa are found in the 25 kg krill bycatch sample. In addition, the Workshop requested the Scientific Committee consider the frequency of sampling for bycatch species and size composition.

6.4 The Workshop noted that observers may be asked by vessels to assist with activities that are not specifically assigned observer tasks, such as completing C1 forms or conducting volume to mass conversion factor tests for the estimation of krill green weight. The Workshop requested the Scientific Committee clarify the intent and prioritisation of observer tasking.

6.5 The Workshop noted that WG-ASAM-2023 developed instructions for acoustic data to be collected by fishing vessels but did not specify if this would be a vessel task or an observer task. The Workshop requested the Scientific Committee consider the role of observers in the collection of acoustic data and metadata, and if tasked to provide training to ensure observers are appropriately skilled for the task.

6.6 The Workshop noted that improvements to sampling procedures, equipment specifications (including stereomicroscope) and training materials (e.g., sex and stage identification) may require updates to both observer forms and instructions. The Workshop noted that some innovative methods to determine sex of krill using bright light (e.g., from a cell phone) were introduced during the Workshop, that such a procedure could provide a fast method with no specialist equipment requirements, and suggested future research detailing and comparing the method with current sex determination methods be presented to the appropriate Scientific Committee Working Group.

6.7 The Workshop requested the Scientific Committee consider the purposes for krill length frequency data collection from fishing vessels and given the purpose, the appropriate minimum number or volume of krill to be measured and the frequency of sampling (paragraph 4.6).

6.8 The Workshop noted that mechanisms existed to improve observer and vessel data quality and requested the Scientific Committee support the development of improved error trapping during data entry, diagnostic capabilities, and training in the use of these methods (paragraph 4.10).

6.9 The Workshop noted the new procedures in development will require improved training and training materials and requested the Scientific Committee consider the development of modern internet-based tools to assist in providing consistent training information among scientific observer training programs.

6.10 The Workshop noted the krill data collection workplan included additional workshops and suggested that the Scientific Committee progress these given the importance and interlinked data collection activities (SC-CAMLR-41, Table 11).

6.11 The Workshop noted that observer time is limited and that automated methods using for example, electronic monitoring, artificial intelligence and machine learning could be used to free observer time for more complex tasks and requested Members to develop these mechanisms to improve the amount and quality of data collected where possible.

6.12 The Workshop noted of the limited time available for observers to conduct necessary activities and requested that the Scientific Committee consider their workloads when prioritising and allocating observer tasks.

Adoption of the report and close of the meeting

7.1 The report of the Workshop was adopted, requiring 2.5 hours of discussion.

7.2 At the close of the Workshop, Professor Zhu thanked Secretariat, co-convener, observers for productive discussions, industry for support and collaboration, and further thanked the support of China Fund on the Workshop, Dr X. Zhao (China) for clarifying contributions, and students from Shanghai Ocean University for their enthusiastic support and discussions. Co-convener Dr Kawaguchi concurred and thanked Professor Zhu for his generosity and expertise in the many aspects of supporting this meeting.

7.3 The co-conveners noted the value of bringing together the fishing industry, observers, and scientists to build common understanding and relationships to improve the scientific information provided to CCAMLR for fishery management.

7.4 Dr Zhao, on behalf of the participants, thanked the co-conveners for their efficient guidance. He noted that we now have an observer task time budget for the first time in CCAMLR history. He also thanked the Secretariat and the rapporteurs for their excellent text.

7.5 Mr Xu Yucheng and Mr Han Yu (China) expressed their appreciation to the participants of the Workshop for their important contributions and looked forward to further development of the observer programme and to support their work.

7.6 Mr Forster congratulated the participants for the fastest report adoption he has witnessed, and thanked all the participants for willingness to travel and contribute to helping us all learn more about data collection in the krill fishery.

7.7 The invited expert, Dr Arata, thanked the Workshop and the co-conveners for inviting him to the Workshop and for giving him the opportunity to contribute to the further development of the observer programme.

7.8 The Workshop thanked the graduate student volunteers Mr Sisong Dong, Ms Yafei Dong, Mr Juntao Du, Ms Linhong Li, Mr Weichang Li, Mr Shiyu Lin, Ms Hui Liu, Ms Jinhui Liu, Ms Yu Liu, Ms Hurui Qian, Ms Chongchong Wang, Mr Huaimo Wang, Mr Jialong Wang, Mr Feng Xue, and Ms Mengchen Zhang (Shanghai Ocean University) for their work in supporting the logistics of the Workshop.

Table 1: Estimated times for conducting current SISO observer tasks in CCAMLR krill fisheries. Unless specified, figures are expressed in hours per day. CT = Continuous Trawlers, TT = Traditional Trawlers. "November – February" and "March – October" headings indicate periods where krill biology sampling requirements are specified under Conservation Measure 51-06.

CCAMLR SISO observer tasks	Time required per event (h)	Average time for daily sampling (h)	Actual average time per day	November – February	March – October	Comments
Krill Biology	3–4	3.5	1.84*	1.2	0.7	* Mean daily sampling rate calculated from 2022 data (WG-EMM-2023/23)
Bycatch composition and measurement	2–4	3.0	2.22*	Tasks not specified under any Conservation Measure. Based on current observer tasking from the actual average time per day, the total number of hours per day for these categories is expected to be 3.26 h. This is not included in the total time required.		* Mean daily sampling rate calculated from 2022 data (WG-EMM-2023/23)
Warp strike observation	0.5	0.5	0.46*			* Mean daily sampling rate calculated from 2022 data (WG-EMM-2023/23)
IMAF during haul	0.75	0.8	0.8			
Vessel sightings (IUU)						
Waste disposal observation	0–1	0.5	0.5			
Marine debris observation						
Cruise report diary	0.5	0.5	0.5	0.5	0.5	
Net monitoring cable	1.5–3	2.3	2.3	2.3	2.3	Continuous trawl vessel specific, additional to warp strike
Mammal mortality sampling	Case specific					Priority to be determined by Scientific Committee
Logbook worksheet data entry/verification/diagnostics	1–3	2.0	1.5	1.5	1.5	Including remote validation
Communication with vessel crew	0.5	0.5	0.5	0.5	0.5	
Subtotal		13.5 CT, 11.2 TT	10.5 CT, 8.2. TT	6.0 CT, 3.7 TT	5.5 CT, 3.2 TT	

(continued)

Table 1 (continued)

CCAMLR vessel tasks with potential SISO observer input	Time required per event (h)	Average time for daily sampling (h)	Actual average time per day	November – February	March – October	Comments
Vessel data collection (C1, CE)	0–2					Vessel specific
Assist vessel species ID	0.5–0.75					
Green weight estimation	2					Only calculated infrequently
Acoustics	1					Vessel specific
Interim reporting	0.5					
Subtotal		1	1	1	1	As considerable variation exists between vessels, WS-KFO estimated an average of one hour per day for all tasks observers provide vessels with assistance.
Total time required		14.5 CT, 12.2 TT	11.5 CT, 9.2 TT	7.0 CT, 4.7 TT	6.5 CT, 4.2 TT	

Appendix A

List of Registered Participants

Krill Fishery Observer Workshop
(Shanghai, People's Republic of China, 19 to 21 July 2023)

Chair		Dr So Kawaguchi Australian Antarctic Division, Department of Climate Change, Energy, the Environment and Water
Chair		Professor Guoping Zhu Shanghai Ocean University
Invited Expert		Dr Javier Arata Association of Responsible Krill harvesting companies (ARK)
China, People's Republic of	Representative:	Mr Jiancheng Zhu Yellow Sea Fisheries Research Institute, Chinese Academy of Fishery Science
	Advisers:	Mr Zhuang Chen Shanghai Ocean University
		Mr Lian Chi Jiangsu Sunline Deep Sea Fishery Co., Ltd
		Mr Gangzhou Fan Yellow Sea Fisheries Research Institute
		Mr Xu Gao China national fisheries corp.
		Mr Hongliang Huang East China Sea Fisheries Research Institute, Chinese Academy of Fishery Science
		Mr Kai Huang Shanghai Ocean University

Mr Shuai Li
East China Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences

Mr Ling Zhi Li
East China Sea Fisheries Research Institute

Mr Rundong Lin
Fujian Zhengguan Fishery Development Company, Ltd

Mr Peiyan Liu
China National Fisheries Corporation

Mr Jun Rong Luo
Fujian Zhengguan Fishery Development Co., Ltd.

Dr Xinliang Wang
Yellow Sea Fisheries Research Institute, Chinese Academy of Fishery Science

Ms Bixue Wang
Shanghai Ocean University

Mr Wan Yong Wang
Jiangsu Sunline Deep Sea Fishery Co., Ltd

Mr Yucheng Xu
Liaoning Pelagic Fisheries Co., Ltd

Ms Mei Xue
Shanghai Ocean University

Dr Yi-Ping Ying
Yellow Sea Fisheries Research Institute

Mr Han Yu
Liaoning Pelagic Fisheries Co., Ltd

Mr Xinggao Zhang
China National Fisheries Corp.

Mr Guoqing Zhao
East China Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences

		Dr Xianyong Zhao Yellow Sea Fisheries Research Institute, Chinese Academy of Fishery Science
		Mr Jiuyang Zhu Shanghai Ocean University
Germany	Representative:	Professor Bettina Meyer Alfred Wegener Institute for Polar and Marine Research
South Africa	Adviser:	Mrs Melanie Williamson Capricorn Marine Environmental (CapMarine)
Ukraine	Representative:	Mr Viktor Podhornyi Institute of Fisheries and Marine Ecology (IFME)
United Kingdom	Adviser:	Ms Georgia Robson Centre for Environment, Fisheries and Aquaculture Science (Cefas)
Secretariat		Dr Steve Parker
		Mr Isaac Forster

Appendix B

Agenda

Krill Fishery Observer Workshop
(Shanghai, People's Republic of China, 19 to 21 July 2023)

1. Introduction

   1.1 Opening of the meeting
   1.2 Adoption of the Agenda

2. Review of the development of data sampling protocols by the Scientific Committee and its working groups

3. Management of appropriate workload

4. Refinement of sampling and reporting protocols

5. Training materials for krill sex determination and length measurement

6. Advice to the Scientific Committee and its working groups

7. Adoption of the report and close of the meeting

Appendix C

List of Documents

Krill Fishery Observer Workshop
(Shanghai, People's Republic of China, 19 to 21 July 2023)

WS-KFO-2023/01	A guide to sexing Antarctic krill, with pictures! Melvin, J.
WS-KFO-2023/02	Krill Observer Workshop, what to expect Zhu, G.P. and S. Kawaguchi
WS-KFO-2023/03	An investigation of variability in krill length and observation duration of scientific observer involving in krill biological data collection in Antarctic krill fishery Zhu, G.P., Z.H. Zheng and S. Qiu
WS-KFO-2023/04	Data quality screening for data reported from vessels and observers in the krill fishery Huang, K., D. De Pooter and S. Parker
WS-KFO-2023/05	Draft data collection form for whale incidental mortality events in the krill trawl fishery Kelly, N.
WS-KFO-2023/06 Rev. 1	A summary of current SISO observer tasks in the krill fishery, and responses to the krill observer survey questionnaire. CCAMLR Secretariat

Appendix D

Protocol for length-frequency measurements, sex and stage determination of krill (*Euphausia superba*) on board traditional trawl krill fishing vessels

Background:

Length measurements and sex and stage determinations of krill will provide data that gives insight into its demographic structure (proportion of juvenile and adult krill, sex ratio). By determining the sex and length of a random subsample of ~200 krill individuals, a representative picture of the targeted krill swarm`s demography can be drawn. Simultaneous collection of simple metadata on position, date, time of day, fishing depth and bathymetry, provides valuable insights into understanding krill distribution, behaviour, and life history across seasons and may contribute to managing the krill fishery.

Materials:

- 3x Plastic buckets/ containers (~5 L volume), can be white or transparent (see example in figure 1)
- 1x One litre container/ bucket if sampling from the fishpond/ hold
- 1x Shovel
- 2x Graduated measuring jugs (500 ml volume, see figure 1)
- 1x Ladle
- 1x Laminated millimeter-gridded paper (spanning at least 0 to 70 mm)
- Paper tissue
- 1x Stereomicroscope (minimum requirements detailed in Scientific Observer Manual - Krill Fisheries)
- 1 x Set of forceps

Sampling:

Prior to the krill sampling procedure, have all the devices you need in place (see Materials above) and check the steps in Figure 1:

Three buckets or containers, with two of them filled with cool surface seawater; one litre container or bucket if sampling from fishpond, one shovel if sampling from conveyer, two graduated measuring jugs, a ladle.

Work with the vessel to determine the safest and most appropriate location to take fresh krill samples. Ideally these should be taken from the fishpond or hold as soon as practicable after the landing of a haul. If it is not possible to take samples from the fishpond or hold then samples can be taken from the factory conveyer belt provided they are fresh, and not from old krill landed in previous hauls. It is not recommended to take samples directly from the trawl net as the trawl deck can be a hazardous environment.

(i) Take 3 x one litre samples of krill, ideally from separate locations within the fishpond or hold if possible. If sampling from the conveyer belt take three shovelfuls of krill. Place either your 3 x one litre samples, or 3 x shovelfuls into a bucket,and mix gently, if required add some seawater to prevent damage to the krill during mixing. (see step 1 in Figure 1).

(ii) From this bucket, fill one graduated measuring jug to the ~200 ml mark with the ladle and the other one to the ~50–100 ml mark (see step 2 in Figure 1). The 200 ml size is suggested as this should contain approximately 200 krill, however as krill size is variable, this 200 ml sample could be adjusted appropriately.

(iii) The krill in each jug should be transferred to each of the two buckets previously filled with cool surface seawater to prevent degradation of the krill (see step 3 in Figure 1).

(iv) In the laboratory, place the bucket with the ~200 ml krill, when possible, on ice and store the bucket with the ~50–100 ml subsample in a refrigerator (see step 4 in Figure 1).

The bucket with the ~50–100 ml subsample will be used as a backup sample in case the first bucket does not contain at least 200 krill. Have the laminated millimetre paper, forceps and paper tissue beside the stereomicroscope in place before starting the length-frequency measurements and sex determination of the krill.

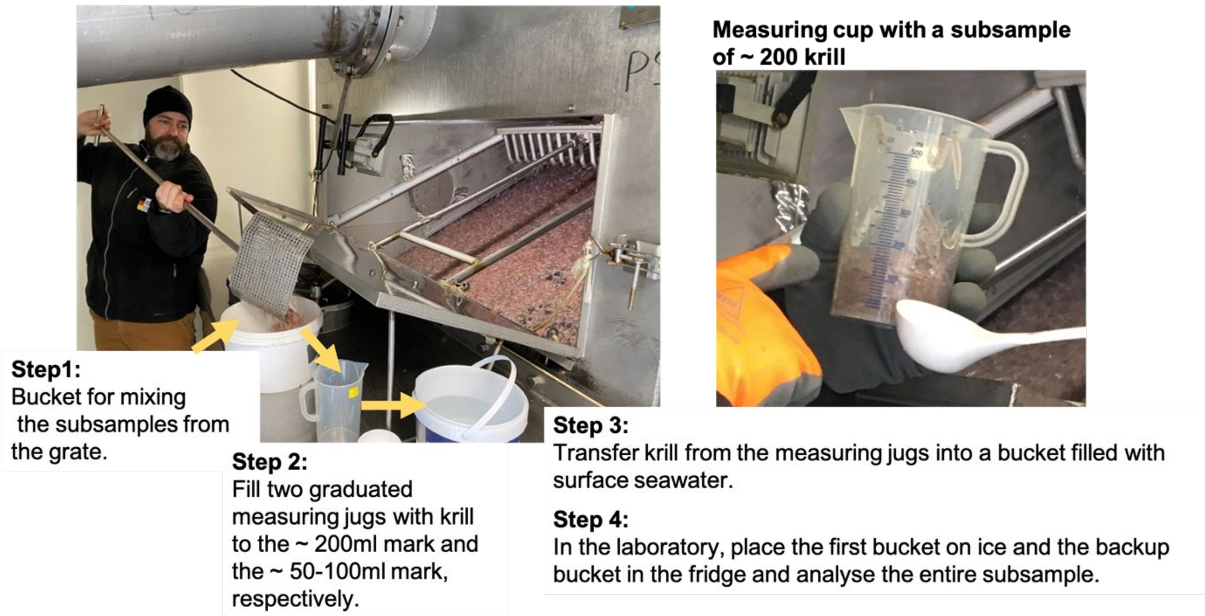


Figure 1: Procedure of krill sampling from the grate in the de-watering or conveyer location. The Workshop noted that the pictures in the draft protocol will be replaced with images taken from traditional trawl vessels before finalising.

Length-frequency measurements and sex determination of krill

To ensure a representative measurement of the length-frequency and sex distribution of the sampled krill, it is essential that all krill individuals in a bucket are processed (length and sex determination), irrespective of the number of individuals in the bucket. Therefore, start with the bucket with the ~200 ml krill subsample and process all krill as described below. If all krill in this bucket are processed, and the number of krill is below 200, process all krill from the bucket containing the ~50–100 ml backup subsample.

For each krill individual, determine and note the length and sex. To determine the length, take one individual with a forceps from the bucket and tap them a few times on the paper tissue to remove the water. Place the krill on the laminated millimeter paper (make sure the animal is stretched out horizontally), and measure the length from the anterior margin of the eye to the tip of the telson, excluding the setae, to the nearest millimeter below.

To determine the sex, krill must be checked for the presence of the male and female copulatory organs, petasma and thelycum, respectively. If you cannot determine the sex of the krill visually (i.e. no eggs are visible for a gravid female or an obvious petasma is not visible for a mature male) it is recommended that you determine the sex under the stereomicroscope. For this, place the individual on its back to look at it ventrally and check between the last pair of exopods for the thelycum (female copulatory organ). In addition, check the inner side of the first pleopod for the presence of a petasma (male copulatory organ). Individuals with a petasma are classified as male and those with thelycum as female. If no petasma or thelycum can be found, krill are categorized as 'juvenile' when smaller than 31mm and when larger than 31 mm as 'unknown'.

Annex 11

Report of the Workshop on Climate Change 2023 (WS-CC-2023)
(Cambridge, United Kingdom and Wellington,
New Zealand, 4 to 8 September 2023)

Contents

Report of the Workshop on Climate Change 2023 (WS-CC-2023)
(Cambridge, UK and Wellington,
New Zealand, 4 to 8 September 2023)

Opening of the meeting

Workshop opening: welcome, workshop structure, housekeeping, adoption of agenda.

1.1 The Workshop on Climate Change (WS-CC-2023) was held in a hub-based, online hybrid format from 4 to 8 September 2023. Two in-person hubs were organised to occur during local business hours; one in Wellington, New Zealand, and one in Cambridge, United Kingdom (UK). In addition, the UK hub had two sub-hubs, with participants in Qingdao, China, and in Paris, France. This hub-based, online hybrid design was implemented as a trial. Additional details on the design and comments on the feasibility are discussed in Attachment I.

1.2 The meeting conveners, Dr R. Cavanagh (United Kingdom) and Mr E. Pardo (New Zealand) welcomed participants (Attachment II) and outlined how the Workshop would be conducted.

1.3 The agenda was adopted (Attachment III).

1.4 Documents submitted to the meeting are listed in Attachment IV and the Working Group thanked all authors of papers for their valuable contributions to the work presented to the meeting. The Terms of Reference for the Workshop are included as Attachment V.

1.5 In this report, paragraphs that provide advice to the Scientific Committee and its other Working Groups have been indicated in grey. These recommendations as well as additional suggested actions are summarised in Tables 1 and 2.

1.6 A glossary of acronyms and abbreviations used in CCAMLR reports is available online at https://www.ccamlr.org/node/78120.

1.7 The report was prepared by T. Earl (UK), S. Grant (SCAR), S. Parker (Secretariat) and C. Waluda (UK).

Expected effects and risks of climate change on Antarctic Marine Living Resources

Invited presentation: Climate change and Antarctic Marine Living Resources

1.8 Each hub received a recorded presentation entitled ‘Climate change and Antarctic Marine Living Resources’ from Dr J. Melbourne-Thomas (Australia) and Dr T. Bracegirdle (UK) which included descriptions of how the physical environment of the Southern Ocean is changing and predicted to change as well as how these changes are likely to affect the ecology of the organisms living there.

1.9 The Workshop welcomed the keynote presentation and suggested that region-specific analysis and effects on species may be useful to better inform CCAMLR, noting that Marine Ecosystem Assessment for the Southern Ocean (MEASO) has developed sector scale/finer scale analyses (WS-CC-2023/12). The Workshop recognised the need to consider the range of environmental and biological conditions that support species and recognised that certain life-history stages may be more vulnerable to the effects of climate change than others.

Climate change effects on harvested species

1.10 WS-CC-2023/01 provided an overview of a new research project to evaluate climate change risks to toothfish populations in Subareas 48.3 and 48.4. Relevant environmental, biological, and fishery information will be reviewed, synthesised and used to undertake a risk assessment of climate-driven change to toothfish populations in the region, and to consider what this means in terms of management. Work with stakeholders is already underway and future findings will be submitted to WG-FSA.

1.11 The Workshop welcomed the research project and discussed how climate change risks to toothfish could be taken into account in fishery management, noting that CCAMLR decision rules could be modified by including uncertainty in trophic effects and the effects of climate change on early life stages.

1.12 WS-CC-2023/04 presented the results from two studies in the Southern Indian Ocean which examined isotherm drift (using climate velocity) at the surface of the ocean compared with depth, as well as a study on marine heatwave impacts. The authors note that isotherm drift in the mesopelagic layers can be faster than at the ocean's surface in climate models under global warming, which could potentially shear vertical pelagic habitats with consequent effects for organisms travelling within one or more oceanic layers. The authors also note that marine heatwaves and global warming could shift the Polar Front (as defined by the northernmost extension of winter waters) locally, therefore potentially influencing marine top predator distribution and foraging patterns. The authors highlight the importance of accounting for the vertical dimension when considering potential impacts of climate change on pelagic ecosystems.

1.13 The Workshop welcomed this paper and the specific questions and considerations from the scientific and management perspectives. The Workshop noted that a collation of Antarctic circumpolar moorings data held by the Southern Ocean Observing System (SOOS) would be useful to understand environmental changes with depth and suggested that an analysis could be undertaken in order to identify gaps in the monitoring of climate change related variables that could be relevant to CCAMLR. The Workshop further noted that CCAMLR Members should ensure that existing datasets are up to date before embarking on a gap analysis.

1.14 The Workshop noted that Argo, BioArgo, under ice and deep ocean observations could be used to create a three-dimensional (3D) view of the ocean and impacts on habitats, and that the relationship between CCAMLR and SOOS could help identify products and appropriate experts to develop routine reporting of these products.

1.15 The Workshop encouraged Members to supply relevant data to SOOS noting that SOOSmap is a data discovery tool, comprising circumpolar standardised and curated data. The Workshop recommended that the Scientific Committee tasks the Secretariat with liaising with SOOS to develop information for use by CCAMLR.

1.16 The Workshop noted the current recommendation by WG-ASAM to collect acoustic data on mesopelagic organisms (but not including physical environmental data) to depths of 1 000 m and observed that toothfish longlines might provide a suitable platform for collecting physical environmental data throughout the water column. In addition, the Workshop noted that the location of the Polar Front could be monitored during North-South transits by scientific vessels.

1.17 WS-CC-2023/08 provided a review of Antarctic toothfish (*Dissostichus mawsoni*) biology and used species distribution models with climate model projections to examine how abiotic and biotic impacts could potentially affect future species distributions. The authors examined the effects of projected climate change scenarios on toothfish distributions as they relate to existing and proposed CCAMLR Marine Protected Areas (MPAs). The results tentatively suggest that medium to high climate change scenarios may decrease areas with high fish availability around the continent but that some of the remaining high fish availability areas would be covered by the Ross and Weddell Sea (P1) MPA Proposals.

1.18 The Workshop welcomed the paper and noted that predictions of which areas would be most vulnerable and where fish availability may increase were important for monitoring and noted that climate change impacts may be different for different life stages. The Workshop considered this aspect to be important given the different ways in which climate change could influence the distribution of different life stages.

1.19 The Workshop noted that using only one high resolution ocean model (FESOM-RecoM) may introduce a bias in the analysis and noted that a range of models with different predictions exist such that ranking different models by their respective fit to historical data may be useful in choosing which models to use for predicting changes to distributions. The Workshop also suggested that certain locations, like Division 58.4.3b, are key spawning areas for Antarctic toothfish and could be included in future analyses but were out of the scope of this study.

1.20 The Workshop also noted that although MPA proposals considered the distributions of Antarctic and Patagonian toothfish as part of their design, MPAs may also act as climate change refugia for these species. Additionally, the Workshop noted that biological differences between the two species (e.g., antifreeze glycoprotein present in Antarctic toothfish) may result in different vulnerabilities to the effects of climate change.

1.21 WS-CC-2023/22 introduced the Climate Genomics of Antarctic Toothfish (ClimGenAT) project, which developed genetic tools to understand climate change impacts on species in the Southern Ocean, with a particular focus on Antarctic toothfish. The project aimed to explore how climate change may impact Antarctic toothfish distribution and connectivity using genomics.

1.22 The Workshop noted that the methodologies presented could be used to identify spawning areas and location changes and could be applied to other species including Patagonian toothfish and highlighted the use of neutral (non-selected) genetic markers to understand population structure versus functional (selected) genetic markers, which can help to identify adaptation to changing conditions.

1.23 The Workshop welcomed the project and noted that data from Argo floats may also be informative in understanding habitats critical to toothfish larvae, such as the Ross Sea Gyre.

1.24 WS-CC-2023/P01 described extreme events that have been observed in Antarctica in recent years that are significantly different to the average ranges of variability across a variety of realms (ocean, atmosphere, cryosphere, biosphere etc). The paper considered the likely causes and implications of such phenomena and concluded that such extreme events are virtually certain to become more frequent and more intense if the ambition of the Paris Climate Agreement is not met. The authors noted that terrestrial and marine protected area tools can be used to minimise additional human stressors on key environments.

1.25 The Workshop welcomed the paper and discussed the importance of tipping points and cascading effects, especially for fisheries management in the next decade and noted that while there may not be sufficient capacity to monitor and predict these effects, these are important issues to address and account for in management approaches. The Workshop also noted that the frequency and intensity of extreme events is of importance because species may not have time to recover in-between successive events.

1.26 The Workshop recalled the approach used in Conservation Measure (CM) 24-04 which provides precautionary protection for newly exposed marine areas following collapse or retreat of ice shelves, and suggested this could serve as a model for how to minimise additional human stressors to facilitate the study of other extreme events.

1.27 The Workshop noted that the use of genomic techniques may be beneficial to understand the degree of isolation between populations, especially after an extreme event, which is important when multiple weather and climate events (spatially and/or temporally related) generate large scale impacts.

1.28 The Workshop recommended that Scientific Committee collate a list of important variables to be monitored following an extreme event to facilitate a coordinated and timely response to such events and their physical/biological effects both on marine components and land-based predators.

1.29 The Workshop noted that it is important to consider all life stages when considering potential climate change impacts on harvested species. The Workshop highlighted the work of the SCAR krill expert group (SKEG) on the krill stock hypothesis and current work on toothfish (e.g., WS-CC-2023/08 and WS-CC-2023/22) as valuable contributions to the understanding of the impacts of climate change on early life history stages.

Climate change effects on dependent and related species

1.30 WS-CC-2023/11 outlined key activities being undertaken by the Scientific Committee on Antarctic Research (SCAR) affiliated groups (in some instances in collaboration with CCAMLR) that may be of interest to SC-CAMLR, particularly in relation to the integration of scientific information on climate change and ecosystem interactions into CCAMLR's work program. SCAR will continue to provide scientific advice to CCAMLR on the impacts of climate change, the status of Antarctic environments and ecosystems, and information to support action on mitigation and adaptation. This advice will draw upon global synthesis reports, peer-reviewed literature, and expertise from across the full range of SCAR's international scientific research programmes, science

groups, expert groups and co-sponsored programmes. The authors encouraged the Workshop to make specific requests for information from SCAR programmes and expert groups relevant to the development of future work on climate change.

1.31 The Workshop welcomed the paper and noted recent SCAR activities related to climate change including collaboration between SCAR and CCAMLR on ecosystem interactions, SCAR's coordination of a Decade Collaborative Centre as part of the UN Decade of the Ocean for Sustainable Development, the Antarctic Climate Change and the Environment (ACCE) report, and MEASO. The Workshop noted that SCAR will continue to provide advice on climate change mitigation and adaptations.

1.32 The Workshop recommended the Scientific Committee continue the collaboration with SCAR to address CCAMLR specific science needs, by making further requests for specific information from SCAR.

1.33 WS-CC-2023/12 Rev. 1. Presented outcomes of the first MEASO, providing a detailed assessment of the current knowledge on status, trends and drivers of change in the Southern Ocean ecosystem. MEASO areas reflect regions within which the dynamics of sea-ice, ocean and benthic habitats combined remain ecologically similar across the region. While they do not perfectly overlap with CCAMLR management areas, and extend north of the Convention Area, they remain suitable for advising CCAMLR on climate change effects on ecosystems and form a suitable basis for monitoring and assessing trends. Summary information and infographics highlight the outcomes of MEASO relevant to CCAMLR, including the pathways of climate impacts into Southern Ocean ecosystems. MEASO has collated and described tools for assessing and managing impacts of climate change, including (i) modelling to support assessment and design of management procedures, (ii) the potential engagement of the SOOS and its regional working groups in facilitating integrated observing of sentinel variables from across the food web, (iii) the breadth of stakeholder engagement that can support the development of management strategies, and (iv) risk assessments.

1.34 The Workshop welcomed the study and noted two general priorities for disentangling climate impacts from other changes: (i) the need for sustained time-series observations of different parts of the food web, taken simultaneously in an area in order to distinguish between changes affecting krill-based and fish-based energy pathways and how climate drivers may interact with these, along with monitoring in different areas to account for different climate impacts in different places, and (ii) models of food webs and ecosystems coupled with Earth System models to help assess the potential for change in CCAMLR areas. The Workshop also noted that not all climate models were suitable for the Southern Ocean and that risk assessments could help to identify what and where to monitor in more detail, especially in the next decade.

1.35 WS-CC-2023/13 presented a summary of the likely effects of climate variability and change on Antarctic skates as a case study for bycatch species. The authors suggest that the most at-risk life history stage for skates may be egg cases. To date, there are only two documented egg case nurseries in the Southern Ocean. The authors recommend that efforts should continue to identify, characterise, and protect areas of essential habitat for bycatch species, including fish nest areas and skate egg case nurseries.

1.36 The Workshop noted that little is known about the effects of climate change on bycatch species in CCAMLR fisheries and supported the recommendations of this study to (i) undertake studies to understand the physiological effects of climate change on marine fishes caught as bycatch in the CCAMLR Convention Area, noting that species may have varying levels of adaptability and that it may not be appropriate to generalise risks and effects to species groups, and (ii) continue to identify, characterise and protect areas of essential habitat for bycatch species, including fish nest areas and skate egg case nurseries.

1.37 The Workshop recalled discussion by WG-EMM-2023 about how to best protect essential fish habitat and the impacts of climate change on such areas, such as fish nurseries and nests (WG-EMM-2023, paragraph 7.73) and noted that the impact of climate change on other bycatch species such as grenadiers also needs to be taken into consideration.

1.38 WS-CC-2023/14 summarised a virtual workshop held by the International Whaling Commission (IWC) in 2021 which considered climate change in the context of the conservation and management of cetaceans. The paper provided a brief overview of discussions including the role of whales in nutrient cycling and the food web and the need for flexible management strategies to deal with uncertainty. The IWC encouraged stronger collaboration with CCAMLR and asked for climate change to specifically be addressed in species management plans alongside other anthropogenic pressures.

1.39 The Workshop welcomed the paper and recognised the importance of collaboration between IWC and CCAMLR, noting that Dr N. Kelly (Australia) is the SC-IWC observer to SC-CAMLR and vice versa, and recommended that the collaboration continues, especially noting the importance of considering marine mammals in the current enhancement of the CCAMLR Ecosystem Monitoring Program (CEMP) (WG-EMM-2023, paragraph 5.14).

1.40 The Workshop recognised the need for information sharing between CCAMLR and IWC with respect to food webs and krill consumption by whales, and the value of these data for informing the estimate of natural mortality of krill.

1.41 WS-CC-2023/15 highlighted the need for pairing biological and environmental information to detect, interpret and manage the responses of benthic habitats, communities, and higher predators to climate change impacts. The authors presented details of the SCAR Antarctic Near-shore and Terrestrial Observing System (ANTOS), which aims to use long-term data to understand complexities and drivers of variability and change in benthic communities across different spatial and temporal scales. The authors recommended i) CCAMLR supports and endorses the SCAR ANTOS initiative and its implementation; ii) communication and, where appropriate, coordination between ANTOS and CEMP and other initiatives for long-term observation programmes; and iii) monitoring of key environmental parameters and benthic communities in tandem.

1.42 The Workshop welcomed the paper and supported the recommendations for coordination between ANTOS and CEMP and other initiatives for long-term observation programmes (e.g., in the establishment of sentinel monitoring sites) and encouraged the authors to participate in the current CEMP review.

1.43 The Workshop noted the importance of monitoring key environmental parameters and benthic communities in tandem, in order to understand natural variability and detect and attribute climate change and/or fishing impacts. The Workshop further noted that there was an opportunity to evaluate the effects of climate change on Vulnerable Marine Ecosystems (VMEs). Information on density and composition of benthic megafaunal indicator taxa provided through CM 22-06 (Annex B) can be used as a baseline to examine and monitor potential impacts of climate change on VMEs far into the future.

1.44 WS-CC-2023/P02 modelled a time series of environmental variables as they relate to the Antarctic silverfish populations. The authors found that silverfish larvae and adults can only exist in a narrow range of temperatures below 2° C. Silverfish abundance is likely related to sea ice, as well as salinity and chlorophyll availability, which can influence life cycle and spawning cues. If silverfish are unable to find suitable habitat or environmental conditions, there may be knock-on effects for predators such as penguins or seals.

1.45 The Workshop welcomed the paper and recognised this direct link between climate change and an important species Antarctic silverfish (*Pleuragramma antarctica*) in the West Antarctic Peninsula, due to the Amundsen Sea Low (a climatological low pressure region centred over the Amundsen Sea) likely impacting sea ice distribution and therefore silverfish spawning habitats. The Workshop noted that the advance of sea ice in autumn can directly influence spawning which can result in trophic cascades, which can reduce the prey field for those species which feed on silverfish.

Summary of the discussion

1.46 The Workshop discussed the importance of links between CCAMLR and other organisations such as SCAR and its range of programmes and affiliated groups (WS-CC-2023/11; WS-CC-2023/12) and noted that CCAMLR will benefit by developing specific requests for information required for management and streamlining the flow of information from such organisations. The Workshop noted that the papers summarising IPCC SROCC for CCAMLR (SC-CAMLR-39/BG/12; WG-EMM-2021/P07) provide a good example of a targeted synthesis providing information in a format of specific relevance to CCAMLR.

1.47 The Workshop discussed the importance of standardising climate modelling frameworks to guide the choice of physical climate model data from which to project future distributions of species. This may help to address scenario and model uncertainty and to reduce model bias.

1.48 The Workshop recommended that the Scientific Committee request advice from SCAR to help develop a framework for using climate models to drive ecological projections for AMLR and dependent and related species.

1.49 The Workshop discussed extreme events and recalled a recent paper reporting on record low sea ice extent which has led to regional breeding failure of emperor penguin colonies (Fretwell et al., 2023).

1.50 The Workshop noted that both extreme events and longer-term changes (e.g., changes in sea ice) must be considered to understand the effects of climate change on ecosystems and species including land-based predators.

1.51 The Workshop acknowledged that extreme events could occur on both seasonal and short (e.g., daily) time scales, recognised that effects might vary depending on the organism, its life stage, and the type of event, and noted that those occurring on seasonal timescales are likely to be of highest priority in terms of potential effects on populations and ecosystems.

1.52 The Workshop recommended that the Scientific Committee develop a catalogue of the different types of extreme events, their time scales and the species and life stages that they are likely to affect (building for example on information in WS-CC-2023/12) which would be a useful aid to communicating data needs to climate modellers.

1.53 The Workshop noted that climate change may result in invasive species entering the CCAMLR Convention Area and managing the effects of these species would need to be considered in future monitoring and management.

1.54 The Workshop noted the impact of extreme temperature and sea ice reduction on land-based predators and the need for better data on local meteorological conditions, noting similar discussions took place during WG-EMM-2023 (WG-EMM-2023, paragraph 5.30). The Workshop discussed the need for better understanding of what causes extreme events and further analysis of how particular characteristics of extreme events (intensity, duration etc.) translate into positive or negative impacts on biological processes.

1.55 The Workshop noted that extreme events might affect land-based animals more quickly than aquatic species and highlighted the importance of understanding the response of land-based predators to climate change, particularly considering the long-term data available from CEMP.

1.56 The Workshop noted that the both the frequency and intensity of extreme events and ability of species (such as fur seals) to recover may have cumulative effects on those species and ecosystems.

1.57 The Workshop noted that while many of the papers discussed during the meeting focussed on finfish species, there is substantial evidence that krill are also sensitive to climate change (Johnston et al., 2022). Understanding the physiological and ecological mechanisms of how extreme events might impact krill is also needed.

1.58 The Workshop noted the importance of disentangling the effects of historical exploitation and climate change on populations and suggested that future comparative studies between Southern Ocean regions with different rates of change in the physical environment might be useful in this regard.

Spatial management approaches to ensure objective of the Convention is met

Invited presentation: Climate change and management approaches for marine living resources

2.1 Each hub received a recorded presentation given by Dr A. Hollowed (United States of America) entitled ‘Climate-linked decision-relevant & adaptation-informing scenarios for ecosystems' describing a case for a polar research partnership between Arctic and Antarctic management organisations as they both face similar challenges.

2.2 The Workshop thanked Dr Hollowed for her presentation and noted that this work could provide a model to develop fisheries management in the Southern Ocean to account for the effects of climate change. The presentation included the following bullet points which could be applicable to fisheries in the Convention Area and could provide a guide for Scientific Committee:

(i) Ecological Understanding

(a) Identify stocks & understand ecological linkages through fishery dependent and independent monitoring and analysis

(b) Develop catch by fleet simulator and ecosystem linked assessments for short-term forecasts

(c) Develop of end-to-end ecosystem models (e.g., Atlantis, MIZER, Ecopath)

(d) Understand oceanographic mechanisms through seasonal coordinated monitoring of ocean physics, chemistry, primary and secondary production

(e) Forecast (3-9 months) distribution and abundance of target species to assess understanding

(f) Assess skill of available re-analysis models and Earth system models (ESMs) output relative to observations. Evaluate where higher resolution ocean models are needed.

(ii) Climate Informed Pathways

(a) Build high resolution models to improve retrospective and forecasting performance

(b) Assess improvement in retrospective performance

(c) Identify ESMs that provide reasonable representations of key oceanographic processes (seasonal ice, carbon cycling, ecoregions)

(d) Project climate impacts on oceanography using high resolution model and selected ESMs for shared socio-economic pathways (SSPs)/ representative concentration pathways (RCPs)

(e) Project climate impacts on marine life using climate enhanced assessment and end-to-end models under status quo fishing and no fishing

(f) Develop information pathway for uptake of climate informed advice within CCAMLR (e.g., Fisheries Ecosystem Plan).

(iii) Operationalised System

(a) Annual workshops in CCAMLR to consider forecasts and evolving understanding

(b) Update projections climate ready management strategies based on evolving science

(c) Develop ensemble modelling techniques to project uncertainty

(d) Maintain forecasts annually and update projection modelling suites every 5-7 years

(e) Consider management plan amendments to implement Climate Ready Fishery Management

(f) Revise MEASO projections and forecasts.

(iv) Final thoughts on Polar Research Partnership (PRP)

(a) Implementing ACLIM type research nodes in Antarctica will be more challenging due to the need for international cooperation and agreement

(b) Within CCAMLR the focus may be simpler due to management of only four fisheries

(c) Common issues of protection of prey base for seabirds and marine mammals

(d) Regional scenario planning differs from global scenario planning – regional specific ecosystem goals and harvest strategies

(e) Linkages across scale matter - bidirectional flow of information is central

(f) Perhaps pick a few regions as test cases.

2.3 The Workshop noted the importance of using appropriate ESMs that realistically represent sea ice dynamics, and that not all ESMs are appropriate for the Southern Ocean. ESMs seek to simulate all relevant aspects of the Earth system and include physical, chemical, and lower trophic level (phytoplankton and some zooplankton) biological processes. Global climate models, the predecessors to ESMs, only included physical processes. Physical downscaling of ESMs can provide high-resolution oceanographic models. With respect to ecosystem models, MEASO has provided a synthesis of models that have been developed for the Southern Ocean (McCormack et al., 2021), while in the Arctic climate-enhanced multispecies stock assessment models have been developed.

2.4 The Workshop noted that some aspects of the approach presented by Dr Hollowed were not directly transferable to CCAMLR, as they were developed for a different management system. Applying such an approach within CCAMLR may present different challenges. In addition, the short-term forecasting of the abundance and distribution of some key fish species would be difficult to operationalise within CCAMLR due to data and analyst availability. The Workshop noted the opportunities and willingness of fishing vessel operators to contribute to data collection.

2.5 The Workshop noted that scientists and managers should engage to develop approaches to better communicate uncertainties from complex biological models. In particular, presenting models with and without climate trends together would aid with understanding model differences due to potential effects of climate change, and increase confidence in model outputs.

2.6 The Workshop noted the benefit of large multi-national funding sources for supporting coordinated data collection and analysis. It further noted that multi-member toothfish research, synoptic surveys for krill and the CEMP provided examples of CCAMLR members pooling resources to maximise scientific benefits. The Workshop noted the benefits of engagement with SCAR and SOOS to maximise breadth of expertise in scientific engagement, as well as building on initiatives such as the International Polar Year (2032-2033), the UN Decade of Ocean Science (2021-2030), and projects coordinated under the UN Decade Collaborative Centre for the Southern Ocean, such as 'Antarctica In Sync' (https://www.iybssd2022.org/en/a-circumpolar-assessment-of-the-connections-between-ice-ocean-climate-environment-and-life/).

Climate change considerations for CCAMLR's management approach

2.7 Paper WS-CC-2023/02 presented a handbook for the adaptation of fisheries management to climate change. The handbook combines adaptive and ecosystem-based management approaches and is designed to guide fisheries managers, scientists and industry through a risk assessment process that can identify feasible options for responding to climate change. The approach provided in the handbook was designed to be inclusive and would involve all relevant stakeholders, scalable so it could be applied with differing degrees of detail and adjusted for the available information and resources, and flexible such that it could be applied to a wide range of fisheries and/or types of risks. The authors noted that this approach to assessing climate change risk to fisheries could be adapted for CCAMLR to help inform management decisions and adaptive management responses.

2.8 The handbook proposed a multi-step process (Figures 1-3) to assess:

(i) Ecological Risk: How is the environment (habitats) changing and what are the impacts on species, food webs and ecosystems.

(ii) Fishery Risk: How might the interactions of fisheries be changing in terms of their spatial and temporal operations and the direct and indirect impacts on species, food webs and ecosystems?

(iii) Management Risk: What management strategies, including modifying existing strategies, are needed to support the Commission's objective in Article II?

2.9 Dr P. Ziegler (Australia) noted that the risk assessment approach had been applied to the Patagonian toothfish fisheries in Division 58.5.2 at Heard Island and McDonald Islands and at Macquarie Island, with involvement from stakeholders including fishing industry, scientists and managers. Dr Ziegler offered to share the results of these assessments with relevant CCAMLR working groups when they are available.

2.10 The Workshop noted that the approach provided by this handbook could be used for initial assessment of stocks within CCAMLR. The Working Group noted that these assessments could be focused on a regional scale rather than across the entire Convention Area. Additional assessments could be triggered by extreme climate events or when new information of long-term change becomes available.

2.11 The Workshop recommended that Scientific Committee review this approach for the adaptation of fisheries management to climate change within CCAMLR.

2.12 The Workshop noted that some of the aspects labelled as 'risks' may better be described as ecological responses, and that some risks such as extreme weather may exist even in the absence of climate change.

2.13 Paper WS-CC-2023/05 presented a current project which investigates tools that could contribute to climate-adaptive management for Patagonian toothfish. Preliminary results suggest three potential areas for discussion:

(i) adapting the current methodology (developing additional stock status indicators);

(ii) developing a risk management approach that includes multiple scenarios associated with future recruitment (ideally based on an understanding of the environmental drivers of recruitment variability but in the meantime different scenarios could consist of using different hypotheses regarding the use of historical recruitment values for projections);

(iii) enhancing stock resilience by protecting key areas such as spawning hotspots or key life history stages. The authors also highlight the need for regular monitoring of Patagonian toothfish recruitment.

2.14 The Workshop encouraged caution in interpreting trends in the estimated recruitment series from stock assessments which may be influenced by changes in the fishery or data collection informing the model. The Workshop noted that between-year variation in recruitment was high, even where there was little change in the spawning stock biomass (SSB), highlighting the importance of short-term environmental conditions.

2.15 The Workshop noted that depth restrictions already exist in many fisheries for the protection of juvenile life stages, and that spawning area closures may have unwanted effects of concentrating fishing effort in other areas.

2.16 The Workshop noted that the approach described in WS-CC-2023/05 could be relevant to all managed species, not just Patagonian toothfish. The further development of alternative methods to include recruitment uncertainty in stock assessment forecasts was included in the table of future actions proposed by the Workshop (Table 1).

2.17 Paper WS-CC-2023/09 described the concept of fishery carbon sink (Tang et al., 2011, 2022), which included the removed carbon from aquatic ecosystem by harvesting and the stored carbon by harvested organisms in the ecosystem (Tang et al., 2022). Meanwhile, rational harvesting will increase the productivity of the remaining target population (Pitcher and Hart, 1982). The paper also assessed the net carbon sink of krill fishery from the 1972/1973 to 2021/2022 fishing seasons and suggested that the krill fishery can increase the carbon sink of the Southern Ocean. The authors proposed that CCAMLR should develop a fishery management approach with a fishery carbon sink perspective, combined with ecosystem-based marine living resources conservation.

2.18 The Workshop noted that further work was needed to investigate carbon cycling in the ecosystem in the Convention Area, including the role of fisheries.

2.19 Some participants had reservations about the methodologies used in WS-CC-2023/09 and suggested that the overall carbon footprint of the fishing activity, including the carbon output of the fishing vessels and from the use of the harvested krill, should be included. In addition, alternate carbon pathways such as mesopelagic zooplankton and fish should be taken into account in the function of carbon sinks.

2.20 The Workshop noted a glossary of terms is needed for both carbon cycling/sequestration and ocean acidification and that CCAMLR should consider adopting the language used by the IPCC as a good starting basis. The Workshop further noted that ESMs as described in the keynote presentation by Dr Hollowed could be a useful way to evaluate interactions of the global carbon cycle and interaction with humans.

2.21 The Workshop also noted that an increase in productivity did not necessarily lead to an increase in carbon sequestration when a critical tipping point is passed, and that existing work has started to quantify the negative impacts of fishing on the ocean carbon sink, such as two recent workshops (ICES WKFISHCARBON, Ocean Carbon & Biogeochemistry: Fish Fisheries and Carbon) and the paper by Cavan and Hill (2022).

2.22 The authors of WS-CC-2023/09 stressed that the paper was focused on the carbon sink function of a fishery only. They further noted that when other aspects of a fishery are involved, it should be considered in a 'global' context, including the positive and relative effects (Hilborn et al., 2023) of a rational fishery to and the food provision service of the ecosystem.

2.23 Paper WS-CC-2023/21 proposed approaches to incorporating climate change research into CCAMLR fisheries management. The authors reviewed potential pathways of climate change impacts on stocks, habitats, and fishery management, and summarised the different mechanisms available in current CCAMLR stock assessment approaches to capture impacts of climate change on toothfish, icefish, and krill stocks. The authors recalled that other regional management bodies have developed organisational structures such as expert groups or workplans to advise specifically on management responses to the impacts of climate change. Resilient management solutions will likely include multiple stakeholders and need to be robust to data-limited stock assessments. The authors put forward key questions and recommendations for CCAMLR's climate change workshop to consider.

2.24 The Workshop noted that the paper raised useful issues and actions for consideration by Scientific Committee (Table 1) for integrating climate change into the CCAMLR fisheries management processes, including:

(i) Work with adjacent RFMOs and RMBs to identify potential for range shifts due to climate change of exploited species/species of interest, and produce a list of species/stocks straddling or likely to straddle CAMLR Convention Area, as well as identifying data sharing needs;

(ii) Work with relevant RFMOs/RMBs to exchange knowledge of ecosystem impacts of climate change, and lessons learned in incorporating climate change into their activities;

(iii) Identify any non-target species within the CAMLR Convention Area likely to increase in commercial importance;

(iv) Review data collection programmes related to the fisheries to ensure they are adequate to detect significant changes in species life history parameters and distribution that affect management;

(v) Develop methods to incorporate the effects of projected climate change on assumed recruitment patterns or uncertainty for toothfish recruitment into assessment projections;

(vi) Develop a workflow to incorporate information on the effects of climate change in management advice and alternative management approaches, including long-term change in spatial distributions and inclusion of climate change projections.

2.25 The Workshop also noted that data collection plans are likely needed for each fishery, and that these plans should be developed if lacking. Data should be collected at an appropriate frequency to capture information needed to investigate climate change.

2.26 The Workshop recommended that the Scientific Committee consider how often stock assessment parameters should be updated and noted that reference points may be non-stationary under the effects of climate change (Szuwalski et al., 2023).

2.27 The Workshop noted the importance of management strategy evaluations (MSEs) for considering how climate change scenarios might affect target species, which are already in the WG-SAM and WG-FSA workplans (SC-CAMLR-42, Tables 6 and 8) for evaluating the performance of harvest control rules and their application under climate change scenarios.

2.28 The Workshop noted that the inclusion of environmental covariates within stock assessment models may provide a way to improve the modelling of future recruitment, but that it was important to select covariates based on a mechanistic understanding, and with robust testing to avoid including relationships that have poor predictive power for future recruitment.

2.29 Paper WS-CC-2023/P03 summarised potential tools to manage fisheries for climate resilience for CCAMLR, noting progress, gaps, and opportunities for implementation. The tools included ecosystem-based management (EBM), use of climate model outputs (projections and simulations), MPAs, and environmentally informed dynamic stock assessments. The paper urged CCAMLR to continue to use and further develop these tools to safeguard the Southern Ocean under changing climate.

2.30 Some participants noted that MPAs can be a useful tool in increasing resilience to climate change.

Specific climate change considerations for spatial management

2.31 Paper WS-CC-2023/03 presented an exploratory analysis of changes in sea surface temperature and sea ice within the proposed Domain 1 Marine Protected Area for climate change under future emissions scenarios. The authors used ensembles of climate variables from the IPCC-WGI AR6 data for observed current periods (1986 to 2005), and projected medium term (2041 to 2060) and long term (2081 to 2100) forecasts. The goal of this analysis was to contribute to the identification of potential refuge areas where the effects of climate change would be minimal or delayed.

2.32 The Workshop noted that there is an increasing discussion in the scientific literature of the role of climate refugia and encouraged contributions to CCAMLR on this subject, and that the discussion within CCAMLR would benefit from clear definitions of the concepts involved. It further noted that refugia designed for a single species may provide limited protection for other species or life stages, and that this complexity may be important for MPA design.

2.33 Paper WS-CC-2023/10 presented a pilot study on crabeater seals in Terre Adélie to predict the future of krill populations and their predators by assessing krill-predator relationships and identifying key feeding areas. The authors plan to conduct a long-term investigation of these predators in both Terre Adélie and Eastern Antarctica. Results of the study will also provide information on the distribution and density of krill in this area, and will therefore provide a better understanding of the influence of sea ice and its role in the ecosystem in the absence of fishing, contributing to a better understanding of polar ecosystems under the influence of climate change.

2.34 The Workshop welcomed the study and noted that it supported the conclusions reached by WG-EMM-2023 regarding the revision of CEMP data collection to inform ecosystem status. The Workshop noted that it may be useful to include crabeater seals in the CEMP programme and encouraged the authors to contribute to the current review of CEMP.

Information, including monitoring and metrics, needed to support management decisions, and mechanisms to develop and integrate these

Climate change information needed to support management decisions

3.1 Each hub received a recorded presentation given by Dr D. Welsford (Chair of the Scientific Committee), providing an overview of CCAMLR's management and decision-making approaches and the mechanisms for incorporating the effects of climate change.

3.2 The Workshop noted the importance of setting achievable goals and providing targeted advice in developing recommendations and plans for further work on climate change information to support management decisions. It suggested that specific elements could be considered for inclusion in the existing strategic workplan of the Scientific Committee (SC-CAMLR-41, Annex 4). The Workshop recalled that the Scientific Committee had recently agreed new work plans for the Working Groups and noted that these should be updated to include additional work in respect of climate change identified during this workshop SC-CAMLR-41, Tables 6 to 10).

3.3 WS-CC-2023/06 summarised recent (2015 to present) climate change discussions within CCAMLR's Scientific Committee, including some of the issues raised, approaches suggested and outcomes, to provide background information for the Workshop.

3.4 The Workshop welcomed the paper, noting that climate change is now included in the terms of reference of all Working Groups (SC-CAMLR-41, Annex 11). It noted that the revised management approach for the krill fishery currently developed by the Scientific Committee could be a useful example in the development of proactive management approaches to address climate change. It also noted that papers from the 2016 Joint SC-CAMLR/CEP Workshop could be a useful source of information for developing further directions.

3.5 WS-CC-2023/07 Rev. 1. provided an overview of recommendations made by ASOC in recent years on climate change issues, with a focus on providing examples of potential spatial management actions, and the data information needs and data flow required to implement climate change action.

3.6 The Workshop thanked the authors for the paper, noting that it had reflected the importance of progressing climate change discussions in CCAMLR as a matter of urgency.

3.7 WS-CC-2023/17 presents the use of ESMs (see also paragraph 2.3) as global climate simulation models. A study in the Ross Sea region examined the physical and biogeochemical performance of 16 CMIP-5 and 16 CMIP-6 (Coupled Model Intercomparison Project) ESMs relative to present day (1976–2005) observational data sets. Ranking the models from 'best' to 'worst' performing provided a measure of confidence about future Ross Sea region predictions of environmental conditions. Predictions for mid and end of the 21st century were produced for sea ice, temperature, salinity, nutrients and other parameters.

3.8 The Workshop welcomed these efforts to evaluate ESMs for the Convention Area. It noted that climate models and emission scenarios can be a major source of uncertainty when projecting future species distributions, so it is important to use a robust ensemble of climate models from which to base ecological projections.

3.9 The Workshop noted that it would be useful to determine levels of spatial comparison between models, and to identify which suites of ESMs or regional models would be most relevant. Support from climate model experts is important in evaluating the performance of models for the Convention Area, and in developing advice on selecting and using them appropriately. The Workshop suggested that SCAR could contribute to the further development of guidance on the use of climate models e.g., CMIP models for the Convention Area.

3.10 The Workshop identified a need for clear terminology (particularly around the use of terms such as 'business as usual' or 'worst-case'), and the selection of plausible emission scenarios (paragraph 3.22). Transparency about uncertainty and likelihood of projected future climates and ecological outcomes is vital for decision makers to understand the level of confidence they should infer. Further information on definitions and means of communicating climate change information could be useful for the Scientific Committee.

3.11 The Workshop noted that while spatial and temporal resolution of models has improved greatly in recent years, there is still a high level of uncertainty in the representation of sea ice in model projections, although ongoing and increasing research in this area was noted.

3.12 WS-CC-2023/19 described how earth observation satellites and models can provide information on environmental variability and change in the Southern Ocean. ‘Essential Climate Variables’ (ECVs) are physical, chemical and/or biological properties (or a group of linked variables) that critically contribute to the characterisation of the state of a natural system. The authors proposed defining sets of ECVs for Antarctic systems targeted to CCAMLR purposes; and identifying regions of the Southern Ocean where multiple environmental characteristics are changing in the same way (‘bioregions of change’).

3.13 The Workshop agreed that the development of a dashboard of ECVs would be an intuitive and rapid way of keeping all Working Groups up to date with the state of the environment in the CAMLR Convention Area, and that this could be conducted at a regional scale to capture spatial differences. Other metrics could be included such as, inter alia, Essential Ocean Variables (EOVs), ecosystem Essential Ocean Variables (eEOVs) and Essential Biodiversity Variables (EBVs).

3.14 The Workshop noted that existing work is being undertaken by the SCAR Antarctic Biodiversity Portal (biodiversity.aq) in collaboration with SOOS, AAD and others, on essential variables in the framework of the ADVANCE (Antarctic bioDiVersity dAta iNfrastrucCturE) project. This includes working on improved coordination and interoperability of a range of diverse tools and facilities that operate globally and create research and policy relevant data products from Antarctic biodiversity data, which will be made available in SOOSmap. The first component of the ADVANCE project was an Essential Variables Workshop held in August 2023. This workshop aimed to create an inventory of Essential Variables (EVs) relevant for the Southern Ocean based on

existing efforts by GEO-BON and MBON, the data requirements, data gaps and workflows for calculating such EVs and develop a framework for developing the workflows required to turn public Southern Ocean biodiversity data into relevant EVs.

3.15 The Workshop recommended that the Scientific Committee identify specific climate variables and metrics for which data are already, or could be, collected, that would be useful in communicating the status of AMLR through time. These should be prioritised in terms of their relevance to CCAMLR and may be specific to individual regions as environmental drivers and marine ecology may vary spatially.

3.16 The Workshop noted that regular reporting on the status of essential climate, ecosystem and ocean variables could be useful in providing the Scientific Committee and its Working Groups with standardised information on change and variability. The Workshop also recalled discussions at WG-EMM-23 on developing an annual report on the state of AMLR in the Convention Area and noted that climate change impacts on AMLR could be considered as part of the CEMP.

3.17 The Workshop noted that it would be useful to provide information on relevant and prioritised essential variables to the CEP and ATCM, and to national Antarctic programmes.

3.18 The Workshop recommended that the Scientific Committee consider forwarding the report from this Workshop to the CEP in order to assist with planning for the proposed joint CEP/SC-CAMLR workshop.

3.19 The Workshop noted that species distribution models (SDMs) or ecosystem models (e.g., Atlantis, Ecosim, Ecopath) linked to climate models are key tools to understand ecological change (see paragraph 2.2). The Workshop noted that it is important to incorporate and communicate uncertainties associated with these models such that confidence levels can be assessed and integrated into management decisions. Mechanistic or process-based models can also provide complementary (and in some cases, opposing) projections as they account for species life histories, behaviours, and optimal physiologies in ways that typical SDMs cannot.

3.20 The Workshop recognised the importance of ground-truthing and model validation, noting that this can be time consuming and expensive, and that coordination and communication of such work would therefore be helpful. The Workshop also highlighted the need to consider which indicators and models will be most useful to CCAMLR, noting that models describing spatial distribution and life history of species are particularly relevant for management.

3.21 The Workshop noted the need for clarity in the use of terms to describe the intended aim of 'resilience'. As an intrinsic trait of a population or ecosystem, it may not be possible for resilience to be enhanced or increased by regulating other activities. However, resilience may be maintained, or rebuilt where it has been previously lost for example as a result of overfishing.

3.22 The Workshop recommended the Scientific Committee consider ways to develop a glossary of climate related terms, definitions, best practices, and standards to aid in the selection and communication of essential variables, climate models and emission scenarios.

3.23 The Workshop noted that fishing vessels and tourist vessels could potentially be used as platforms for the collection of relevant environmental or climate data, as some vessels are doing this already for some variables. The development of instructions for standardised environmental data collection or instrument calibration would be useful in this regard. The Workshop noted that dialogue with COLTO, ARK and IAATO would be useful in coordinating requests for specific types of data or the deployment of instruments. COLTO confirmed that they would be happy to collaborate with relevant scientific communities to progress this.

Mechanisms to improve input, and use of, relevant scientific information and advice on climate change throughout CCAMLR's work program

3.24 WS-CC-2023/16 used the examples of recent rapid reductions in sea ice extent and increased occurrence of extreme climate events such as marine heat waves and cyclones to highlight key climate change risks. While noting limitations on model predictions, the authors recommended that CCAMLR notes the value of developing a risk assessment of the potential ecological impacts of changes to critical environmental and ecological parameters due to extreme climate events.

3.25 The Workshop recommended that the Scientific Committee consider the development of a risk assessment for management responses to extreme events. It would be useful to seek further information on whether such assessments are already being undertaken, recognising the considerable resources required for such work. The Workshop noted that there is value in running multiple scenarios, including examining ‘large ensemble’ datasets (for which climate models are run up to 50-100 times) to examine the probability and frequency of extreme events, and that it is useful to understand shorter temporal variability as well as longer term projections.

3.26 The Workshop noted that the Scientific Committee and its working groups could consider using seasonal climate forecasts on a year-to-year basis to understand the ecological implications of extreme climate conditions occurring in a particular year, and how proactive measures could be taken in advance of extreme events. The workshop noted that this approach is used in other fisheries worldwide, including in the Arctic.

3.27 WS-CC-2023/18 presented a summary of research aiming to understand how sea-ice drift, ocean circulation, and prey resources may affect recruitment of Antarctic toothfish in the Ross Sea region. Improving knowledge of the factors affecting recruitment, and especially climate-related factors, will help anticipate future changes to stock productivity and potential future catch levels. The paper examines potential changes in the physical transport pathways by which eggs and larvae are advected; and the biological resources (prey) available for larvae and early-stage juveniles.

3.28 The Workshop noted that understanding early life history is an important component of fish stock management, that sea ice plays an important role in Antarctic toothfish recruitment, and that early life stages are likely to be most vulnerable to the effects of climate change. Understanding how the system may change, and how extreme events link to recruitment failure will be important. It would also be useful to compare development and maturity among different regions and stocks to understand how stocks already respond and adapt to different environments.

3.29 The Workshop recommended that the Scientific Committee considers how information on projected short-term (interannual, multi-year) and long-term (decadal) changes to the recruitment of toothfish should be taken into account in the context of CCAMLR’s principles of conservation and decision rules.

3.30 WS-CC-2023/20 described a method to identify changes to key toothfish stock assessment parameters associated with environmental variability, including climate change. Stock assessment parameters or population processes that could be influenced by climate change were presented in a table that outlined the feasibility to monitor these impacts to the population and assess the severity of climate change impacts on monitored populations. The authors recommended that CCAMLR develops and implements methods for monitoring and evaluation of the effects of climate change on stocks.

3.31 The Workshop noted that the table in WS-CC-2023/20 provides a good framework for monitoring approaches relevant to both harvested and non-harvested species. While the paper is focused on toothfish, similar tables could be developed for other species such as krill and icefish, with relevant parameters. Such information would be applicable to current work on krill fishery management including development of a krill stock hypothesis and parameterisation of the Grym.

3.32 The Workshop noted that methods could be further developed to use existing data to investigate trends in key productivity parameters for all stocks with adequate data. New sample collection, approaches and analyses (e.g., new genomic, bio-informatic and microchemistry methods) should also be considered.

3.33 The Workshop encouraged the development of models to test for long-term change in the spatial distribution of Southern Ocean fish that may be linked to environmental drivers, for example by using spatiotemporal analyses, and incorporating genomic methods. These models could then be coupled with future projections of the environmental state, e.g., from ESMs, to anticipate change in species distributions.

3.34 The Workshop noted that an assessment of feasibility could help to narrow the parameters to a subset for further discussion, and high priority parameters could be included in data collection plans for specific fisheries. It would also be useful to consider the source and relevance of current estimates for productivity parameters used in assessments, as these may not be recent.

3.35 The Workshop recommended that SC develop a template report for monitoring the potential effects of environmental variability and climate change on stock assessments and key stock productivity parameters, for inclusion in the annual CCAMLR Fishery Reports (WS-CC-2023/20, Table 1).

3.36 The Workshop further noted that where trends in key productivity parameters are identified, the effect on yield and management advice of these trends should be considered as part of scenarios to be included in model projections and MSEs in conjunction with decision rules.

3.37 Considering the potential for extensive information needs on fish stock productivity and other relevant parameters, the Workshop welcomed the suggestion that interested individuals create a proposal for a new SCAR Action Group focused on the effects of climate variability and change on fish populations in the Convention Area. This could add capacity and expertise in compiling and coordinating relevant research, including on e.g., finfish life history and population parameters most likely to be correlated with climate variability. The Workshop suggested that such a group might initially prioritize target species (toothfish and icefish), followed by bycatch species, silverfish, mesopelagic fish, and then other species. The Workshop also noted that the SCAR Krill Expert Group is a useful example of successful collaboration between SCAR and CCAMLR on the development of research objectives and priorities.

3.38 The Workshop noted the relevance of 'Antarctica In Sync' (one of a number of activities coordinated through the UN Decade Collaboration Centre for the Southern Ocean, paragraph 2.6) in obtaining relevant climate information, particularly through synchronous observations. It encouraged the Scientific Committee to engage with the 'Antarctica In Sync' programme and other relevant Decade actions to provide input on climate, ocean and ecosystem variables relevant to CCAMLR objectives, and to investigate the potential involvement of fishing vessels.

3.39 The Workshop recommended that the Scientific Committee include further detail on tasks relevant to climate change in its work plan, with the objective of identifying and progressing the work necessary to ensure that CCAMLR can continue to meet its objectives as stated in Article II of the CAMLR Convention in a changing climate. This work is likely to include research and modelling as well as testing and possible refinement of management approaches. In developing this work plan, the SC should consider the elements summarised in Tables 1 and 2.

3.40 The Workshop further recommended that the Scientific Committee identify ways to address the following immediate priorities:

(i) Update the fishery reports to include more information on the potential effects of climate change on harvested species and stocks, and management response to these effects (3.35);

(ii) Develop a web page to explain CCAMLR's response to climate change to the public.

Report adoption

4.1 The report of the Workshop was adopted requiring 4 h and 45 minutes of discussion.

Close of the Meeting

5.1 At the close of the meeting, the Co-conveners thanked the participants for their contributions to a successful workshop. They noted the complex nature of the hub-based hybrid format and the short timescales required of the rapporteurs, as well as for the note takers for the hub sessions to allow for reporting back to Plenary. They noted that despite the challenges, the workshop demonstrated the constructive and collaborative attitudes of the participants to progress this important topic.

5.2 Dr M. Collins (UK) noted the unique format of the meetings and that although challenging for the conveners it was a useful test of the format and thanked the Co-conveners and the Secretariat for their efforts.

5.3 Mr N. Walker (NZ) also thanked the Co-conveners, the Secretariat and the participants for their work, noting the meeting was more complex than normal but that there was good attendance and participation.

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Table 1: Summary of tasks recommended by the Workshop for the Scientific Committee to consider while progressing its work on monitoring and formulating management responses to the effects of climate change, to ensure that CCAMLR can continue to meet its objective in Article II of the Convention in a changing climate. Timescale indicates the time needed to complete the task, with “Short” indicating within the next 1-2 years, “Medium” indicating 3-5 years, “Long” indicating 5+ years, and “C” indicating continuous. TBD indicates no discussion due to the lack of time available during the meeting.

No.	Task	Suggested WG / fora	Timescale	Priority (H/M/L)	Paragraph
1	Work with adjacent RFMOs and RMBs to identify potential for range shifts due to climate change of exploited species/species of interest, and produce a list of species/stocks straddling or likely to straddle CAMLR Convention Area, as well as identifying data sharing needs.	Secretariat WG-FSA	Short	H	2.24
2	Work with relevant RFMOs/RMBs to exchange knowledge of ecosystem impacts of climate change, and lessons learned in incorporating climate change into their activities.	Secretariat	Short (C)	M	2.24
3	Provide public-facing information explaining how climate change variability is included in stock assessments and management of exploited stocks, through a dedicated CCAMLR webpage, and inclusion of information in Fishery Reports.	Secretariat	Short	H	3.40
4	Identify any non-target species within the CAMLR Convention Area likely to increase in commercial importance.	WG-EMM	Short	H	2.24
5	Review data collection programmes related to the fisheries to ensure they are adequate to detect significant changes in species life history parameters and distribution that affect management.	WG-FSA (SISO) WG-EMM WG-ASAM	Short	H	2.24 See 3.32
6	Develop methods to incorporate the effects of projected climate change on assumed recruitment patterns or uncertainty for toothfish recruitment into assessment projections.	WG-EMM WG-SAM WG-FSA	Medium	M	2.16 2.24 See 3.29
7	Develop appropriate parameters for all exploited species (e.g., WS-CC-2023/20 Table 1) to monitor the effects of climate variability/change on parameters and processes relevant to stock assessments.	WG-FSA WG-SAM	Medium	H	3.35 See 3.30
8	Develop a workflow to incorporate information on the effects of climate change in management advice and alternative management approaches, including long-term change in spatial distributions and inclusion of climate change projections.	WG-SAM WG-FSA	Medium	M	2.24
9	Use a risk assessment framework to obtain an initial prioritisation of the likely impacts of climate change on harvested species with focus on regional scale.	WG-EMM WG-FSA	Short	H	2.11 See 2.10
10	Use a risk assessment framework to obtain an initial evaluation of the likely effects of climate change on dependent and bycatch species.	WG-EMM WG-FSA	Medium	M	2.11

(continued)

Table 1 (continued)

11	The Workshop encouraged Members to supply relevant data to SOOS noting that SOOSmap is a data discovery tool, comprising circumpolar standardised, curated data. The Workshop recommended that the Scientific Committee tasks the Secretariat with liaising with SOOS to develop information for use by CCAMLR.	TBD	TBD	TBD	1.15
12	The Workshop recommended that the Scientific Committee request advice from SCAR to help develop a framework for using climate models to drive ecological projections for AMLR and dependent and related species.	TBD	TBD	TBD	1.48
13	The Workshop recommended that the Scientific Committee develop a catalogue of the different types of extreme events, their time scales and the species and life stages that they are likely to affect (building for example on information in WS-CC-2023/12) which would be a useful aid to communicating data needs to climate modellers.	TBD	TBD	TBD	1.52
14	The Workshop recommended that the Scientific Committee consider the development of a risk assessment for management responses to extreme events.	SC	Medium	M	3.25
15	The Workshop recommended that Scientific Committee collate a list of important variables to be monitored following an extreme event to facilitate a coordinated and timely response to such events and their physical/biological effects both on marine components and land based predators.	TBD	TBD	TBD	1.28
16	The Workshop recommended that the Scientific Committee consider forwarding the report from this Workshop to the CEP in order to assist with planning for the proposed joint CEP/SC-CAMLR workshop.	TBD	TBD	TBD	3.18
17	The Workshop recommended that the Scientific Committee include further detail on tasks relevant to climate change in its work plan, with the objective of identifying and progressing the work necessary to ensure that CCAMLR can continue to meet its objectives as stated in Article II of the CAMLR Convention in a changing climate. This work is likely to include research and modelling as well as testing and possible refinement of management approaches.	TBD	TBD	TBD	3.39
18	The Workshop further recommended that the Scientific Committee identify ways to address the following immediate priorities: i) Update the fishery reports to include more information on the potential effects of climate change on harvested species and stocks, and management response to these effects; ii) Develop a web page to explain CCAMLR’s response to climate change to the public.	TBD	TBD	TBD	3.40
19	Identify specific information requirements and develop requests for information from other organisations, such as SCAR or SOOS.	SC WG-EMM	Short	M	1.32

(continued)

Table 1 (continued)

20	The Workshop welcomed the paper and recognised the importance of collaboration between IWC and CCAMLR, noting that Dr N Kelly (AUS) is the SC-IWC observer to SC-CAMLR and vice versa, and recommended that the collaboration continues, especially noting the importance of considering marine mammals in the current enhancement of the CCAMLR Ecosystem Monitoring Program (CEMP).	TBD	TBD	TBD	1.39
21	The Workshop recommended that the Scientific Committee consider how often stock assessment parameters should be updated and noted that reference points may be non-stationary under the effects of climate change.	TBD	TBD	TBD	2.26
22	Consider how information on projected short-term (interannual, multi-year) and long-term (decadal) changes to the recruitment of toothfish should be taken into account in the context of CCAMLR's principles of conservation and decision rules.	SC WG-SAM WG-FSA	Medium	H	3.29
23	Develop a template for reporting on monitoring of the potential effects of environmental variability and climate change for stock assessments (potentially based on the parameters described in WS-CC-2023/20), for inclusion in the annual CCAMLR Fishery Reports.	SC WG-FSA	Short	H	3.35
24	Identify specific climate variables and metrics for which data are already, or could be, collected, that would be useful in communicating the status of AMLR through time.	WG-EMM WG-SAM WG-FSA	Medium	H	3.15
25	Develop a glossary of climate related terms and definitions, as well as best practices and standards to aid in the selection and communication of essential variables, climate models and emission scenarios.	SC	Medium	L	3.22

Table 2: Additional work highlighted by the Workshop for consideration within the Scientific Committee's workplan. Timescale indicates the time needed to complete the task, with "Short" indicating within the next 1-2 years, "Medium" indicating 3-5 years, "Long" indicating 5+ years, and "C" indicating continuous. TBD indicates no discussion due to the lack of time available during the meeting.

No.	Task	WG / fora	Timescale	Priority (H/M/L)	Paragraph
1	Understand causes of extreme weather and climate events, and how particular characteristics of extreme events (intensity, duration etc.) translate into positive or negative impacts on biological processes, including tipping points and cascading effects. Use this understanding to develop monitoring programmes suitable for detecting and monitoring the ecological impact of extreme events.	WG-EMM	Long	M	1.54 See 1.28, 1.52, 3.25
2	Develop mechanisms, potentially analogous to CM 24-04, to respond to the effects of high impact and/extreme events.	SC	Long	M	1.26
3	Develop a gap analysis to identify CCAMLR environmental monitoring needs and the potential to source these data or derived metrics from relevant organisations.	WG-SAM WG-EMM	Short	H	1.13
4	Consider approaches used in Arctic fisheries which could be applicable to Antarctic fisheries.	SC WG-FSA	Short	M	2.2
5	Continue IWC-CCAMLR information sharing to help inform krill management, for example on food webs and krill consumption rates, whale recovery, abundance and distribution.	SC WG-EMM	Long (C)	M	1.40
6	Understand the physiological effects of climate change on marine species including bycatch in the Convention Area (e.g., skates).	WG-EMM	Long	L	1.36
7	Establish coordination between ANTOS and CEMP for long-term monitoring programmes (e.g., in the establishment of sentinel monitoring sites).	WG-EMM	Long	M	1.42
8	Monitor benthic communities in tandem with key environmental parameters, in order to understand natural variability and detect and attribute climate change and/or fishing impacts.	WG-EMM WG-FSA	Medium (C)	L	1.43
9	Obtain and disseminate expert advice (with SCAR support) on best practices for selecting, using and communicating earth system models, regional climate models and emission scenarios when undertaking ecological projections.	WG-EMM	Short	H	3.8, 3.9 and 3.10
10	Investigate impact of uncertainty in trophic effects and climate change on early life stages on uncertainty in CCAMLR Decision Rules.	WG-SAM	Medium	L	1.11
11	Integrate the likely effects of climate change into the Krill Stock Hypothesis.	WG-EMM	Long	M	1.29
12	Evaluate, and consider output/results from genomic techniques to detect climate change adaptations, as well as finer stock boundaries for Patagonian or Antarctic toothfish.	WG-EMM	Long	L	1.27

(continued)

Table 2 (continued)

13	Identify and protect areas of essential habitat such as fish nest areas and skate egg case nurseries.	SC	Short (C)	H	1.36 and 1.37
14	Use CM 22-06 to examine climate change impacts on VMEs and use VMEs to monitor changes in ecosystems.	WG-EMM	Medium	L	1.43
15	Identify bioregions with faster/slower warming to consider for climate refugia, including the development of definitions associated with refugia.	WG-EMM	Medium	L	2.32
16	Develop approaches to better communicate uncertainties from complex climate and ecological models and their future projections to managers.	SC	Medium (C)	H	2.5, 3.10 and 3.19
17	Develop a dashboard of standardised "Essential Climate Variables" to monitor for trends or changes in key physical variables which can be linked to species distributions and population level processes. This could be conducted at a regional scale to capture spatial differences.	WG-EMM WG-SAM	Medium (C)	H	3.13
18	Engage with SCAR on the further development of guidance on use of climate models, e.g., CMIP models, for the Convention Area.	WG-EMM	Medium	M	3.9
19	Further develop methods to use existing data to test for trends in key productivity parameters for all stocks with adequate data. New sample collection, approaches and analyses (e.g., new genomic, bioinformatic and microchemistry methods) should also be considered.	WG-SAM WG-FSA	Medium	H	3.32
20	Develop models to test for long-term change in the spatial distribution of Southern Ocean fish that are linked to environmental drivers, for example by using spatiotemporal analyses, and based on genomic methods. These models could then be coupled with future projections of environmental state, *e.g.*, from ESMs, to anticipate change in species distributions.	WG-SAM	Long	L	3.33
21	The Workshop noted that it would be useful to provide information on relevant and prioritised essential variables to the CEP and ATCM, and to national Antarctic programmes.	SC	Short	M	3.17
22	Engage with the 'Antarctica In Sync' programme to provide input on climate, ocean and ecosystem variables relevant to CCAMLR objectives, and to investigate the potential involvement of fishing vessels.	SC	Short	M	3.38
23	The Workshop noted that the Scientific Committee and its working groups could consider using seasonal climate forecasts on a year-to-year basis to understand the ecological implications of extreme climate conditions occurring in a particular year, and how proactive measures could be taken in advance of extreme events. The workshop noted that this approach is used in other fisheries worldwide, including in the Arctic.	TBD	TBD	TBD	3.26

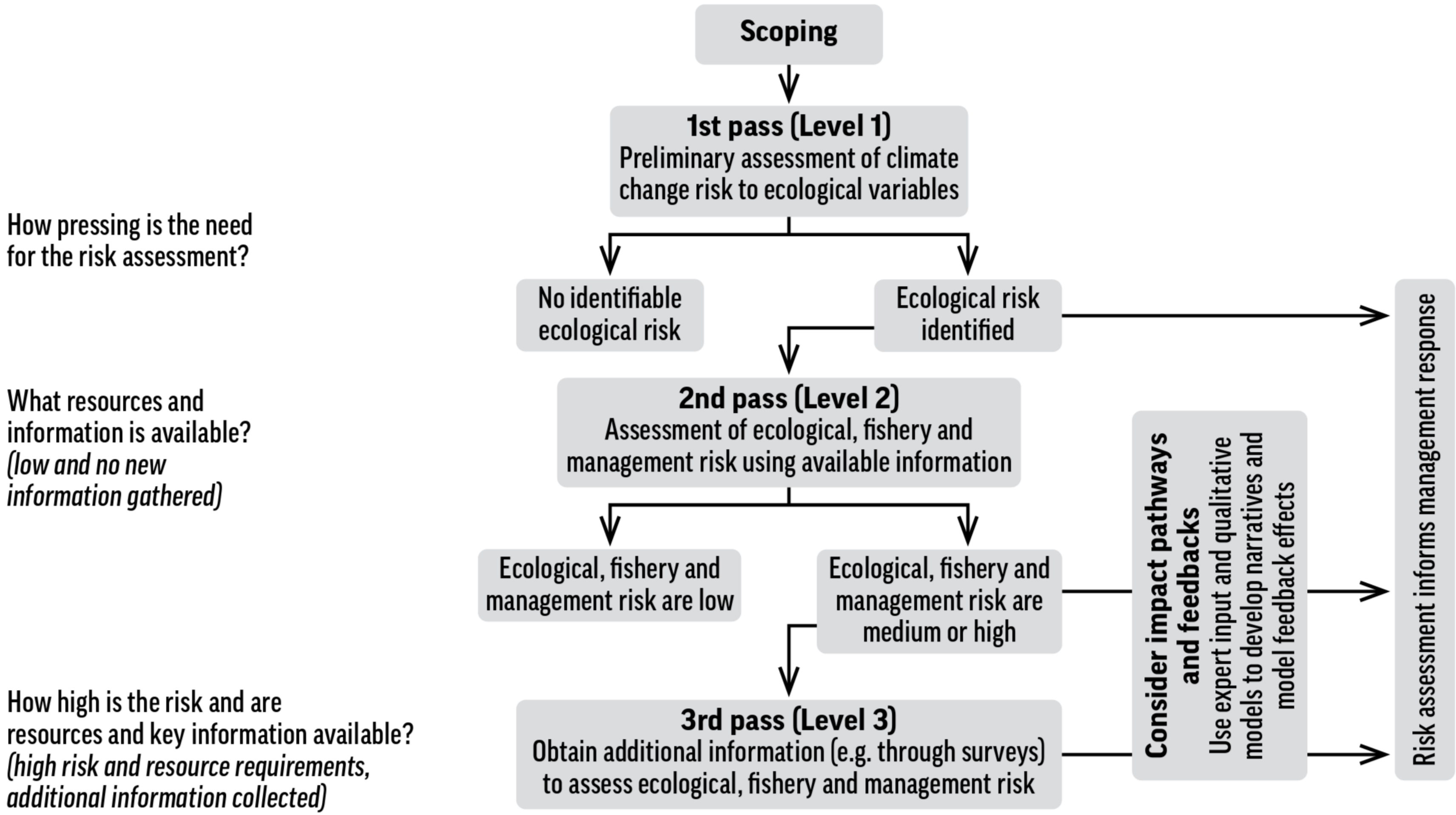

Figure 1: Diagram describing three levels of fishery and ecosystem risk assessment (from WS-CC-2023/02)

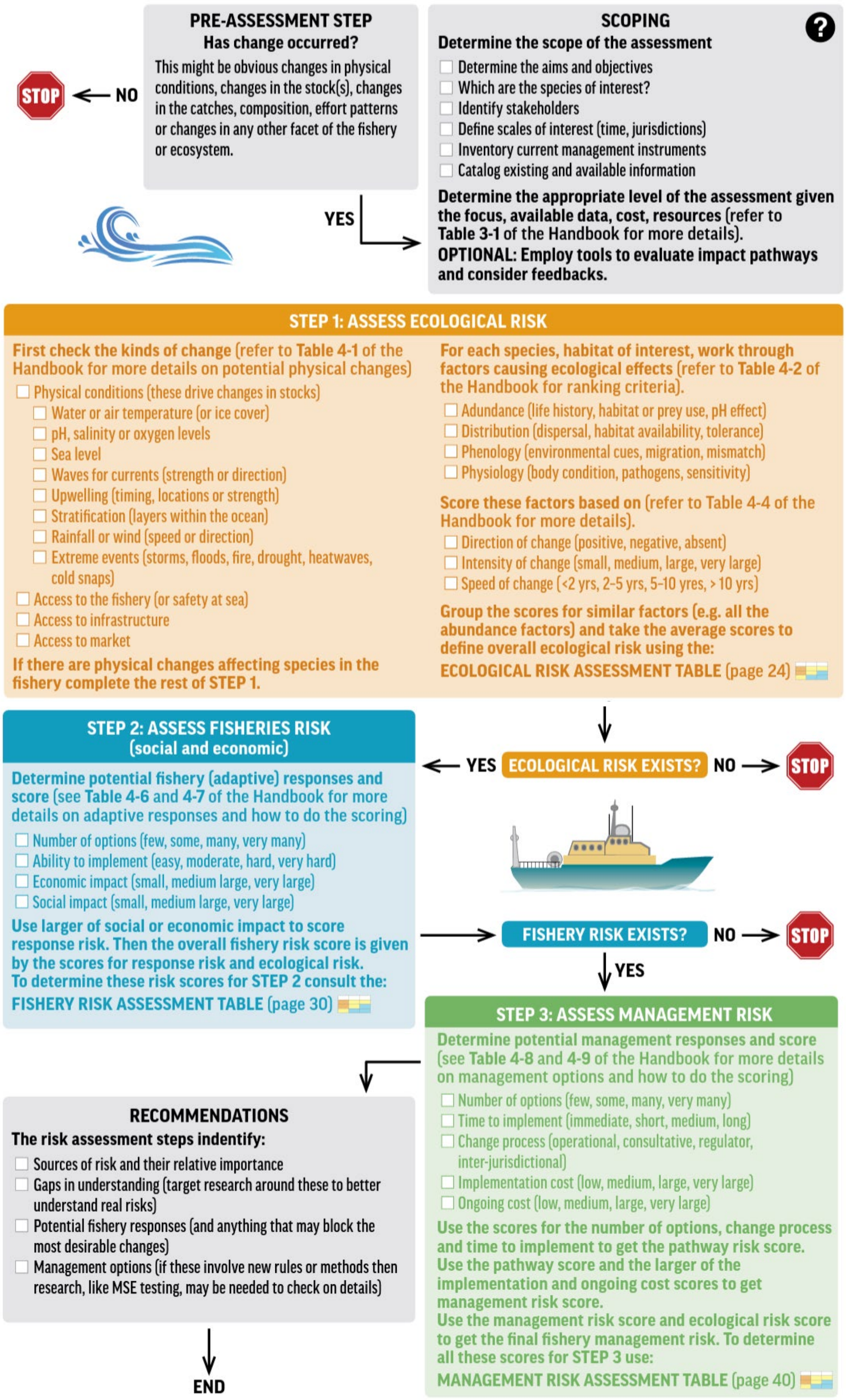

Figure 2: Diagram explaining the key steps to assess ecological, social and economic, and management risks to fisheries associated with climate change (from WS-CC-2023/02).

STEP 1: ASSESS ECOLOGICAL RISK ▶ (see Table 4-4, page 24)

Group the scores for similar factors (e.g. all the abundance factors) and take the average scores to define overall ecological risk using this table. Cross reference the direction of change, intensity of change and the speed of change to find the final level of ecological risk.

Table A: Ecological risk

	Negative Direction of Change				Positive	Absent
	Intensity of Change					
Speed of Change	Very large	Large	Medium	Small		
Next 2 years	High	High	High	Low	Low	None
Next 2-5 years	High	High	Medium	Low	Low	None
Next 5-10 years	High	High	Medium	Low	Low	None
More than 10 years	High	High	Medium	Low	Low	None

STEP 2: ASSESS FISHERIES RISK (social and economic) ▶ (see Table 4-7, page 31)

Tally up the potential options available to the fishery and rate these responses in terms of how easy they will be to implement and any economic and social impacts. Then use larger of social or economic impact to score response risk – cross reference the impact score (which ever is the larger of the social and economic impacts), ease of implementation and the number of options available and this will give you the response risk.

Table B: Response risk

Options available		Economic or social impact (whichever is LARGER)			
	Implementation	Very large	Large	Medium	Small
Few	Hard / very hard	High	High	High	Medium
	Moderate	High	High	Medium	Low
	Easy	Medium	Medium	Medium	Low
Some	Hard / very hard	High	High	Medium	Low
	Moderate	High	High	Medium	Low
	Easy	Medium	Medium	Low	Low
Many or very many	Hard / very hard	High	High	Medium	Low
	Moderate	Medium	Medium	Low	Low
	Easy	Medium	Medium	Low	Low

Then determine the overall fishery risk score by cross referencing the scores for response risk and ecological risk.

> Ecological risk from Table A
> Response risk from Table B

Table C: Fishery risk

	Response risk		
Ecological risk	High	Medium	Low
High	High	High	Medium
Medium	High	Medium	Low
Low	Medium	Low	Low
Absent	None	None	None

STEP 3: ASSESS MANAGEMENT RISK ▶ (see Table 4-9, pages 41 and 42)

Determine the list of potential management responses and score them based on time to implement, how difficult it will be to change the relevant management processes or policies, and any associated implementation or operational costs. Cross reference the scores for the number of tools available, change process and time to implement to get the pathway risk score.

Table D: Pathway risk

Tools available	Process and pathway	Time to implementation			
		Long	Medium	Short	Immediate
Few options	Inter-jurisdictional	High	High	High	High
	Regulator	High	High	High	Medium
	Consultative group	High	Medium	Medium	Medium
	Operational	High	Medium	Low	Low
Some options	Inter-jurisdictional	High	High	High	Medium
	Regulator	High	Medium	Medium	Medium
	Consultative group	High	Medium	Medium	Low
	Operational	High	Medium	Low	Low
Many options	Inter-jurisdictional	High	High	High	Medium
	Regulator	High	Medium	Medium	Low
	Consultative group	High	Medium	Low	Low
	Operational	High	Medium	Low	Low

Then cross reference the pathway score and the cost scores to get the base management risk score.

> Pathway risk from Table D

Table E: Base management risk

	Cost (implementation & ongoing, whichever is LARGER)			
Pathway risk	Very high	High	Medium	Low
High	High	High	Medium	Medium
Medium	High	High	Medium	Low
Low	Medium	Medium	Low	Low

Lastly, cross reference the base management risk score and ecological risk score to get the final fishery management risk.

> Ecological risk from Table A
> Base management risk from Table E

Table F: Fishery management risk

	Base management risk		
Ecological risk	High	Medium	Low
High	High	High	Medium
Medium	High	Medium	Low
Low	Medium	Low	Low
Absent	None	None	None

Figure 3: Diagram explaining the process to assess risk levels for ecological, fisheries and management risks (from WS-CC-2023/02).

Attachment I

Perspectives on the hub-based hybrid meeting format from participants

These comments are a synthesis of comments from participants and were not adopted.

The workshop was comprised of two hub meetings (NZ and UK) occurring during their local business hours for 3 hours each day (Monday-Wednesday). The UK hub included two additional sub-hubs, one in China and one in France. In addition, a daily joint plenary session was held at 1000 to 1200 UTC (Monday-Wednesday) for synthesis of the hub discussions. No meeting was held on Thursday to allow for report preparation. Report adoption was held on Friday in a plenary session at 1000 to 1300 UTC.

The Workshop was well attended with variable numbers of participants attending in different ways across the week (Table A1), noting many participants attended one hub and the plenary, some participants attended both hubs and some attended only report adoption, which had up to 106 participants of the total 129 participants registered.

Workshop participants recognised the importance of including meeting attendance as part of the consideration of climate change across all of CCAMLR's activities. Reflecting on the pros and cons of the hybrid format of this workshop in terms of carbon footprint, engagement of participants, and practical/logistical issues will be useful in planning for future events.

Participants noted several benefits of this arrangement and several shortcomings, compiled here for reference:

Benefits noted

(i) Increased number of participants, inclusivity of specialists for particular agenda items, training opportunities, and broader perspectives as the cost to attend was mostly staff time and the usual space limitations of in-person meetings were overcome by the online option.

(ii) Much lower travel commitment than fully in-person meetings with significantly reduced (a) carbon footprint (very important in the context of climate change), (b) travel costs, (c) conflict with other commitments (including family, caring responsibilities, other travel commitments and a meeting-heavy calendar for many (CCAMLR and otherwise)), (d) exclusion of those unable to travel for health reasons.

(iii) Hub structure allowed for more of the meeting time to occur during local business hours than a single time hybrid meeting.

(iv) The use of in-person hubs retained some of the personal interaction that would be lost with a fully online meeting.

(v) The use of two hubs at the extremes of the time difference with an additional plenary was effective at synthesizing and extending discussion.

Shortcomings noted

Participation

(i) Presentations of papers were generally given in one hub or the other limiting question and answer periods and in-depth understanding/discussion of the papers.

(ii) The flow of discussion was halted, participants were more reserved to engage, and therefore there was less widespread participation in discussions. Participation within hubs was likely better than for online individuals.

(iii) With this format, there is no possibility for break out subgroups to explore some of the more complex topics in greater depth.

Meeting scheduling

(i) The timing of the hubs and plenary was very inconvenient for some participants. An additional third hub, while allowing for more participants to have local time discussions, would compound this problem. The NZ hub timings spread meetings over 15 hours per day, reducing engagement in plenary.

(ii) The time available for summarizing hub discussions, developing and commenting on report text was too constrained.

(iii) Even with short discussion periods, more and longer comfort breaks were needed.

Technical issues

(i) The sound quality made some participants very difficult to understand. In some cases the audio didn't work at all and participants had to text their comments. Technical issues, especially with sound quality reduced effective communication.

(ii) It was often difficult to determine who was speaking at hubs with a wide-angle camera view, requiring reliance on individuals to manage their own cameras during interventions. Speakers often did not identify themselves or turn on their own laptop camera.

(iii) Both sound and video issues are made more complex when mixing completely online participants with other participant groups in a single room. High quality equipment and technical support is necessary to manage the audio and video environment. It is much simpler to either have all online or all in person audio and video arrangements.

(iv) Management of audio and video and presentations at each hub required a person to do this, which reduced their participation.

(v) Significant meeting activity occurred at all times of day, some problems inevitably occurred when no Secretariat support was available, which then temporarily halts progress.

(vi) Logistic support required essentially running three simultaneous meetings, with support work spanning 16 hours each day and therefore five Secretariat staff to be involved with significant overtime.

(vii) Report text development and timing was complex, with rapporteuring needing to occur quickly and all from one hub. Different times zones required careful sequencing of when report text could be commented on. Configuring report text development across time zones was complex with no equitable solution.

General comments

(i) Participants commented that it was important to try different approaches to meetings to reduce carbon footprint and facilitate more participation and that we learn from the experiences.

(ii) The peculiarities of the meeting format, and novel issues raised, created many *ad hoc* decisions and therefore confusion among participants. Despite extensive planning and communication (3 detailed SC circulars), and information posted on the website, the unique aspects created misunderstandings. Written guidance on how to prepare papers, presentations, recommendations, make interventions and participate in mixed-format meetings would be useful.

(iii) Future online meetings should be shorter (less than three days) to minimize issues. If hybrid meetings are considered, a shorter meeting each day with all present may be a better approach.

(iv) Secretariat presence or alternative local designated support team should be available in-person at each hub along with appropriate equipment to ensure convener and meeting support is available during the local operation times.

(v) A 2–3 minute pre-recorded presentation for each paper may have reduced the time taken for presentations, and given both hubs the same information.

(vi) Encourage additional sub-hubs (perhaps one per delegation) in future meetings recognising this does not increase inter-delegation interactions.

Table A1: Summary of the number of participants by hub location and mode of connection for each day of the workshop.

Date	**NZ Hub**		**UK Hub**		**Plenary**	
4-Sep-23	Online	47	Online	69	Online	55
	NZ Hub	10	UK Hub	13	NZ	10
			China Sub-hub	5	UK	13
			French Sub-hub	7	China Sub-hub	5
					French Sub-hub	7
	Subtotal	57		94		90
5-Sep-23	Online	46	Online	67	Online	58
	NZ Hub	8	UK Hub	15	NZ	8
			China Sub-hub	5	UK	15
			French Sub-hub	7	China Sub-hub	5
					French Sub-hub	7
	Subtotal	54		94		93
6-Sep-23	Online	46	Online	43	Online	57
	NZ Hub	6	UK Hub	14	NZ	6
			China Sub-hub	5	UK	14
			French Sub-hub	7	China Sub-hub	5
					French Sub-hub	7
	Subtotal	52		69		89
8-Sep-23					Online	82
					NZ	6
					UK	9
					China Sub-hub	5
					French Sub-hub	7
	Subtotal					109

Attachment II

List of Participants

Co-conveners	Dr Rachel Cavanagh British Antarctic Survey Mr Enrique Pardo Department of Conservation
Argentina	Dr Dolores Deregibus Instituto Antártico Argentino/CONICET Dr Emilce Florencia Rombolá Instituto Antártico Argentino Dr María Mercedes Santos Instituto Antártico Argentino
Australia	Dr Louise Emmerson Australian Antarctic Division, Department of Climate Change, Energy, the Environment and Water Ms Maya Gold Australian Antarctic Division, Department of Climate Change, Energy, the Environment and Water Dr So Kawaguchi Australian Antarctic Division, Department of Climate Change, Energy, the Environment and Water Dr Nat Kelly Australian Antarctic Division, Department of Climate Change, Energy, the Environment and Water Mr Dale Maschette Institute for Marine and Antarctic Studies (IMAS), University of Tasmania Dr Cara Masere Australian Antarctic Division, Department of Climate Change, Energy, the Environment and Water

	Dr Jess Melbourne-Thomas CSIRO
	Dr Philippe Ziegler Australian Antarctic Division, Department of Climate Change, Energy, the Environment and Water
Belgium	Dr Anton Van de Putte Royal Belgian Institute for Natural Sciences
Brazil	Dr Elisa Seyboth Universidade Federal do Rio Grande
Chile	Dr César Cárdenas Instituto Antártico Chileno (INACH)
	Dr Lucas Krüger Instituto Antártico Chileno (INACH)
	Mr Mauricio Mardones Instituto de Fomento Pesquero | Universidad de Magallanes
	Dr Luis Pertierra Instituto Milenio BASE
	Dr Lorena Rebolledo Instituto Antártico Chileno (INACH)
	Mr Francisco Santa Cruz Instituto Antartico Chileno (INACH)
China, People's Republic of	Dr Shunan Cao Polar Research Institute of China
	Mr Longwen Ge Chinese Arctic and Antarctic Administration
	Dr Honglei Li Chinese Arctic and Antarctic Administration
	Dr Xiu Xia Mu Yellow Sea Fisheries Reserch Institue, Chinese Academy of Fishery Sciences
	Dr Xinliang Wang Yellow Sea Fisheries Research Institute, Chinese Academy of Fishery Science

Dr Lei Xing
Polar Research Institute of China

Mr Lei Yang
Chinese Arctic and Antarctic Administration

Dr Yi-Ping Ying
Yellow Sea Fisheries Research Institute

Dr Guangtao Zhang
Institute of Oceanology, Chinese Academy of Sciences

Dr Xianyong Zhao
Yellow Sea Fisheries Research Institute, Chinese Academy of Fishery Science

Dr Yunxia Zhao
Yellow Sea Fisheries Research Institute

Professor Guoping Zhu
Shanghai Ocean University

European Union

Dr Sebastián Rodríguez Alfaro
European Union

France

Mrs Clara Azarian
Centre interministériel de gestion des ingénieurs des ponts, des eaux et des forêts (CEIGIPEF)

Dr Jilda Caccavo
Institut Pierre-Simon Laplace - Laboratoire des Sciences du Climat et de l'Environnement

Dr Cotte Cedric
MNHN

Ms Anaelle Durfort
Université de Montpellier

Dr Marc Eléaume
Muséum national d'Histoire naturelle

Ms Maude Jolly
Ministère de la Transition Ecologique

Dr Akiko Kato
CNRS

	Professor Philippe Koubbi Sorbonne Université
	Dr Sara Labrousse Sorbonne Université
	Dr Sylvain Lenoir TAAF
	Dr Yan Ropert-Coudert IPEV
Germany	Ms Patricia Brtnik Federal Agency for Nature Conservation
	Dr Stefan Hain Alfred Wegener Institute for Polar and Marine Research
	Mr Fritz Hertel Umweltbundesamt/ German Environment Agency
	Dr Manuela Krakau German Environment Agency
	Ms Rebecca Konijnenberg Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research
	Dr Katharina Teschke Alfred Wegener Institute for Polar and Marine Research
Italy	Dr Erica Carlig National Research Council of Italy (CNR), Institute for the study of the anthropic impacts and the sustainability of the marine environment (IAS)
	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)

	Dr Marino Vacchi National Research Council of Italy (CNR), Institute for the study of the anthropic impacts and the sustainability of the marine environment (IAS)
Japan	Dr Takehiro Okuda Fisheries Resources Institute, Japan Fisheries Research and Education Agency
Korea, Republic of	Dr Sangdeok Chung National Institute of Fisheries Science (NIFS)
Netherlands, Kingdom of the	Dr Fokje Schaafsma Wageningen Marine Research
New Zealand	Dr Clare Adams Ministry for Primary Industries
	Ms Clara Beauvoir Ministry for Primary Industries
	Dr Erik Behrens NIWA
	Professor Nancy Bertler Antarctica New Zealand
	Dr Vonda Cummings NIWA
	Dr Jennifer Devine National Institute of Water and Atmospheric Research Ltd. (NIWA)
	Mr Jack Fenaughty Silvifish Resources Ltd
	Mr Simon Lamping Department of Conservation
	Dr Matt Pinkerton NIWA
	Dr Graham Rickard NIWA
	Dr Kirsten Rodgers Department of Conservation

	Mr Nathan Walker Ministry for Primary Industries
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	Dr Bjørn Krafft Institute of Marine Research
	Dr Cecilie von Quillfeldt Norwegian Polar Institute
Russian Federation	Dr Svetlana Kasatkina AtlantNIRO
South Africa	Dr Azwianewi Makhado Department of Forestry, Fisheries and the Environment
	Mr Sobahle Somhlaba Department of Agriculture, Forestry and Fisheries
Sweden	Dr Thomas Dahlgren University of Gothenburg
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	Dr Otis Brunner British Antarctic Survey
	Dr Martin Collins British Antarctic Survey
	Dr Tracey Dornan British Antarctic Survey
	Dr Timothy Earl Centre for Environment, Fisheries and Aquaculture Science (Cefas)
	Dr Sophie Fielding British Antarctic Survey
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Dr Sally Thorpe
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United States of America	Dr Jefferson Hinke National Marine Fisheries Service, Southwest Fisheries Science Center
	Dr Anne Hollowed School of Aquatic and Fishery Sciences, University of Washington
	Dr Christopher Jones National Oceanographic and Atmospheric Administration (NOAA)
	Professor Deneb Karentz University of San Francisco
	Dr Polly A. Penhale National Science Foundation, Division of Polar Programs

	Dr Christian Reiss National Marine Fisheries Service, Southwest Fisheries Science Center
	Ms Gina Selig NSF
	Dr Andrew Titmus National Science Foundation
	Dr George Watters National Marine Fisheries Service, Southwest Fisheries Science Center

Observers – Acceding States

Canada	Ms Jasmine Jarjour Fisheries and Oceans Canada
	Ms Olivia Lassaline Fisheries and Oceans Canada

Observers – International Organisations

IUCN	Ms Minna Epps Ocean Team, Centre for Conservation Action, IUCN
	Professor Catherine Iorns Victoria University of Wellington, NZ
	Dr Aurélie Spadone Ocean Team, Centre for Conservation Action, IUCN
IWC	Mr Mark Simmonds University of Bristol
	Dr Iain Staniland International Whaling Commission
SCAR	Dr Cassandra Brooks University of Colorado Boulder
	Dr Andrew Constable University of Tasmania
	Dr Susie Grant British Antarctic Survey

	Dr Chandrika Nath Scientific Committee on Antarctic Research
	Dr Kirsten Steinke Oregon State University
SCOR	Dr Alyce Hancock Southern Ocean Observing System (SOOS)

Observers – Non-Governmental Organisations

ARK	Dr Javier Arata Association of Responsible Krill harvesting companies (ARK)
ASOC	Dr Ricardo Roura Antarctic and Southern Ocean Coalition
COLTO	Mr Rhys Arangio Coalition of Legal Toothfish Operators
	Mr Richard Ball SA Patagonian Toothfish Industry Association
Oceanites	Mr Steven Forrest Oceanites, Inc.
	Professor Philip Trathan Oceanites, Inc.

Agenda

Workshop on Climate Change
(Cambridge, UK and Wellington,
New Zealand, 4 to 8 September 2023)

1. Expected effects and risks of climate change on Antarctic Marine Living Resources

    1.1 Workshop opening: welcome, workshop structure, housekeeping, adoption of agenda
    1.2 Invited presentation: Climate change and Antarctic Marine Living Resources (Dr Jess Melbourne-Thomas and Dr Tom Bracegirdle)
    1.3 Climate change effects on harvested species
    1.4 Climate change effects on dependent and related species
    1.5 Summary of the discussion
    1.6 Close

2. Spatial management approaches to ensure objective of the Convention is met

    2.1 Day 1 plenary report summary
    2.2 Invited presentation: Climate change and management approaches for marine living resources (Dr Anne Hollowed)
    2.3 Climate change considerations for CCAMLR's management approach
    2.4 Specific climate change considerations for spatial management
    2.5 Summary of the discussion
    2.6 Close

3. Information, including monitoring and metrics, needed to support management decisions, and mechanisms to develop and integrate these

    3.1 Day 2 plenary report summary
    3.2 Climate change information needed to support management decisions
    3.3 Mechanisms to improve input, and use of, relevant scientific information and advice on climate change throughout CCAMLR's work program
    3.4 Summary of the discussion
    3.5 Close

4. Report drafting

5. Report adoption

Attachment IV

List of Documents

(Cambridge, UK and Wellington,
New Zealand, 4 to 8 September 2023)

WS-CC-2023/01	Evaluating climate change risks to Patagonian and Antarctic toothfish Cavanagh, R., O. Brunner, M.A. Collins, T. Earl, J. Freer, S. Hill, O. Hogg, P. Hollyman, H. Peat, M. Soeffker, S. Thorpe, C. Waluda and M. Whitelaw
WS-CC-2023/02	Adaptation of fisheries management to climate change Handbook Fulton, E.A. , E.I. van Putten, L.X.C. Dutra, J. Melbourne-Thomas, E. Ogier, L. Thomas, R.P. Murphy, I. Butler, D. Ghebrezgabhier, A.J. Hobday, N. Rayns
WS-CC-2023/03	An exploratory evaluation of forecasted changes in sea surface temperature and sea ice in the Domain 1 Marine Protected Area Krüger, l., F. Santa Cruz, L. Rebolledo and C.A. Cárdenas
WS-CC-2023/04	Climate change impacts vary with depth: what can be the consequences for pelagic ecosystems and for conservation ? Examples from the Southern Indian Ocean Azarian, C., L. Bopp and F. d'Ovidio
WS-CC-2023/05	Potential implications of climate change on the Patagonian toothfish fisheries management Azarian, C., L. Bopp and F. d'Ovidio
WS-CC-2023/06	Summary of recent climate change science discussions within CCAMLR (2015-present) Cavanagh, R. and E. Pardo
WS-CC-2023/07	Turning the page on CCAMLR's response to climate change ASOC
WS-CC-2023/08	Predicting future fishable distribution of Antarctic toothfish (Dissostichus mawsoni), with implications for Marine Protected Areas in the Southern Ocean Konijnenberg, R., C. Nissen, C. Kraan, J.A. Caccavo, C.A. Cárdenas, M. Collins, T. Okuda, R. Sarralde Vizuete, P. Yates, Ziegler, P. and K. Teschke
WS-CC-2023/09	Carbon sink fishery: a climate change perspective in CCAMLR ecosystem based fishery management Ying, Y., L. Liu, X. Mu and X. Zhao

WS-CC-2023/10	The crabeater seal as a candidate species for climate change monitoring and the CCAMLR Ecosystem Monitoring Program (CEMP): East Antarctica monitoring program Labrousse, S., J-B. Charrassin, M. LaRue, L. Huckstadt and M. Eleaume
WS-CC-2023/11	SCAR affiliated research activities relevant to the integration of climate change information into CCAMLR's work program SCAR
WS-CC-2023/12	Outcomes of the first Marine Ecosystem Assessment for the Southern Ocean (MEASO) useful to CCAMLR in developing science to support managing the effects of climate change SCAR
WS-CC-2023/13	Potential effects of climate variability and change on bycatch using Antarctic skates as a case study Finucci, B. and M. Pinkerton
WS-CC-2023/14	Summary of the IWC Climate Change Workshop Report related to the Southern Ocean and CCAMLR IWC
WS-CC-2023/15	Taking climate change effects on benthos into account in CCAMLR Cummings, V., D. Lohrer et al.
WS-CC-2023/16	A Risk Assessment of Changing Climate on Antarctica and the Southern Ocean Bertler N.A.N. and I. Hawes
WS-CC-2023/17	Anticipating environmental and biogeochemical changes in the Southern Ocean using Earth System Models: the importance of evaluation Rickard, G., E. Behrens, A. Bahamondes Dominguez and M. Pinkerton
WS-CC-2023/18	Effects of climate variability and change on the recruitment of Antarctic toothfish in the Ross Sea region: the impact of sea-ice drift, ocean circulation, and prey resources Behrens, E., M. Pinkerton, G. Rickard, A. Grüss, C. Collins and I. Blixt
WS-CC-2023/19	Environmental change in the Southern Ocean: observations, trends, bioregions and species-distribution models Pinkerton, M. and S. Halfter
WS-CC-2023/20	Monitoring the effects of environmental variability and climate change on toothfish assessments Pinkerton, M., J. Devine, A. Dunn and S. Mormede

WS-CC-2023/21	Approaches to incorporating climate change considerations into fisheries management in CCAMLR Earl, T., J. Pinnegar and M. Soeffker
WS-CC-2023/22	Climate Genomics of Antarctic Toothfish (ClimGenAT) Caccavo, J.A., F. d'Ovidio and M. Gehlen

Other Documents

WS-CC-2023/P01	Antarctic Extreme Events Siegert, M.J., M.J. Bentley, A. Atkinson, T.J. Bracegirdle, P. Convey, B. Davies, R. Downie, A.E. Hogg, C. Holmes, K.A. Hughes, M.P. Meredith, N. Ross, J. Rumble and J. Wilkinson. 2023. Antarctic Extreme Events. *Front. Environ. Sci.*, 11:1229283, doi: 10.3389/fenvs.2023.12292.
WS-CC-2023/P02	Climate drives long-term change in Antarctic Silverfish along the western Antarctic Peninsula Corso, A.D., D.K. Steinberg, S.E. Stammerjohn and E.J. Hilton 2022. Climate drives long-term change in Antarctic Silverfish along the western Antarctic Peninsula. *Commun. Biol.,* 5:104, doi: 10.1038/s42003-022-03042-3
WS-CC-2023/P03	Managing for climate resilient fisheries: Applications to the Southern Ocean Chavez-Molina, V., S.L. Becker, E. Carr, R.D. Cavanagh, D. Dorman, E. Nocito, Z. Sylvester, B. Wallace, C. White and C.M. Brooks. 2023. Managing for climate resilient fisheries: Applications to the Southern Ocean. *Ocean Coast. Manag.*, 239:106580, doi: 10.1016/j.ocecoaman.2023.106580

Attachment V

Terms of Reference for the Climate Change Workshop

Objective

To improve the integration of scientific information on climate change and ecosystem interactions throughout CCAMLR's work program.

Draft Terms of Reference

1. Review information on climate change in the Southern Ocean relevant to CCAMLR objectives and how climate change effects are being addressed by management both inside and outside the Convention Area.

2. Use the information from (1) to:

   (i) review the effects/risks of climate change to Antarctic marine living resources (including disentangling the effects of climate change and fishing)

   (ii) review the effects of harvesting activities on key Antarctic marine living resources as well as the ecosystem services they provide (inter alia carbon sequestration)

   (iii) identify and prioritise issues that should be considered by CCAMLR

   (iv) identify further research needs, including the use of novel platforms for data collection (inter alia vessels of opportunity) and the enhancement of CEMP.

3. Identify mechanisms to improve input, and use, of relevant scientific information and advice on climate change into the Commission.

4. Provide advice to Scientific Committee and it's working groups on adaptive management approaches available to CCAMLR to address climate change impacts on marine living resources.

Annex 12

Draft of Requirements for Acoustic Surveys of Krill in Area 48 for the implementation of the revised krill fishery management approach

Draft of Requirements for Acoustic Surveys of Krill in Area 48 for the implementation of the revised krill fishery management approach

Acoustic surveys of krill conducted by krill fishing vessels in Area 48 for the implementation of the revised krill fishery management approach shall meet the following minimum requirements. The document titled 'Specifications for CCAMLR Acoustic Surveys' shall be regularly reviewed and, as needed, revised by the Scientific Committee and subsequently posted on the CCAMLR website.

Spatial extent – To the extent possible given sea-ice extent, surveys shall be conducted in all management units defined within each subarea and identified in the document titled 'Specifications for CCAMLR Acoustic Surveys' with spatial coverage sufficient to provide an estimate of biomass within each management unit and which is suitable for revising biomass estimates if the definitions of management units or the regional distribution of fishing effort within the subarea change.

Timing – In Subarea 48.1, surveys shall be completed between 1 January and 1 May of each year.

Acoustic transects – Acoustic data should be collected along transects identified within all management units in each Subarea and identified in the document titled 'Specifications for CCAMLR Acoustic Surveys'. Alternatively, acoustic data within each management unit shall be collected along the minimum of 7 transects and the number of transects that would occur if spaced 20 nmi apart. Each alternative transect shall span the length of one axis of each management unit, and the spacing between the alternative transects shall average the length, divided by 8, of the axis that is perpendicular to the transects. Within management units, acoustic transects shall be oriented approximately orthogonal to known sources of variation in krill biomass and, if possible, to prevailing surface currents.

Acoustic data collection - Acoustic backscatter data collected at the frequencies specified in the document titled 'Specifications for CCAMLR Acoustic Surveys' shall be used to estimate krill biomass for stock assessments. Collection of backscatter data at other frequencies to apply target-identification methods specified in the document titled 'Specifications for CCAMLR Acoustic Surveys' is encouraged. Acoustic data should be collected continuously along transects and to a depth of at least 300 m.

Acoustic instrument calibration - The instruments used to collect acoustic backscatter data shall, at a minimum, be calibrated once annually using procedures specified in the document titled 'Specifications for CCAMLR Acoustic Surveys'. The calibrations shall be made in water with similar temperature and conductivity conditions as in the subarea within which the survey will be conducted.

Oceanographic data collection - A CTD (conductivity, temperature, depth) cast shall be conducted in connection with any acoustic calibration. To collect sound speed and absorption data pertaining to acoustic processing, CTD casts shall also be undertaken once per day (nominally around noon) during survey operations. CTD instruments shall be calibrated at intervals according to the manufacturers' recommendations.

Krill length data collection - Acoustic surveys shall include sampling designed to characterize the length-frequency distribution of krill in each management unit, with net characteristics (e.g., area of the mouth opening and mesh size in the codend) and tow parameters (e.g., number and type of tows, depth, and time during the day) as specified in the document titled 'Specifications for CCAMLR Acoustic Surveys'. The total lengths of 100 randomly sampled krill, or all krill if fewer than 100 are caught, from each net tow shall be measured to the nearest mm and recorded following protocols outlined in the document titled 'Specifications for CCAMLR Acoustic Surveys'.

Data submission and processing - All acoustic, oceanographic, and length-frequency data and associated metadata are needed to estimate krill biomass and update catch limits and shall be submitted to the Secretariat by the end of each fishing season.

Annex 13

Specifications for CCAMLR Acoustics Surveys

Specifications for CCAMLR Acoustics Surveys

Spatial management units

The management units currently identified within Subarea 48.1 (SC-CAMLR-41):

1) Joinville (J)

2) Elephant Island (EI)

3) Bransfield Strait (BS)

4) South Shetland Islands West (SSIW)

5) Gerlache Strait (GS),

6) Powell Basin (PB)

7) Drake passage (DP)

Shapefiles defining these polygons are available in a CCAMLR GitHub repository (https://github.com/ccamlr).

Acoustic transects

Historical transect grids exist for many of the Subarea 48.1 management areas (see WG-ASAM 2023 Table 1). Additional transects could be considered as described in Figure 2 WG-ASAM 2022/09 that extend into the Gerlache Strait.

Further work for WG-ASAM to identify transect grid including a list of transect start and end locations and map of transects for each management area.

Acoustic data for krill biomass estimation

WG-ASAM endorse krill biomass estimates for krill stock assessments to be made from 120 kHz acoustic data (paragraph 5.16 from SG-ASAM 2016)

WG-ASAM currently endorse two methods to identify krill in acoustic data: a two (120-38) or three (200-120 & 120-38) frequency dB method or the swarms-based method applied on 120 kHz data (WG-ASAM 2021, Table 1)

WG-ASAM-2023 Appendix D, Chapter 2 presents a list of recommended settings for echosounders mounted on research and fishing vessels. Analogous settings should be considered for non-conventional vessel platforms and agreed in WG-ASAM.

Acoustic instrument calibration

WG-ASAM currently endorse the following methods for acoustic instrument calibration for acoustic data collected to estimate krill biomass:

Standard sphere calibration following the method outlined in ICES 2015 (ICES calibration report). SG-ASAM 2015, paragraph 3.21

Further work for ASAM – to consider metadata guidelines and forms for reporting of calibration values, including ancillary information as discussed in ASAM 2023 (paragraphs 4.1 to 4.4).

Oceanographic data collection protocols

Currently drawn from (TBD)

Further work for ASAM and EMM to provide guidance for fishing vessels for CTD casts, including metadata requirements.

Net sampling protocols

Collect data according to these protocols Microsoft Word - CCAMLR-2000 krill synoptic survey RMT8 protocol.doc adjusted for sample size of 100 krill (following SISO recommendation)

Further work for ASAM and EMM – to update the CCAMLR2000 scientific net protocols into current

Acoustic metadata requirements

Information pursuant to creating metadata tables 2-8 (WG-ASAM2022) from processed acoustic data need to be lodged alongside the raw data with the secretariat. WG-ASAM to create metadata documents that will achieve this, if WG-ASAM2023, Appendix D, Chapter 4 isn't sufficient.

Further work for ASAM: to ensure the metadata requirements listed in Appendix D, Chapter 4 are sufficient for the data processor to create the required survey metadata tables 2-8 (WG-ASAM2022)

Acoustic data processing

All processing templates to determine krill biomass should be lodged with the Secretariat. Noting the swarms template is already available on the CCAMLR Github (2019Area48Survey/acoustic_data at master · ccamlr/2019Area48Survey · GitHub). Likewise, other software tools such as Krillscan are also publicly available (github.com/sebastianmenze/krillscan).

Further work for ASAM: to use exemplar datasets (para: 4.12 WG-ASAM-2023) to benchmark processing software and methods

ICES. 2015. Calibration of acoustic instruments. ICES Coop. Res. Rep., 326: 136 pp, doi: https://doi.org/10.17895/ices.pub.5494.

Details of proposed symposium on harmonisation of conservation and krill fishery management initiatives in the Antarctic Peninsula Region

Details of proposed symposium on harmonisation of conservation and krill fishery management initiatives in the Antarctic Peninsula Region

Title: Symposium on harmonisation of conservation and krill fishery management initiatives in the Antarctic Peninsula Region

Objectives: Provide recommendations to CCAMLR for steps to harmonise the implementation of the revised krill fishery management approach and the establishment of a Domain 1 MPA in the Antarctic Peninsula Region, and recommendations for practical and cost-effective collection and analysis of data.

Terms of Reference:

1) The geographical focus of the symposium is on Subarea 48.1. It will also consider interactions with and implications for adjacent Subareas (48.2, 48.5 and 88.3).

2) The symposium will provide a forum to bring together SC-CAMLR and CCAMLR delegates, representatives from the krill fishing industry, and other CCAMLR Observers with relevant expertise in ecosystem and fisheries research and monitoring, climate change, conservation and resource management, and operations in the krill fishery to progress conservation in the Antarctic Peninsula region.

3) The symposium will develop ways to promote understanding within the CCAMLR community (Working Groups, Scientific Committee, Commission and Observers) of the current spatial management initiatives in the region, including:

(i) the needs for developing a revised krill fishery management approach, including the state of knowledge of the krill population in Subarea 48.1 and adjacent Subareas,

(ii) proposed management units for distributing catch limits in the krill fishery in Subarea 48.1, and the current D1MPA proposal, including the ARK VRZs,

(iii) that the Commission may consider revision of several Conservation Measures related to the krill fishery in the region.

<u>Developing scenarios for harmonisation</u>

4) The symposium will provide recommendations to CCAMLR for steps to harmonise the implementation of the revised krill fishery management approach and the establishment of a Domain 1 MPA in the Antarctic Peninsula Region.

5) The symposium will provide recommendations for practical and cost-effective collection and analysis of data and status indicators to support periodic CCAMLR decisions in the region. These recommendations include priority elements of an RMP pertaining to the krill-based ecosystem for a Domain 1 MPA and the development of a data collection plan for management of the krill fishery, including:

(i) data collected within the CCAMLR Ecosystem Monitoring Program (CEMP)

(ii) standardised at-sea krill predator observations

(iii) data to allow regular updates to krill biomass estimates, stock assessments, spatial-overlap analyses, and to further develop the Krill Stock Hypothesis

(iv) monitoring of MPA reference areas

(v) data standardisation.

(vi) identifying sustainable resources to support monitoring needs (including contributions by national programs and the fishing industry).

6) The symposium will produce an adopted report to be submitted to Scientific Committee and Commission, 2024.

7) The steering committee will identify and coordinate preparatory work for the symposium, which will be held after WG-EMM to allow initial discussions and analyses in the Working Group.

Other information

Host: TBD

Convener(s): TBD

Steering Committee: Nicole Bransome, Simeon Hill, So Kawaguchi, Andrew Lowther, Steve Parker, Mercedes Santos, others TBD,

Date: Soon after EMM-2024

Duration: 5 days

Invited experts: Yes

Observers or external organisations: CCAMLR observers

Funding required by CCAMLR: TBD (offers of support from ASOC and ARK)

Secretariat Support required: Yes

Ability to submit papers: Yes

Output: Adopted report

Reported to: Scientific Committee and Commission, 2024.

Annex 15

Compilation of working group workplans for 2024

Compilation of working group workplans for 2024

Annotated table of **WG-ASAM** workplan updated for 2024. CEMP – CCAMLR Ecosystem Monitoring Program, DSAG – Data Services Advisory Group, SISO – Scheme of International Scientific Observation.

Theme	Topic/task	Timeframe	Contributors	Secretariat participation
1. Target Species	(a) Develop methods to estimate biomass for krill			
	(i) Survey design standards for regional and synoptic surveys	Short	ASAM members	
	(ii) Develop methods to use fishing fleets as monitoring platforms:			
	Task 1: Methods for calibrating echosounders on fishing vessels	Short	Dr Macaulay, Dr Fielding	
	Task 2: Survey design for fishing fleets	Short	Linked to 1.a.i	
	Task 3: Develop the use of krill length frequency data in the estimation of target strength and krill weight for biomass estimates	Short	Dr Cox, Dr Zhao	
	(iii) Data collection – SISO, vessels and CEMP Specification for sample size and the use of krill length frequency data	Short	Annex 4, Table 2, 1.a.ii and 1.a.iv.4	Yes
	(iv) Acoustic data storage and processing			
	(1)(A) Identify metadata (B) Acoustic raw data storage requirements and processing	Short	ASAM	Yes
	(2) Automated data processing of acoustic data from fishing vessels, including frequency of updates to biomass updates	Long	Dr Menze, Dr Wang, Dr Fielding	
	(3) Standardised procedures to check and verify acoustic data	Medium	Dr Macaulay	
	(4) Develop the use of krill length frequency data in the estimation of target strength and krill weight for biomass estimates, including seasonal and regional effects of developmental stage	Medium	Dr Cox, Dr Wang	Yes
	(5) Submission of acoustic data and the inclusion of metadata by Members in the repository held by the Secretariat	Annual	Annex 4, Table 2, 1.a.iv.1	
	(6) Develop statistical approaches to acoustic data emerging from new acoustic observation platforms	Long	Dr Reiss, Dr Menze, Dr Dornan	
	(v) Biomass estimation			
	(4) Krill biomass estimate in Division 58.4.1	Long	Dr Cox, Dr Murase	
	(5) Krill biomass estimate in Division 58.4.2	Long		
	(b) Develop stock assessments to implement decision rules for krill			

Theme	Topic/task	Timeframe	Contributors	Secretariat participation
	(i) Krill management approach (biomass estimates)			
	(1) Subarea 48.1	Short		
	(2) Subarea 48.2 etc.	Short	ASAM	
	(ii) Develop diagnostic tools			
	(iii) Develop ecosystem indicators to inform risk assessment framework			
	(iv) Methods to account for uncertainty in stock status			
	(1) Movement of krill (flux)	Medium	Dr Kasatkina	
	(2) Spatial structure within subareas		Dr Ying	
	(3) Interannual variability			
	(c) Develop methods to estimate biomass for finfish			
	(i) Survey design	Medium	Dr Kasatkina	
	(ii) Data collection – SISO and vessels			
	(iii) Improve biomass estimation methods	Long	Dr Wang	
2. Ecosystem impacts	(a) Ecosystem monitoring (Second Performance Review, recommendation 5)			
	(i) Structured ecosystem monitoring programs (CEMP, fishery)			
	(1) CEMP			
	(2) Fishery via SISO			
	(3) Research surveys			
	(b) Monitoring and adaptation to effects of climate change (see Table 2. SC-CAMLR-41/10)	Medium		
	(i) Develop methods to detect change in ecosystems given variability and uncertainty			
	(1) autonomous platforms		Dr Dornan	
Administrative topics	(a) Advise on database facilities required throughout DSAG	Annex 4, Table 2, 1.a.iv		
	(b) Advise on quality control and assurance processes for data provided to and supplied by the Secretariat	Annex 4, Table 2, 1.a.iv		
	(c) Refine SISO across all fisheries	Annex 4, Table 2, 1.a.iv		
	(d) Further develop data management systems	Annex 4, Table 2, 1.a.iv		
	(e) Communication of progress, internal and external			
	(f) Working group terms of reference	2022		
	(g) Scientific Committee Symposium in 2027			

Annotated table of **WG-SAM** workplan updated for 2024. Timeframe periods are: short = 1–2 years, medium = 3–5 years and long = 5+ years. Items tasked to WG-SAM from the Scientific Committee Strategic Plan (SC-CAMLR-41, Table 6). Numbers following level of urgency indicates the stated value in the box which replaced 'X', i.e., the year. CEMP – CCAMLR Ecosystem Monitoring Program, MSE – management strategy evaluation, SISO – Scheme of International Scientific Observation. Grey indicates specific tasks identified.

Theme		Priority research topic	Timeframe			Contributors	Secretariat participation
			Global	2024	2025		
1. Target species	(a)	Develop methods to estimate biomass for krill					
		(iii) Data collection – SISO and vessels and CEMP					
		Task 1: Effective sampling to estimate length-frequency distribution	Short	X		Dr Robson, Dr Kawaguchi	
	(b)	Develop stock assessments to implement decision rules for krill					
		Task 2: Development of integrated stock assessment for krill	Medium	X	X	Mr Mardones, Dr Watters	
	(c)	Develop methods to estimate biomass for finfish					
		(i) Survey design					
		Task 3: Gear standardisation – tagging program	Short	X	X	Dr Péron, Dr Masere, Dr Kasatkina	Yes
		(ii) Data collection – SISO and vessels					
		Task 4: Metrics of vessel tagging performance	Short	X	X	Dr Péron, Dr Masere, Mr Dunn, Dr Hoyle	Yes
		Task 5: Recording selection of non-random biological data	Medium	X	X	Mr Gasco, Dr Massiot-Granier	Yes
		Conversion factors					
		Task 6: Develop protocol for conversion factors	Short	X		Mr Gasco, Dr Massiot-Granier, Mr Walker	Yes
		(iii) Improve biomass estimation methods					
		Task 7: Optimise tag-based study (spatial overlap)	Medium	X	X	Dr Masere, Dr Péron, Dr Devine	
		Task 8: Vessel configuration factors affecting tagging mortality	Medium	X	X	Dr Devine	Yes

Theme	Priority research topic	Timeframe Global	2024	2025	Contributors	Secretariat participation
	(iv) Data for stock assessment					
	Task 9: Determine bias of poor otolith readability	Short		X	Dr Devine, Dr Quiroz, Mr Sarralde	
	Task 10: Develop target precision levels for ageing	Short		X	Dr Devine, Dr Quiroz, Mr Sarralde	
	Task 11: Determine minimum double reading level for ageing	Short		X	Dr Devine, Dr Quiroz, Mr Sarralde	
	Task 12: Determine minimum otolith sample size for age composition	Short		X	Dr Devine, Dr Quiroz, Mr Sarralde	
	Task 13: Build an otolith image reference collection - In-person ageing workshop	Short		X	Dr Devine, Dr Quiroz, Mr Sarralde	Yes
	(d) Develop stock assessments to implement decision rules for finfish					
	(i) Research to develop new assessments					
	(1) Research plan evaluations:					
	Task 14: Research plan assessment	Short			WG-SAM	
	48.2 Icefish		X	X		
	48.6 Antarctic toothfish		X			
	58.4.1–58.4.2 Antarctic toothfish		X	X		
	88.1 shelf survey Antarctic toothfish		X	X		
	88.3 Antarctic toothfish		X			

Theme	Priority research topic	Timeframe			Contributors	Secretariat participation
	(ii) Develop new assessment tools (1) Casal2 development					
	(e) Management strategy evaluations for target species (Second Performance Review, Recommendation 8) (i) Evaluation of the CCAMLR decision rules and potential alternative harvest control rules for assessed fisheries:	Medium				
	Task 15: Develop and agree on an operating model		X	X	Dr Ziegler, Mr Dunn,	Yes
	Task 16: MSE		X	X	Dr Massiot-Granier, Dr Earl, Mr Somhlaba	Yes
	(ii) Development and testing of data-limited fishery decision rules	Medium				
	Task 17: Develop and agree on an operating model		X	X	Dr Ziegler, Mr Dunn,	Yes
	Task 18: MSE (FSA-2022/53, WG-FSA-2022, paragraph 4.67)		X	X	Dr Massiot-Granier, Dr Earl, Mr Somhlaba	Yes
	(iii) Finfish management strategies that are robust to climate change					
2. Ecosystem impacts	(a) Ecosystem monitoring (Second Performance Review, Recommendation 5) Structured ecosystem monitoring programs (CEMP, fishery)					
	Task 19: effective sample size for fish by-catch monitoring in the krill fishery	Medium	X	X	Dr Jones	
3. Adminis-trative topics	(e) Communication of progress, internal and external: Task 20: Diagnostic graphs on stock status	Short	X	X	Stock assessors	

Annotated table of **WG-EMM** workplan updated for 2024. Timeframe periods are short = 1–2 years, medium = 3–5 years and long = 5+ years. Items tasked to WG-EMM from the Scientific Committee Strategic Plan (Annex 4 in SC-CAMLR-41). CEMP – CCAMLR Ecosystem Monitoring Program, SISO – Scheme of International Scientific Observation. Orange colour indicates the topic is in progress, red indicates not yet started, green indicates completed.

Theme	Priority research topic	Priority research topic task	Timeframe	Contributors	Secretariat participation
1. Target species	(a) Develop methods to estimate biomass for krill	(iii) Data collection – SISO, vessels, and CEMP Urgency: High (2) Develop diagnostic approaches for data quality Urgency: High	Short	Dr Zhu Dr Kawaguchi Dr Collins	Yes
		(iv) Acoustic data storage and processing Urgency: High (3) Develop the use of krill length frequency data in the estimation of target strength, and krill weight for biomass estimates Urgency: High	Medium	Dr Cox, Dr Wang	Yes
		(v) Biomass estimation methods Urgency: High (1) Establish Grym parameters for krill stock assessments in Areas 48 and 58 Urgency: High	Short	Dr Ying Mr Johannessen Dr Lowther	
		(vi) Account for spatial structure of krill Urgency: Medium	Short		
	(b) Develop stock assessments to implement decision rules for krill	(i) Krill management approach (synthesis of krill recruitment, spatial scale, biomass estimates, predator risk) Urgency: High (1) Subarea 48.1 (2022) Urgency: High (2) Subareas 48.2, etc… (2023/24) Urgency: Medium	Short/medium	Dr Kawaguchi Dr Watters	
		(ii) Develop diagnostic tools Urgency: Medium	Short/medium	Mr. Maschette	

Theme	Priority research topic	Priority research topic task	Timeframe	Contributors	Secretariat participation
		(iii) Develop ecosystem indicators to inform risk assessment framework Urgency: Low		Dr Warwick-Evans	
		(iv) Methods to account for uncertainty in stock status Urgency: Low (2) Spatial structure within subareas Urgency: High (3) Interannual variability Urgency: Low			
		(v) Develop krill management approach as a multiannual cycle Urgency: High		Dr Hill Dr Watters	
		(vii) Krill management strategies that are robust to climate change Urgency: Medium	Long	Dr Hill	
	(e) Management strategy evaluations for target species (Second Performance Review, Recommendation 8)	(iii) Finfish management strategies that are robust to climate change Urgency: Medium	Medium/Long	Dr. Devine	
		(iv) MSE for krill	Medium	Mr. Mardones Dr. Lowther Mr. Johannessen	
	(f) Krill Stock Hypothesis Information Collection Plan	See Table 1	See Table 1	See Table 1	

(continued)

Theme	Priority research topic	Priority research topic task	Timeframe	Contributors	Secretariat participation
2. Ecosystem impacts	(a) Ecosystem monitoring (Second Performance Review, Recommendation 5)	(i) Structured ecosystem monitoring programs (CEMP, fishery) (1) CEMP	Short/medium	Dr Collins Dr Hinke Dr Lowther Dr Hill Dr Waluda Dr Santos Dr Emmerson Dr Makhado	Yes
		(2) Fishery via SISO Urgency: Medium			
		(ii) Ecosystem modelling Urgency: Low	Long	Dr Schaafsma Dr Pinkerton	
		(iii) Invasive species Urgency: Low	Long		
		(iv) Marine debris monitoring Urgency: Low	Long	Dr Waluda Dr Schaafsma Dr Makhado Dr Emmerson Dr Santos	Yes

(continued)

Theme	Priority research topic	Priority research topic task	Timeframe	Contributors	Secretariat participation
	(b) Spatial management	(i) Science advice on proposals for a Representative System of MPAs Urgency: High (1) Current proposals Urgency: High (2) Future proposals Urgency: Low	Short/Medium	Prof. Koubbi Dr Teschke	
		(ii) the harmonisation and/or integration of different spatial management initiatives within Subarea 48.1, including the ARK voluntary restricted zones and the D1MPA proposal (SC-CAMLR-41, paragraph 3.65) Urgency: High	Short	Dr Santos Mr Santa Cruz Dr Lowther	
		(ii) Research and monitoring plans Urgency: High	Medium/Long	Dr Devine et al	
	(c) By-catch risk assessment for krill and finfish fisheries	(i) Monitoring status and trends Urgency: High	Medium		
		(ii) By-catch species catch limits Urgency: High		Dr Devine	
	(d) Habitat protection from fishing impacts	(i) Habitat classification, bioregionalisation and monitoring Urgency: Low			
		(ii) VME identification and management Urgency: Medium		Dr Eléaume Dr Teschke Dr Devine et al.	

	(iii) Protection of biodiversity and ecosystems (Second Performance Review, Recommendation 7) Urgency: High (1) Ecosystem impacts from krill and finfish fishing, including analyses whether research and sampling design is able to detect such impacts Urgency: High (2) Physical disturbance of longline fishing on benthic ecosystems Urgency: Low (3) Suitability of reference areas for comparison between fished and unfished areas Urgency: Medium		Dr Hill Dr Hill	
(e) Monitoring and adaptation to effects of climate change	(i) Develop methods to detect change in ecosystems given variability and uncertainty (Second Performance Review, Recommendation 6) Urgency: Medium	Medium	Dr Schaafsma Dr Dahlgren Dr Hill, Dr Collins, Dr Emmerson, Dr Waluda, Dr Knutsen Mr Pardo Dr Cavanagh	Yes
	(ii) Develop integrated ecosystem reporting (WG-EMM-2022, paragraph 2.18) (iii) Develop mechanisms for integration in SC work	Medium	Dr Parker Mr Pardo Dr Cavanagh	Yes
Administrative topics	(a) Advise on database facilities required through DSAG Urgency: High (b) Advise on quality control and assurance processes for data provided to and supplied by the Secretariat Urgency: High (c) Refine the scheme of international scientific observation (SISO) across all fisheries Urgency: Medium			Yes Yes Yes

	(d) Further develop data management systems Urgency: Medium (1) Quality assurance Urgency: High (2) DOI Urgency: Medium (3) Data access Urgency: Low	Yes
	(e) Communication of progress, internal and external Urgency: Medium	Yes
	(f) Working group terms of reference Urgency: Low	
	(g) Scientific Committee Symposium in 2027 Urgency: High	

Annotated table of **WG-IMAF** workplan updated for 2024. Timeframe periods are short = 1–2 years, medium = 3–5 years and long = 5+ years. AI = artificial intelligence, EM = electronic monitoring, MMED = marine mammal exclusion device.

Theme	Task	Timeframe	Contributors	Secretariat participation
1. Review of incidental mortality	1.1 Presentation of incidental mortality information at a finer scale (spatial and temporal) (supplemental information in addition to Secretariat report to WG-IMAF)	Short	Dr Favero, Mr Walker and Prof. Phillips	Yes
	1.2 Development of a web-based tool to allow examination of interactions and incidental mortality data across CCAMLR fisheries	Medium	Dr Favero, Mr Walker and Prof. Phillips	Yes
2. Marine mammals – incidental mortality	2.1 Refine design of additional data to be collected by observers and crew when whale entanglements occur (see list developed under paragraph 4.17)	Short (to be completed intersessionally 2024)	Dr Kelly and Mr Pardo	Yes
	2.2 Investigate the use of underwater sensor/cameras attached to the net (and AI) to provide information on the occurrence of whale interactions and any subsequent entanglements/capture (continuous)	Short	Dr Kelly, Dr Lowther and Dr Lindstrøm	-
	2.3 Development of data collection protocols for pinniped mortalities and training materials	Short (to be completed intersessionally in 2024)	Mr Pardo	Yes
3. Seabirds and Marine mammals – risk assessment	3.1 Consider developing risk assessment for seabirds and marine mammals	Medium	Dr Lindstrøm, Dr Kelly and Prof. Phillips	-
4. Marine mammals – mitigation	4.1 Review designs of marine mammal exclusion devices and develop specifications for those in use in CCAMLR trawl fisheries (including consideration towards a convex shape to the exclusion mesh to deflect whales (and seals) away from the net mouth)	Ongoing	Dr Kelly, Dr Lowther, Mr Pardo and Dr Lindstrøm	-
	4.2 Undertake experiments into effectiveness of different MMED designs (for various species)	Medium	Dr Kelly, Dr Lowther, Dr Lindstrøm and Dr Ying	-

Theme	Task	Timeframe	Contributors	Secretariat participation
5. Seabirds – incidental mortality	5.1 Power analysis of required observer sampling required for warp strikes	Update if required	Dr Kelly, Dr Hinke and Mr Walker	-
	5.2 Redesign the warp strike observation protocols	Short	Dr Debski	Yes
	5.3 Exploration of approaches to undertake warp strike extrapolations	Short	Dr Favero, Dr Hinke and Mr Walker	Yes
	5.4 Review required levels of observer sampling for seabird incidental mortality with longline fishery	Short	Mr Zhu, Dr Kawaguchi	Yes
6. Seabirds – mitigation	6.1 Consider performance of trawl warp/cable strike mitigation approaches utilised by continuous trawl vessels (including environmental conditions and other factors) including the improvement and specification development for the 'sock' design.	Short	Dr Debski and Dr Arata	-
	6.2 Review existing use of and consider mitigation requirements in conventional trawl vessels and develop specifications for suitable mitigation	Short	Dr Debski and Dr Arata	-
	6.3 Review developments in demersal longline mitigation	Update if required	Mr Barrington, Dr Debski and Mr Arangio/ Mr McNeill	-
7. Observer reports and data collection	7.1 Consider IMAF-related tasks for observers in the various CCAMLR fisheries	Ongoing	Mr Clark	Yes
	7.2 Consider use of EM and AI to improve the efficiency of data collection to aid observers	Medium/ Long	Mr Clark	-
8. Marine debris effects on seabird and marine mammals	8.1 Review information on the effect of marine debris on marine mammals and seabirds in the Convention Area	Short	Mr Barrington	Yes
9. Light pollution effect on seabirds	9.1 Consider options for the management of light pollution for vessels fishing in the Convention Area	Update if required	Mr Barrington	-

Annotated table of **WG-FSA** workplan updated for 2024. Items tasked to WG-FSA from the Scientific Committee Strategic Plan (SC-CAMLR-41, Table 8). Numbers refer to the numbering in the original tables. DSAG – Data Services Advisory Group, SISO – Scheme of International Scientific Observation, AUS – Australia, CHN – People's Republic of China, ESP – Spain; FRA – France, JPN – Japan, KOR – Republic of Korea, NZ – New Zealand, ZAF – South Africa, UK – United Kingdom, USA – United States.

Theme	Priority research topic	Priority research topic task	Timeframe	Contributors	Secretariat participation
1. Target species	(a) Develop methods to estimate total fish by-catch for the krill fishery	(iii) Data collection – SISO, vessels Priority: High	2024-2025	Secretariat	Yes
	(b) Develop stock assessments to implement decision rules for krill	(i) Krill management approach (synthesis of krill recruitment, spatial scale, biomass estimates, predator risk) Priority: High (1) Subarea 48.1 (2023) Priority: High (2) Other areas (48.2 and 48.3) Priority: High	2024-2025	WG-ASAM-2024/ WG-EMM-2024	Yes
		(ii) Methods to account for uncertainty in stock status Priority: Low			
		(iii) Develop krill management approach as a multiannual cycle Priority: Medium	Upon completion of (i)		
		(iv) Krill management strategies that are robust to climate change Priority: High	2027	WG-SAM-2027/ WG-EMM-2027	Yes
	(c) Develop methods to estimate biomass for finfish	(i) Data collection – SISO and vessels Priority: High			
		(1) Conversion factors Priority: mostly done	2024	Secretariat, FRA and NZ	Yes
		(2) Tagging protocols Priority: done	2023	Dr Jones/Mr Arangio	Yes
		(3) Ross Sea data collection program Priority: Medium	2024–2028	All involved Members (NZ Lead)	Yes

Theme	Priority research topic	Priority research topic task	Timeframe	Contributors	Secretariat participation
		(ii) Accounting for potential spatial bias in assessments. Priority: Urgent	2024–2025	WG-SAM 2024 and Members	
	(d) Develop stock assessments to implement decision rules for finfish	(i) Research to develop new assessments Priority: Low		WG-SAM	
		(1) Research plan evaluations Priority: Required	Annual	WG-SAM/WG-FSA	Yes
		(2) Subarea 88.2 fishery structure Priority: Low	2027 2023–2027	(NZ lead) All involved Members	Yes
		(3) Stock structure and connectivity (cross ref modelling of spatial structure, done in Areas 48, 58 and Subareas 88.1 and 88.2) Priority: Low		JPN/NZ/CHN/KOR/USA Members	Yes
		(ii) Develop new assessment tools			
		(1) CASAL2 development Priority: done	2023–2025	NZ/All involved Members	
		(2) CASAL 2 data limited assessment. Priority: high	2024	ZAF, ESP, JPN and other Members	Yes
		(iii) Provide precautionary catch limits Priority: Required	Annual	WG-FSA regular updates	Yes
		(iv) Developing sex disaggregated assessment models for areas with combined sex assessments Priority: Medium	2026	Members	
	(e) Management strategy evaluations for target species (Second Performance Review,	(ii) Development and testing of data-limited fishery decision rules Priority: Medium	2024–2025	Interested Members (WG-FSA-2024, paragraph 7.2)	Yes

Theme	Priority research topic	Priority research topic task	Timeframe	Contributors	Secretariat participation
	Recommendation 8 independent review)	(iii) Finfish management strategies that are robust to climate change Priority: Urgent	2024	AUS/NZ/UK Interested Members	Yes
		(iv) Analysis of current and alternative decision rules Priority: High (see also WG-SAM-2023 Table 1, then 1, task (e)(i))	2024	Members and WG-SAM-2024	Yes
	(f) Refine stock assessment procedures	i) Improve methods for inclusion of ageing data, e.g.: • Determining the CVs on the age compositions and effective sample sizes Priority: Medium • Determining the effect of different target levels of precision for age determination, Priority: Medium	2024-2025	Members	
		ii) Incorporating environmental and ecosystem parameters in toothfish population models Priority: Medium	2024-2025		
		iii) Investigate the impact of covarying productivity parameters. Priority: Medium	2026-2027		
		iv) Continuing development of stock assessment diagnostics Priority: ongoing	2026-2027		
		v) Developing methods to validate and pool multimember age data Priority: ongoing	2026-2027		

Theme	Priority research topic	Priority research topic task	Timeframe	Contributors	Secretariat participation
2. Ecosystem impacts	(a) Ecosystem monitoring (Second Performance Review, Recommendation 5)	(i) Structured ecosystem monitoring programs (CEMP, fishery) (2) Fishery via SISO Priority: Medium (3) Research surveys Priority: Low (iii) Invasive species Priority: Low		 Regular monitoring Members fishing under CM-24-01 Surveys	 Yes
	(c) By-catch risk assessment for krill and finfish fisheries	(i) Monitoring status and trends Priority: High (ii) By-catch species catch limits Priority: High (iii) Review of by-catch decision rules Priority: Medium (iv) By-catch mitigation methods Priority: Low	Annual 2026 2027 2026	Secretariat Members Members	
	(d) Habitat protection from fishing impacts	(i) Habitat classification, bio-regionalisation and monitoring Priority: Low (ii) VME identification and management Priority: Low	 2025	 Members	 Yes

Theme	Priority research topic	Priority research topic task	Timeframe	Contributors	Secretariat participation
		(iii) Protection of biodiversity and ecosystems (Second Performance Review, Recommendation 7) (1) Ecosystem impacts from krill and finfish fishing, including analyses whether research and sampling design is able to detect such impacts Priority: Low (2) Physical disturbance of longline fishing on benthic ecosystems Priority: Low (3) Suitability of reference areas for comparison between fished and unfished areas Priority: Medium	2027	Members and WG-EMM	Yes
	(e) Monitoring and adaptation to effects of climate change, including acidification	(i) Develop methods to detect change in ecosystems given variability and uncertainty (Second Performance Review, Recommendation 6) Priority: Medium		Members and WG-EMM	
Administrative topics	(a) Advise on database facilities required through DSAG Priority: ongoing		Annual	DSAG	Yes
	(b) Advise on quality control and assurance processes for data provided to and supplied by the Secretariat Priority: ongoing		Annual	DSAG	Yes

Theme	Priority research topic	Priority research topic task	Timeframe	Contributors	Secretariat participation
	(c) Refine the scheme of international scientific observation (SISO) for: (1) finfish Priority: Medium (2) krill Priority: High		2027 2024-2025		Yes
	(d) Further develop data management systems Priority: Medium	(1) Quality assurance Priority: ongoing	Annual	DSAG	Yes
		(2) DOI Priority: Low		DSAG	Yes
		(3) Review Data access rules Priority: Low		DSAG	Yes
	(e) Communication of progress, internal and external Priority: ongoing		Annual	Convener	Yes
	(f) Working group terms of reference Priority: Done		2022	SC-CAMLR-41	Yes
	(g) Scientific Committee Symposium in 2027 (Include annual review) Priority: Medium		2027	SC Chair	Yes

Working Group on Incidental Mortality Associated with Fishing (WG-IMAF)
Terms of Reference

Working Group on Incidental Mortality Associated with Fishing (WG-IMAF)
Terms of Reference [1]

1. The purpose of the Working Group on Incidental Mortality Associated with Fishing (WG-IMAF) is to contribute to the conservation of Convention Area seabirds and marine mammals through the provision of advice to the CCAMLR Scientific Committee and its working groups, including consideration of the impacts of climate change on its advice. To achieve this, WG-IMAF will address the following terms of reference:

(i) the level and significance of direct impacts of interactions and incidental mortality associated with fishing

(ii) the efficacy of mitigation measures and avoidance techniques currently in use, and improvements to them, taking into account experience from both inside and outside the Convention Area

(iii) the level and significance of direct impacts of marine debris originating from fishing activities on seabirds and marine mammals within the Convention Area

(iv) improvements to the reporting and data collection requirements regarding incidental mortality

(v) approaches to improve the conservation status of seabirds and marine mammals directly impacted by fishing outside the Convention Area, by collaborating and coordinating with relevant organisations that the Commission has a cooperative arrangement with, including with invited experts as required.

2. To provide any other advice, within its area of expertise, to the Scientific Committee and its working groups as directed by the Scientific Committee.

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[1] 2023

Proposal for an SC-CAMLR and CEP joint workshop on climate change

Proposal for an SC-CAMLR and CEP joint workshop on climate change

Title: Joint CEP/SC-CAMLR climate change and monitoring workshop

Location and timing:

TBD, May-June 2025

Objectives:
Identify synergies and collaboration opportunities between CEP and SC-CAMLR to monitor and manage climate change effects.

Terms of Reference:

Building on the 2009 and 2016 joint workshops and the 2023 SC-CAMLR climate change workshop:

(i) examine how to progress on matters of mutual interest in the marine realm in the context of climate change (including the five joint priority areas identified in the 2009 joint workshop);

(ii) identify common research, monitoring and information needs;

(iii) examine the need to enhance existing monitoring programs to assess the impacts of climate change; and

(iv) propose improvements to strengthen cooperation and coordination between the CEP and SC-CAMLR.

Convener(s): Ms M. Jolly (France) for CEP and Dr. R. Cavanagh (UK) for SC-CAMLR

Steering Committee: Co-conveners, SC-CAMLR bureau, Chair or Vice-Chair of the CEP, experts.

Duration: 2-3 days

External experts and observers: invited

Outputs: Report adopted by the workshop presented to CEP and to CCAMLR's Scientific Committee summarising the outcomes and recommendations of the workshop.

Protocol for toothfish fishery data sharing between SPRFMO and CCAMLR

Protocol for toothfish fishery data sharing between SPRFMO and CCAMLR

Arrangements of the SPRFMO-CCAMLR Data Exchange

SPRFMO and CCAMLR have mutual interests and shared responsibilities for managing the fishery resources of regions of the South Pacific Ocean. In particular, there is overlap between the two organisations with respect to toothfish fisheries. In 2016 CCAMLR and SPRFMO established an arrangement to facilitate data sharing, which was expanded in 2018 with additional specifications to facilitate cooperation on toothfish tagging research and the CCAMLR Catch Documentation Scheme. While the arrangement provides the framework, a specific protocol which details how data of toothfish stocks which potentially straddle the CCAMLR and SPRFMO areas can be exchanged between Members of both Organisations had not yet been developed.

This paper proposes a protocol for exchanging toothfish fishery data between SPRFMO and CCAMLR, developed by the Secretariats of both organisations. This protocol is consistent with the SPRFMO-CCAMLR Arrangement and based on the protocol developed during the SIOFA/CCAMLR joint workshop on the exchange of scientific toothfish data (held online on 29 November and 1 December 2021) which has been endorsed by CCAMLR and SIOFA (SC-CAMLR-41 paragraph 12.4, SC-CAMLR-41/02, Annex 1).

Toothfish fishery data holdings

The toothfish fishery in CCAMLR started in the 1980's and quickly expanded during the 1990's. The CCAMLR toothfish fishery database contains catch data associated to more than 200,000 hauls, of which more than 35,000 have been collected from CCAMLR areas adjacent to the SPRFMO Convention area (Area 88 and Division 58.4.1). Since 1998, CCAMLR Members have released more than 400,000 tagged toothfish and recaptured over 45,000 tagged toothfish among which among which more than 120,000 have been released and 6,000 have been recaptured in CCAMLR area's adjacent to the SPRFMO Convention area.

In SPRFMO, all toothfish fisheries are currently exploratory in nature. The first exploratory fishery, conducted by NZ began in 2016. The European Union began conducting exploratory fishing activities for toothfish to evaluate the feasibility establishing a fishery in 2019. Between 2016 and 2022, 217 fishing events have been carried by two vessels. Since 2016, Members have tagged and release 1,275 toothfish and have recaptured 19 tagged toothfish in the SPRFMO Convention Area.

Toothfish fishery data are reported to the SPRFMO and CCAMLR Secretariat by their Members using the CCAMLR Longline Vessel Data Logbook (C2) and the CCAMLR Scientific Observer Logbook for Longline Fishing. CCAMLR publishes aggregated catch data through the CCAMLR Statistical Bulletin and the CCAMLR Fishery Reports provide additional data summaries.

Catch data from SPRFMO relevant to CCAMLR are included in Member reports to the SPRFMO Scientific Committee. These reports are publicly available through the Scientific Committee meeting webpage on the SPRFMO site.

Specifications for Data Exchange

Annex 1 (paragraph A2-b) of the CCAMLR/SPRFMO data sharing arrangement requires the CCAMLR Secretariat and the SPRFMO Secretariat exchange the release and recapture information (the vessel name and all dates and positions as well as the information about the tags and the biological information of the fish and its fate) for any toothfish released in the waters of one Convention and recaptured in waters covered by the other Convention. To this end, in July each year the SPRFMO Secretariat provides the CCAMLR Secretariat with data for all toothfish which have been recaptured or released in the SPRFMO area during the previous fishing season. The CCAMLR Secretariat then stores those data in its database so they can be included in the tag-linking algorithm. The CCAMLR Secretariat then informs the SPRFMO Secretariat during August of all reliable links between toothfish which have been recaptured or released in the CCAMLR Convention area and recaptured or released in the SPRFMO Convention area. This process is detailed by the flowchart provided in Figure 1.

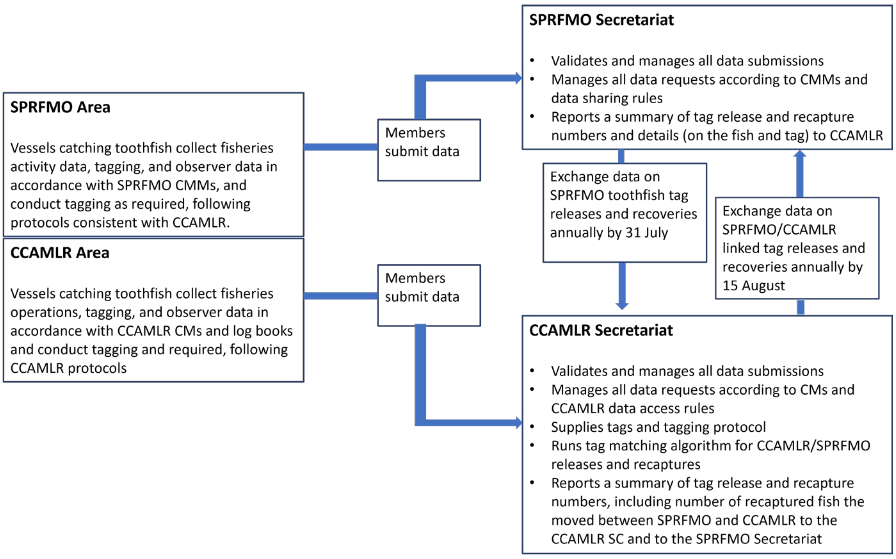


Figure 1: Flowchart of data exchange of tagging information between the CCAMLR and SPRFMO Secretariats

The CCAMLR/SPRFMO data sharing arrangement allows analysts of SPRFMO and CCAMLR Members access to the fine scale toothfish fish fishery data, consistent with the data access, use, and confidentiality rules of each organisation (paragraph 2iic). CCAMLR data can therefore be requested by SPRFMO Members consistent with the CCAMLR Rules for Access and Use of CCAMLR Data. SPRFMO data can be requested by CCAMLR Members consistent with SPRMFO CMM 02-2022 paragraph 6c (ii).

Following the process outlined in the flowchart provided in figure 2, analysts of CCAMLR Members can make their requests for cross-boundary data to the CCAMLR Secretariat through their CCAMLR Scientific Committee representative and analysts from SPRFMO Members can make their requests for cross-boundary data to the SPRFMO Secretariat. For data under the competence of CCAMLR and owned by a CCAMLR Member, the SPRFMO Secretariat would seek permission via the CCAMLR Secretariat. When CCAMLR Members have provided their approval to release the data following standard CCAMLR procedures, the CCAMLR Secretariat will release the data to the SPRFMO Secretariat, who will then release the data to the analyst and highlight the rules for using those data. The opposite would occur in the case of a request for data owned by SPRFMO Members by an analyst of a CCAMLR Member.

Both Secretariats include a summary of all data exchanges into their reports to their Scientific Committees.

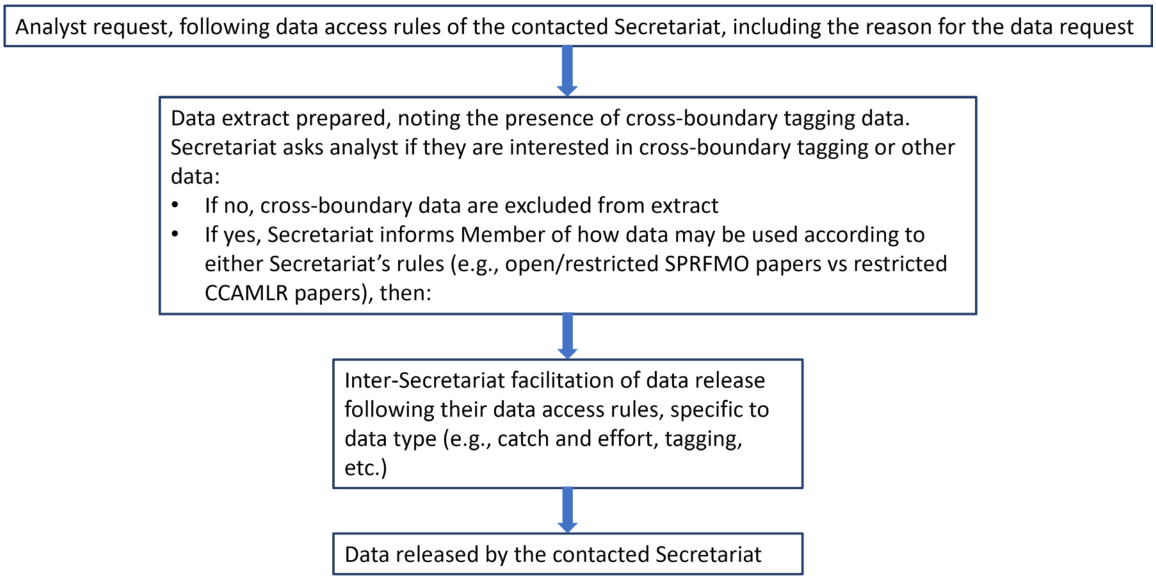
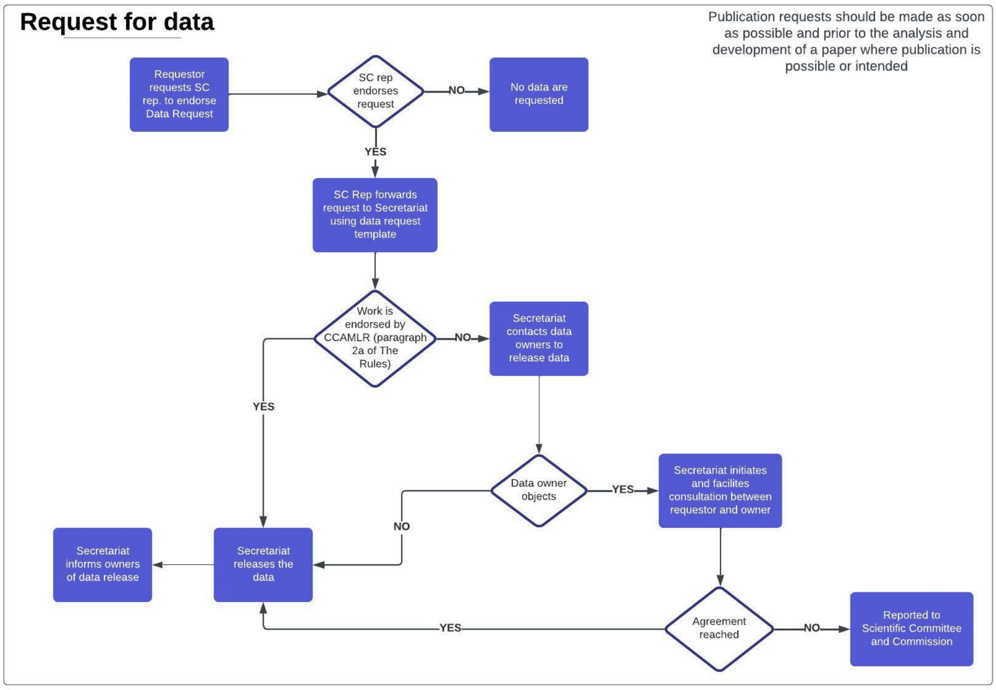


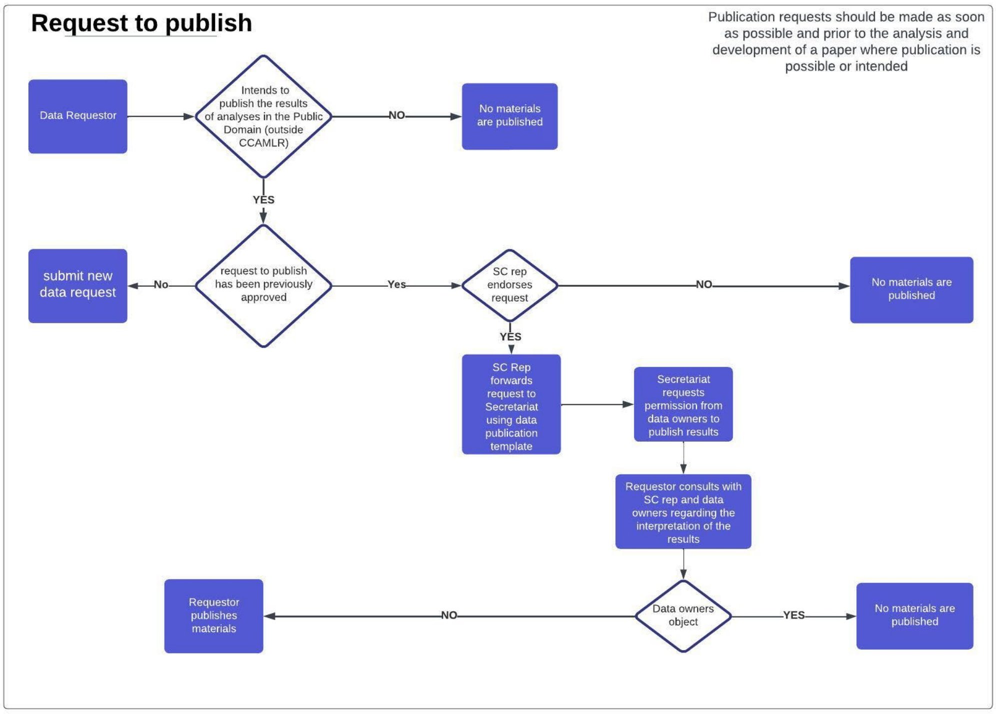
Figure 2: Flowchart of data request pathways for analysts requesting data.

Annex 19

Preliminary data access rules workflow

Preliminary data access rules workflow





Data access rules flow diagrams to be further developed intersessionally (SC-CAMLR-42 paragraph 10.12).