SC-CAMLR-41

**SCIENTIFIC COMMITTEE FOR THE CONSERVATION
OF ANTARCTIC MARINE LIVING RESOURCES**

REPORT OF THE FORTY-FIRST MEETING OF THE SCIENTIFIC COMMITTEE

HOBART, AUSTRALIA
24 – 28 OCTOBER 2022

CCAMLR
181 Macquarie Street
Hobart 7000
Tasmania Australia

Telephone: 61 3 6210 1111
Facsimile: 61 3 6224 8766
Email: ccamlr@ccamlr.org
Website: www.ccamlr.org

Chair of the Scientific Committee
November 2022

This document is produced in the official languages of the Commission: English, French, Russian and Spanish.

Abstract

This document presents the adopted report of the Forty-first Meeting of the Scientific Committee for the Conservation of Antarctic Marine Living Resources held in Hobart, Australia, from 24 to 28 October 2022.

1031-2889

Contents

Report of the Forty-first Meeting
of the Scientific Committee
(Hobart, Australia, 24 to 28 October 2022)

Opening of the meeting

1.1 The Scientific Committee for the Conservation of Antarctic Marine Living Resources met from 24 to 28 October 2022 at the CCAMLR Headquarters in Hobart, Tasmania, Australia. The meeting was chaired by Dr D. Welsford (Australia).

1.2 Dr Welsford acknowledged that the meeting of the Scientific Committee was held on the traditional lands of the Muwinina people.

1.3 Dr Welsford welcomed to the meeting representatives from Argentina, Australia, Belgium, Brazil, Chile, People's Republic of China (China), Ecuador, European Union (EU), France, Germany, India, Italy, Japan, Republic of Korea (Korea), the Kingdom of the Netherlands (Netherlands), New Zealand, Norway, Poland, Russian Federation (Russia), South Africa, Spain, Sweden, Ukraine, United Kingdom of Great Britain and Northern Ireland (UK), United States of America (USA) and Uruguay.

1.4 Other Contracting Parties, Bulgaria, Canada, Cook Islands, Finland, Greece, Mauritius, Islamic Republic of Pakistan, Republic of Panama, Peru and Vanuatu were invited to attend the meeting as Observers. Canada, Finland, Panama and Peru attended. Luxembourg was also invited and attended the meeting.

1.5 Dr Welsford also welcomed to the meeting Observers from intergovernmental organisations the Agreement on the Conservation of Albatrosses and Petrels (ACAP), Commission for the Conservation of Southern Bluefin Tuna (CCSBT), Committee on Environmental Protection (CEP), the International Union for the Conservation of Nature and Natural Resources – the World Conservation Union (IUCN), the Scientific Committee on Antarctic Research (SCAR), the Scientific Committee on Oceanic Research (SCOR), the Southern Indian Ocean Fisheries Agreement (SIOFA), the South Pacific Regional Fisheries Management Organisation (SPRFMO), Western and Central Pacific Fisheries Commission (WCPFC) and non-governmental organisations the Association of Responsible Krill harvesting companies (ARK), the Antarctic and Southern Ocean Coalition (ASOC), the Coalition of Legal Toothfish Operators (COLTO) and Oceanites Inc.

1.6 The List of Participants is given in Annex 1. The List of Documents considered during the meeting is given in Annex 2.

1.7 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.

1.8 Dr Welsford noted that this was the CAMLR Convention's 40th anniversary, and the Scientific Committee had much to be proud of in providing ecosystem-based precautionary advice to enable the Commission to achieve its objective. However, he noted the Scientific Committee still has significant work to do to account for the significant challenges facing the region, and 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 be respectful of each other.

1.9 The report of the Scientific Committee was prepared by M. Belchier (UK), T. Brey, P. Brtnik and J. Caccavo (Germany), C. Cárdenas (Chile), M. Collins and C. Darby (UK), A. Dunn (New Zealand), T. Earl (UK), M. Eléaume (France), M. Favero (Argentina), J. Fenaughty (New Zealand), S. Fielding, (UK), S. Hain (Germany), J. Hinke (USA), S. Hill (UK), C. Jones (USA), S. Kawaguchi and N. Kelly (Australia), B. Krafft (Norway), L. Krüger (Chile), A. Lowther (Norway), D. Maschette (Australia), B. Meyer (Germany), C. Miller (Australia), T. Okuda (Japan), E. Pardo (New Zealand), P. Penhale (USA), C. Péron (France), G. Robson (UK), S. Rodríguez Alfaro (EU), S. Somhlaba (South Africa), Z. Sylvester (Belgium), K. Teschke (Germany), A. Van de Putte (Belgium), N. Walker (New Zealand), G. Watters (USA), X. Zhao and G. Zhu (China) and P. Ziegler (Australia).

Adoption of the agenda

1.10 The Scientific Committee adopted the Provisional Agenda which had been circulated as SC CIRC 22/68 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

1.11 Dr Welsford noted the Scientific Committee's work in the 2021/22 intersessional period. The following meetings had taken place:

(i) SIOFA/CCAMLR joint workshop on exchange of scientific toothfish data (online), 29 November to 1 December 2021 (SC-CAMLR-41/02, Annex 1). Convened by Dr D. Welsford (Australia) and Mr A. Dunn (New Zealand) and attended by 42 participants from 11 Members

(ii) Scientific Committee Symposium (SC-Symposium, online), 8 to 10 February 2022 (Annex 4). Convened by Dr D. Welsford (Australia) and attended by 110 participants from 23 Members with 8 papers considered

(iii) Workshop on Conversion Factors for Toothfish (WS-CF, online), 12 and 13 April 2022 (WG-FSA-2022, Appendix J). Convened by Mr N. Gasco (France) and Mr N. Walker (New Zealand) and attended by 45 participants from 11 Members with 6 papers considered

(iv) Workshop on the Ross Sea Data Collection Plan (WS-RSDCP, online), 12 August (WG-FSA-2022, Appendix D). Convened by Dr L. Ghigliotti (Italy) and Mr N. Walker (New Zealand) and attended by 30 participants from 11 Members with 3 papers considered

(v) Working Group on Acoustic Survey and Analysis Methods (WG-ASAM, online), 30 May to 3 June 2022 (Annex 5). Convened by Dr S. Fielding (UK) and Dr X. Wang (China) and attended by 37 participants from 13 Members with 17 papers considered

(vi) Working Group on Statistics, Assessments and Modelling (WG-SAM, online), 27 June to 1 July 2022 (Annex 6). Convened by Dr T. Okuda (Japan) and Dr C. Péron (France) and attended by 67 participants from 17 Members with 35 papers considered

(vii) Working Group on Ecosystem Monitoring and Management (WG-EMM, online), 4 to 11 July 2022 (Annex 7). Convened by Dr C. Cárdenas (Chile) and attended by 120 participants from 21 Members with 67 papers considered

(viii) Working Group on Incidental Mortality Associated with Fishing (WG-IMAF), 10 to 14 October 2022 (Annex 8). Convened by Dr M. Favero (Argentina) and Mr N. Walker (New Zealand) and attended by 4 invited experts and 39 participants from 13 Members with 20 papers considered

(ix) Working Group on Fish Stock Assessment (WG-FSA), 10 to 20 October 2022 (Annex 9). Convened by Mr S. Somhlaba (South Africa) and attended by 77 participants from 17 Members with 74 papers considered.

1.12 The Scientific Committee Chair also attended CEP XXIV, which was held from 23 to 27 May 2022 in Berlin, Germany, and made a pre-recorded presentation on vulnerable marine ecosystems (VMEs) and fishing and sustainable deep-sea fisheries management in CCAMLR at the UN DOALOS workshop 2 August 2022 (online).

Advances in statistics, assessments, modelling, acoustics and survey methods

Statistics, assessments and modelling

2.1 The Scientific Committee reviewed advice from WG-SAM (SC-CAMLR-41/05), presented by the Co-conveners Dr Péron and Dr Okuda, which was directed to WG-FSA, Members, or to the Scientific Committee.

Assessments to estimate sustainable yield in established or assessed fisheries

2.2 The Scientific Committee noted the work undertaken by WG-SAM in reviewing the latest updates on developing the krill stock assessment model (Grym) and considered that the structure of the Grym krill assessment model is suitable for use, although further discussion is required on a number of parameters such as proportional recruitment parameters, length-weight relationship and length-at-maturity relationship. The Scientific Committee noted that WG-SAM agreed that further study of these parameters was needed but also considered that methods currently used represented the best available science.

2.3 The Scientific Committee noted the new method for calculating precautionary yield in krill stock assessment projections (WG-SAM-2022/28 Rev. 2) and endorsed the recommendation of WG-SAM to consider management strategy evaluations and effects of any changes in decision rules on the krill fishery as priority future work (WG-SAM-2022, paragraph 3.21).

2.4 The Scientific Committee noted the need to consider climate change impacts when undertaking management strategy evaluations and that the CCAMLR decision rules may need to be revised in light of climate change. The Scientific Committee noted the need to monitor population changes in response to climate change, including changes in distribution.

2.5 The Scientific Committee also considered that more recent recruitment trends should be considered in analyses to inform management advice.

2.6 The Scientific Committee noted the discussions of WG-SAM on the standardisation of longline fishing hauls, the validation of the Casal2 software and its user guide, vector-autoregressive spatio–temporal (VAST) spatial models for by-catch, and finally the development of stock assessment models in Subareas 48.3 and 48.4.

2.7 The Scientific Committee agreed that Casal2 has been validated for use by CCAMLR for integrated statistical catch-at-age toothfish stock assessments (WG-SAM-2022, paragraph 3.31) recognising the collaborative approach in testing the approach in the lead-up to WG-SAM.

2.8 The Scientific Committee recommended that the technical settings and guidelines for validating Casal2 files be used for any Casal2 models presented to CCAMLR (WG-SAM-2022, Appendix D) and encouraged further research on parameter transformations to improve stability and Markov Chain Monte Carlo (MCMC) performance in Casal2 models.

2.9 The Scientific Committee noted that a Casal2 training workshop, potentially held in conjunction with WG-SAM-2023, would be helpful to build capacity across the CCAMLR science community in the use of Casal2 in time for WG-FSA-2023.

2.10 The Scientific Committee noted the benefit of experiments to evaluate the impacts of longline fishing practices (such as bait type, soak time) on subsequent analyses of fishing data, such as catch rate standardisation analyses (WG-SAM-2022, paragraphs 3.23 to 3.25).

Assessment of stocks of established toothfish fisheries

2.11 The Scientific Committee noted the multiple papers submitted by UK scientists to WG-SAM on the Subarea 48.3 Patagonian toothfish (*Dissostichus eleginoides*) fishery (WG-SAM-2022, paragraphs 3.37 to 3.48) recognising that these papers fully responded to the requests of WG-FSA from 2019 and 2021, as well the recommendations of CCAMLR's independent review of the toothfish stock assessments. These papers included a new estimate of tag-loss rates, new methods for estimating age at maturity and growth for each sex, stock evaluation updates and model diagnostics.

2.12 The Scientific Committee noted that WG-SAM considered the stock assessment of *D. eleginoides* in Subarea 48.3 as being among the most advanced in the Convention Area and that it represents best available science.

Stock assessment for data-limited toothfish fisheries

2.13 The Scientific Committee noted the discussions at WG-SAM about data-limited approaches, including recommendations to the Secretariat on improvements of the trend analysis, which was further discussed at WG-FSA-2022.

2.14 The Scientific Committee noted examples of data-limited approaches provided in addition to the toothfish stock assessment in Subarea 48.3 (also see paragraphs 2.11 and 2.12) which indicated similar exploitation rates (4%) as those estimated by the integrated CASAL stock assessments and which are also consistent with CCAMLR's management objectives for research fishing on toothfish stocks. The Scientific Committee noted the value of this comparative approach to improve communication and understanding of stock estimates between Members.

2.15 The Scientific Committee noted the development of a survey design tool to create simulated survey outputs by resampling historic catch, effort and observer data, and test survey designs in areas where longline fishing has previously occurred. It welcomed the proposal of the authors to share this tool with the Secretariat and other Members for work on research design.

2.16 The Scientific Committee noted the value in using different numerical approaches to corroborate stock assessment outputs. It further supported the idea of using simple methods and graphical approaches to communicate fishery performance to Commissioners and encouraged all Members to consider such an approach in parallel to the communication of stock assessment outputs.

2.17 The Scientific Committee noted that the graphical summaries of stock performance reviewed by WG-SAM for the Subarea 48.3 toothfish stock demonstrated that the current fishing selection pattern and harvest rate is precautionary in achieving the CCAMLR objective of a long-term average of 50% of B_0. In addition, the graphical analysis showed that the Subarea 48.3 toothfish stock is exploited at a fishing mortality that is currently at around half of maximum sustainable yield (F_{MSY}). It is therefore well below the thresholds that regional fishery management organisations would consider appropriate limits or targets.

Review of new research proposals

2.18 The Scientific Committee noted that WG-SAM provided advice on two proposals: the Ross Sea shelf survey and the Antarctic toothfish (*D. mawsoni*) exploratory fishery in Divisions 58.4.1 and 58.4.2. These were further considered by WG-FSA.

Review of results of current research plans and research proposals

2.19 The Scientific Committee noted that WG-SAM considered four proposals: two acoustic proposals targeting icefish and two *D. mawsoni* research plans. The Working Group considered that WG-ASAM's participation in the evaluation process of acoustic proposals for icefish would be relevant.

Other matters

2.20 The Scientific Committee noted the value of open-access data and analysis scripts to share analysis approaches. An example provided in SC-CAMLR-41/BG/25 highlights the first full reconstruction of time series of catch densities for all species throughout the Convention Area, based on data in the *CCAMLR Statistical Bulletin* and publicly available knowledge and information (Grant et al., 2021). A freely available R script enables assessments of the fishing pressure that may have occurred in different locations at different times, better supporting ecosystem assessments of the effects of fishing in the Southern Ocean.

Acoustic survey and analysis methods

2.21 Dr Fielding and Dr Wang co-convened the WG-ASAM-2022 meeting and the report (Annex 5) was presented by Dr Fielding.

2.22 The Scientific Committee noted the discussions on standardisation of procedures for survey design, data analysis and quality control of acoustically derived areal krill biomass estimates, identifying the strengths and weaknesses of the two different methods agreed by WG-ASAM to identify krill in acoustic data (dB-difference and swarm-based technique, WG-ASAM-2022, paragraph 2.4).

2.23 The Scientific Committee noted that the Secretariat had developed a method to standardise the computation of the area of CCAMLR management strata for krill. This method and updated strata metrics were used during WG-ASAM-2022 for krill biomass estimations in Subarea 48.1.

2.24 The Scientific Committee noted that Table 9 of WG-ASAM-2022 presents four different time periods over which krill biomass estimates could be averaged in each stratum. Although these estimates can be considered as best available science, WG-ASAM highlighted that they should be considered with caution until further analyses and standardised surveys are conducted.

2.25 The Scientific Committee noted the discussion in WG-ASAM-2022, paragraph 3.24, and WG-EMM-2022, paragraph 2.34, and agreed that in those strata where only a single survey was available, the lower one-sided 95% confidence limit of the biomass estimate is used to provide short-term precautionary advice, as applied for mackerel icefish (*Champsocephalus gunnari*) assessments using trawl surveys.

2.26 Some Members requested a discussion in WG-EMM and WG-ASAM about the framework of the lower 95% confidence level regarding the acoustic survey standardised confidence levels of krill biomass.

2.27 The Scientific Committee endorsed the recommendation of WG-ASAM-2022 that acoustic krill biomass surveys presented to CCAMLR should be accompanied by a set of standardised metadata describing data collection and processing methods as described in Tables 2 to 8 of WG-ASAM-2022 and that the computer programs used to derive the estimate should be validated against a reference dataset.

2.28 The Scientific Committee also endorsed the recommendation of WG-ASAM for Members to submit acoustic survey metadata to the Secretariat.

2.29 The Scientific Committee highlighted the importance of standardisation of data collection and data reporting procedures for acoustic krill biomass surveys.

2.30 The Scientific Committee noted that the ongoing improvement of technology and algorithms for processing acoustic data may make near real-time processing of acoustic data possible in the near future. It requested that WG-ASAM include consideration of how acoustic data from fishing vessels, moorings, autonomous vehicles and other platforms could enable rapid updates of krill fishery management, including detection of impacts caused by changing environmental conditions and fishing activity.

2.31 The Scientific Committee further noted that results from traditional vessel surveys, together with data collected from other types of data collection platforms, will provide better understanding of krill population dynamics and its main drivers.

2.32 The Scientific Committee stressed the importance of contributions by commercial vessels in acoustic data collection for use in estimating krill biomass and in developing estimates of spatial and temporal dynamics. It endorsed the WG-ASAM recommendation of updating the acoustic instrument instructions for unsupervised acoustic data collection on commercial vessels and encouraged discussion on how to use the automated data processing techniques for on-board processing of data. It also encouraged Members to explore ways to enable near real-time processing of acoustic data and present them at WG-ASAM in the future.

2.33 The Scientific Committee noted the discussions and technical advice provided by WG-ASAM on a proposal for acoustic trawl surveys of *C. gunnari* in Subarea 48.2 by Ukraine. It recognised the merit of acoustic surveys for estimating the pelagic fraction of *C. gunnari* biomass, which may not be vulnerable to bottom trawl surveys used in icefish stock assessments.

2.34 The Scientific Committee welcomed the discussions at WG-ASAM on icefish acoustic surveys and encouraged Members to develop methods for acoustic-based investigation of other pelagic and demersal organisms besides krill. WG-ASAM noted that when assessing organisms, including icefish that may spend all, or part of, their life in the pelagic environment, the Scientific Committee would benefit using the multidisciplinary expertise across all working groups when developing its advice.

Harvested species

Catches in the Convention Area

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

Krill resources

Status and trends

3.2 The Scientific Committee reviewed krill fishing activities for 2020/21 and 2021/22 (SC-CAMLR-41/BG/01). The Scientific Committee noted that:

(i) in 2020/21 (1 December 2020 to 30 November 2021), five Members fished in Subareas 48.1 and 48.2 and the total catch of krill reported was 371 526 tonnes, of which 161 772 tonnes and 209 754 tonnes were taken from Subareas 48.1 and 48.2 respectively

(ii) in 2021/22 (to 31 July 2022), five Members fished in Subareas 48.1, 48.2 and 48.3, and the total catch of krill reported was 353 885 tonnes, of which 143 413 tonnes, 191 183 tonnes and 19 289 tonnes were taken from Subareas 48.1, 48.2 and 48.3 respectively.

3.3 The Scientific Committee noted SC-CAMLR-41/BG/35 that used a range of monitoring methods (predator breeding performance and diets, icefish diets and plankton tows) to indicate a scarcity of krill in Subarea 48.3 for an extended period during much of 2021. This followed similar anomalies in 1991, 1994, 1998, 2009 and 2016.

3.4 The Scientific Committee noted that the standing stock of krill in Subarea 48.3 is not considered to be self-sustaining, with some previous studies demonstrating that krill in Subarea 48.3 originates from Subareas 48.1 and 48.2. It agreed that mechanisms influencing the dynamics of krill in Subarea 48.3 require further study. The Scientific Committee recommended that further analysis of these anomalies be undertaken and presented at WG-EMM-2023.

Acoustic surveys of krill

3.5 SC-CAMLR-41/09 proposed requirements for vessel-based acoustic surveys of krill in Subarea 48.1 in responses to the revision of CM 51-07. The authors recommend that Members fishing for krill coordinate and conduct regular acoustic surveys at subarea scale and specified minimum requirements for those acoustic surveys. The authors propose that requirements for vessel-based acoustic surveys of krill in Subarea 48.1 should include:

(i) participation by all Members fishing for krill

(ii) full spatial coverage of all management units in Subarea 48.1

(iii) random transects with respect to distribution of krill within each management unit, ≥7 transects with average spacing determined by number of transects and size of management unit, transects oriented orthogonal to main sources of variation in density

(iv) acoustic echosounders should be calibrated before or after each survey, include acoustic returns at about 120 kHz, enable data capture from the surface to 250 m and other settings standardised as far as possible

(v) net tows and conductivity temperature depth probe (CTD) stations should have calibrated flowmeters to quantify volume filtered by nets and calibrated CTD instruments, stations spaced every 25 km along acoustic transects, oblique near-surface to 250 m net tows, codends ≤5 mm knot-to-knot, ≥100 krill length measurements per net tow

(vi) all metadata and quality-assured and -controlled data should be submitted to the Secretariat prior to WG-ASAM. WG-ASAM will then estimate krill biomass, or validate and combine biomass estimates using agreed standardised procedures. Resultant data will be disseminated via the Krill Fishery Report.

3.6 The Scientific Committee noted that the proposal in SC-CAMLR-41/09 required further consideration, such as first season from when these coordinated surveys are to be implemented, and the frequency and timing (e.g. month) of such surveys.

3.7 The Scientific Committee noted the existing capacity for conducting krill surveys by the fishing fleet, which have in many cases similar acoustic capabilities and longer presence in the field than available scientific vessels.

3.8 The Scientific Committee agreed that there is a need for more frequent biomass surveys to monitor status of the krill stock and other elements of the ecosystem, and that linking these surveys to the CCAMLR Ecosystem Monitoring Program (CEMP) would be valuable. It further noted that integrating data obtained from various platforms on krill resources will be important.

3.9 The Scientific Committee noted that mesh size of nets should be tailored to the specific objectives of any survey, as sampling for recruitment estimates or biomass estimates of the stock may have different design requirements.

3.10 The Scientific Committee noted that data from a series of fishing-vessel-based krill surveys could provide valuable information to study the effects of climate change on Antarctic marine ecosystems. Obtaining this information would be strengthened through collaboration and integration between research surveys and fishing vessel surveys, especially as the fishery expands.

3.11 The Scientific Committee agreed that further discussions on how to implement an integrated data collection plan for the krill fishery is required and tasked WG-ASAM and WG-EMM to include a special agenda item to advise on specifications of echosounders, krill sampling protocols and other practical implementation aspects to most effectively collect data during vessel-based surveys. In addition to these aspects, the Scientific Committee agreed that other information to inform future management should be collected, which may include a broader data collection plan for the fishery.

Krill observer workshop

3.12 The Scientific Committee noted the krill observer workshop which was due to be held by China in 2020 (SC-CAMLR-38, paragraph 13.1), had been postponed due to COVID-19 restrictions. The Scientific Committee noted that China offered to host this workshop in 2023, and reflected that this workshop would provide a forum for discussion of biological data collection protocols to ensure that data collected are appropriate for the further developments of the CCAMLR krill spatial overlap analysis framework and Grym input parameters, as well as any other monitoring of the fishery that may be required from observers.

3.13 SC-CAMLR-41/16 Rev. 2 proposed a workplan for developing and implementing data collection needs for CCAMLR krill fisheries, and re-scoping of the krill observer workshop. Table 1 provided topics identified by the Scientific Committee related to data collection requirements and time allocation, krill length-weight relation, fish by-catch sampling and reporting, marine mammal interactions and sampling, bird warp strikes and revisions to the C1 form.

3.14 The Scientific Committee noted that the krill observer workshop is tentatively scheduled for three days in Shanghai, China, beginning 10 days after the completion of WG-EMM in July 2023. The 10-day lag after WG-EMM is to accommodate potential quarantine requirements for entering China. If such restrictions are lifted, the start time of the workshop could be brought forward. The organisers will provide an update on the situation closer to the workshop.

3.15 The Scientific Committee agreed that this workshop should be held in 2023 in China and endorsed the following terms of reference:

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

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

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

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

5. Discuss increases in Scheme of International Scientific Observation (SISO) observer coverage, and refinement of sampling and reporting protocols.

Progress towards acoustic biomass estimates

3.16 The Scientific Committee noted WG-EMM discussions on the review of trawl gear information provided by vessels operating in the krill fishery as part of the notification process. These include the consideration of a proposed framework to standardise reporting requirements on trawl gear based on SC-CAMLR-XXVIII, Annex 9, and in accordance with CM 21-03 (WG-EMM-2022, paragraphs 2.21 and 2.22).

3.17 The Scientific Committee recommended that information submitted on gear configuration should include details on the mesh size of any codend liners as these will affect gear selectivity.

3.18 The Scientific Committee endorsed WG-EMM recommendations that the Secretariat be tasked with collating net diagrams and net configuration measurements submitted during the fishery notification process in the CCAMLR gear library, and that Members be requested to submit papers with additional net diagrams, configurations and descriptions of operations to subsequent meetings of WG-EMM for inclusion in the gear library.

3.19 The Scientific Committee noted WG-EMM discussions on krill acoustic biomass estimations and confidence intervals (WG-EMM-2022, paragraphs 2.25 to 2.37) (see also WG-ASAM-2022).

3.20 The Scientific Committee endorsed WG-EMM's recommendation that future analyses would benefit from including data from the long time series of surveys conducted by Peru in the Antarctic Peninsula area (WG-EMM-2022, paragraph 2.29) and requested the Secretariat liaise with relevant scientists to seek access to these data.

3.21 The Scientific Committee noted that WG-EMM had identified that the best contemporary biomass estimate would, for the purpose of an initial revision to catch limits in Subarea 48.1, be obtained by computing the long-term average, and therefore recommended using all available data ('yall', 1996–2020) for those strata with more than one survey (WG-EMM-2022, Table 1).

3.22 The Scientific Committee noted WG-EMM discussions on estimating and representing uncertainty in krill acoustic biomass and recommended that the lower bound of the one-sided 95% confidence interval (assuming a lognormal distribution) be used for strata with a single survey to provide a precautionary biomass estimate (WG-EMM-2022, paragraph 2.34).

3.23 The Scientific Committee recommended that working groups should consider the issue of uncertainty in acoustic biomass estimates and in particular, the issue of choosing the most appropriate time series/period of acoustic survey data to derive biomass estimates and how this should be applied in data-limited management areas.

3.24 The Scientific Committee recommended that given the periodic and dynamic nature of krill population dynamics, future catch limits should be revised frequently to ensure a precautionary management of the krill fishery.

3.25 The Scientific Committee noted that the use of fishing vessels to undertake regular acoustic surveys within management strata will be essential in order to obtain regular biomass estimates. However, it noted that the calibration of echosounders on fishing vessels was essential and tasked WG-ASAM to prioritise reviewing fishing vessels' echosounder calibration methods (paragraph 3.11).

Stock hypotheses

3.26 The Scientific Committee noted that as a proportion of the krill stock is transported from Subarea 48.1 to Subareas 48.2 and 48.3, a holistic approach to all subarea catch limits is required when fully implementing the new management strategy. The Scientific Committee supported the recommendation from WG-SAM-2022 and WG-EMM-2022 that establishing a krill stock hypothesis would provide a framework for interpreting patterns observed in survey and fishery data, and provide a crucial tool to direct surveys and analytical efforts (e.g. surveys designed to investigate recruitment in hypothesised source areas).

3.27 The Scientific Committee endorsed WG-EMM's recommendation for a krill stock hypothesis workshop but noted that the need for the development of a holistic approach for Area 48 should not preclude the development of management measures at finer spatial scales (SC-CAMLR-40, paragraph 3.28).

3.28 The Scientific Committee noted that the SCAR Krill Expert Group (SKEG) intends to convene an online expert group to discuss and develop krill stock hypotheses in 2023. The Scientific Committee requested that SKEG develop a working stock hypothesis for the krill in Area 48 based on best available science and submit a report for consideration by WG-EMM. The Scientific Committee noted that SKEG intended that the outputs of the online expert group would be a 'living document' that would be updated as new information on the krill stock in the region became available.

3.29 The Scientific Committee encouraged contributions to SKEG on stock hypothesis and suggested that the spatial scope could be extended beyond Area 48, i.e. to include Subarea 88.3 for which there is little information on krill.

Progress towards a stock assessment

3.30 The Scientific Committee noted WG-FSA discussions on krill biomass estimation (WG-FSA-2022, paragraphs 7.9 to 7.14) and on estimation of a precautionary exploitation rate (gamma) (WG-FSA-2022, paragraphs 7.5 to 7.18).

3.31 The Scientific Committee endorsed the recommendation by WG-FSA (WG-FSA-2022, paragraph 7.19) to use the US AMLR survey recruitment series from all trawls (day and night) from years which include data from the Joinville stratum, as well as the Russian Subarea 48.1 survey to derive recruitment parameters for Grym which resulted in a new value of gamma, 0.0338 (WG-FSA-2022, Appendix G).

3.32 The Scientific Committee welcomed the revised estimate of gamma and noted that it was the first revision to this parameter for several decades and that it was based on the best available science. The Scientific Committee noted that it would be useful to record the sources of uncertainty in the estimation of gamma and noted that the parameter should be revised based on updated Grym models as new sources of data become available.

3.33 The Scientific Committee also endorsed the recommendation by WG-FSA (WG-FSA-2022, paragraph 7.20) that a gamma value of 0.0338 be used in the calculation for the Subarea 48.1 catch limits.

3.34 Dr T. Ichii (Japan) recalled that the revised estimate of gamma for krill (0.0338) was lower than the exploitation rate for toothfish (4%). He recalled that the low value of gamma resulted from both the high variability of the krill stock (WG-EMM-2022, paragraph 2.41) and the high target level of escapement (75%) in contrast with 50% for toothfish due to the demand of krill predators (WG-Krill-1994, paragraph 4.95). He noted that the conservation of krill predators is already considered in estimating gamma and thus further subdividing the quota through the spatial overlap analysis (baseline scenario) could be considered over-precautionary.

Progress towards a spatial overlap assessment

3.35 The Scientific Committee noted WG-EMM discussions on the development of the risk assessment for Subarea 48.1 (WG-EMM-2022, paragraphs 2.66 to 2.77) and endorsed the Working Group's recommendation to rename the risk assessment analysis the 'spatial overlap analysis'. The Scientific Committee noted that the Working Group considered that the term krill risk assessment was potentially misleading to managers and Commissioners as it implied an unspecified level of threat, whereas the values produced from the analysis produce relative risk levels.

3.36 The Scientific Committee endorsed WG-EMM-2022, paragraph 2.8, which recommended that data on the overwinter distribution of South Shetland Islands (SSI) fur seal juveniles be integrated into the data layers of the spatial overlap analysis and the Domain 1 marine protected area (D1MPA) proposal. The Scientific Committee also noted that this previously depleted population has fallen below a level which ensures greatest net annual increment. As such, it should be of concern to the Commission.

3.37 The Scientific Committee considered SC-CAMLR-41/18 Rev. 1 which provided details of Russian proposals for the risk assessment framework based on recent Russian survey data obtained in Subarea 48.1. The authors noted that krill flux should be a key factor in developing management advice and highlighted that during the survey period changes in krill dynamics were observed that were thought to be independent of fishery effects or predator consumption and conclude that whilst there may be spatial overlap between the fishery and predators there may not be functional overlap. The paper emphasised the need to integrate CEMP data into the risk assessment framework.

3.38 The Scientific Committee noted that whilst a range of uncertainties remain including variable CEMP coverage between strata and the effects of krill flux, it should not prevent progress with the development of the spatial overlap analysis in Subarea 48.1. It noted that spatial overlap analyses are preliminary, and their results need to be considered with caution when developing advice.

3.39 The Scientific Committee recalled that the D1MPA proposal, which many Members consider is based on the best available science (SC-CAMLR-38, paragraph 6.58), might provide a way to ensure protection not only of the distinctive fur seal colony at Cape Shirreff but to the wider Antarctic Peninsula ecosystem.

Ecosystem effects in the krill fishery

3.40 The Scientific Committee considered SC-CAMLR-41/BG/33 which outlines a proposal for a workshop to enhance CEMP based on recommendations arising from WG-EMM-2022. The Scientific Committee recalled that the last review of CEMP was in 2003 and that revised terms of reference were developed in 2018. The paper proposes a staged approach, with the first workshop to be held alongside WG-EMM in 2023 and a follow-up virtual workshop schedule for 2024.

3.41 The Scientific Committee noted that the revised CEMP should be introduced at the same time as the development of the new krill management strategy to ensure that appropriate monitoring of predators is in place should krill catch limits be increased. The Scientific Committee requested that the Convener of WG-EMM consider how this can be best facilitated and integrate the CEMP review in the Working Group's workplan.

3.42 The Scientific Committee endorsed the recommendation of WG-EMM-2022, paragraph 2.99, that there is a need to develop sustainable funding mechanisms for the CEMP work required to deliver and maintain the krill fishery management approach. This could be developed using contributions to the CEMP Special Fund and the CCAMLR General Capacity Building Fund.

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

3.43 The Scientific Committee considered WG-FSA deliberations and recommendations concerning the spatial allocation of krill catch derived from the new stock assessment and the spatial overlap analysis (WG-FSA-2022, paragraphs 7.23 to 7.46).

3.44 The Scientific Committee recognised the extensive amount of work that had been undertaken by its working groups in the last year to progress the development of the new krill management approach in Subarea 48.1. The Scientific Committee noted that substantial scientific progress had again been made this year, despite the restrictions on time available due to the requirement for virtual intersessional meetings of some working groups.

3.45 The Scientific Committee recommended that the Grym data and parameters in WG-FSA-2022, Appendix G, and acoustic biomass estimates in WG-EMM-2022, Table 1, be used for computing precautionary catch limits within Subarea 48.1 using the baseline scenario from the spatial overlap analysis was the most appropriate (Table 2).

3.46 The Scientific Committee noted that a total catch limit for Antarctic krill (*Euphausia superba*) in Subarea 48.1 set at 668 101 tonnes for 2022/23 would be consistent with the precautionary yield estimated using the CCAMLR decision rules for krill. It noted that subdividing this total catch limit among management units and seasons as presented in Table 2, would be consistent with the process agreed for setting krill catch limits (SC-CAMLR-38, paragraph 3.30). The Scientific Committee further agreed that the catch limits presented in Table 2 are based on the use of the best available science.

3.47 The Scientific Committee noted that that there had been considerable progress towards the development of a revised krill fishery management approach over the last three years and, following reviews and comments on the approach and information contributing to it during 2022 by WG-ASAM, WG-SAM and WG-EMM, it can form the basis for advice on the revision of CM 51-07 (WG-FSA-2022, paragraph 7.33).

3.48 The Scientific Committee noted WG-FSA's discussions in WG-FSA-2022, paragraphs 7.41 to 7.45, regarding the implementation of the new management unit catch limits proposed in WG-FSA-2022 (Table 2). The Scientific Committee noted that substantial increases in catch limits compared with historical catches in the Elephant Island, Gerlache Strait, Drake Passage and Powell Basin management units could outpace the ability to monitor catches, by-catch and the impact on the wider ecosystem (Table 3). A staged increase in catch limits, in line with increased survey frequency, implementation of CEMP sites and enhanced data collection on vessels should be considered by the Scientific Committee and Commission in order to ensure that increases in harvesting are concomitant with an increased collection of data.

3.49 The Scientific Committee recommended future monitoring include:

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

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

(iii) monitoring of the status of dependent predator species, including cetaceans

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

3.50 The Scientific Committee expressed concern over the potential implications of the rapid expansion of the krill fishery into data-limited areas such as the Gerlache Strait and noted that the impact of increased krill catches and their spatial and temporal concentration had yet to be evaluated. The Scientific Committee also noted that the Gerlache Strait has been identified as a priority area for conservation during the participatory process of the D1MPA proposal (SC-CAMLR-39, paragraph 5.27iii), and that the new management strategy should be considered alongside the proposed D1MPA conservation objectives so that both processes are integrated.

3.51 The Scientific Committee recommended that the Commission consider the consequential actions needed with increased catch limits on monitoring of the fishery, including:

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

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

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

(iv) refinement of sampling and reporting protocols for scientific observers (paragraphs 3.12 to 3.15).

3.52 The Scientific Committee agreed that the current management approach as outlined in CM 51-07 is considered precautionary but noted that it does not include recently completed science (paragraph 3.58) and that if the future monitoring of the krill and ecosystem status and reporting (for example see WG-FSA-2022, paragraphs 7.42 and 7.43) does not provide regular information updates required to support the krill management approach used in Subarea 48.1, the catch limit currently outlined in CM 51-07 should be reinstated.

3.53 Dr S. Kasatkina (Russia) noted that considerable progress had been made during the intersessional meetings by the different working groups and that the advice provided in WG-FSA-2022, paragraph 7.28, accurately reflected the outputs of the Working Group’s activities. However, she highlighted the concerns of Russia, as outlined in SC-CAMLR-41/19 and reflected in paragraph 7.35 of the WG-FSA-2022 report. She noted that in her opinion it is important to consider that the management process is currently working on one area, Subarea 48.1, and does not yet include Subareas 48.2, 48.3 and 48.4 assuming that a management review of the fishery in other Subareas 48.2, 48.3 and 48.4 will be provided at a later stage. In her opinion this stepwise approach to reviewing the management of the krill fishery in Area 48 has no scientific justification and assumes independent krill subpopulations in each Subarea 48.1, 48.2, 48.3 and 48.4.

3.54 The Scientific Committee agreed 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. It agreed that this should also include measures to mitigate potential wildlife interactions. However, there was insufficient time to allow further consideration of these important issues.

3.55 The Scientific Committee noted that, although the COVID-19 pandemic had impacted most science programs and the ability to hold in-person meetings, the krill management workplan remained on track.

3.56 The Scientific Committee noted that outstanding items in the workplan remained, and that these should be reviewed at WG-EMM-2023.

3.57 Dr Kasatkina highlighted that in her opinion there were still a range of issues that needed to be resolved relating to the new krill management approach and there was no urgent need for the new measures to be introduced. She stated that the current management approach based on CM 51-01 and CM 51-07 was precautionary and in her view should be maintained for another year to allow time for the outstanding issues with the new approach to be addressed.

3.58 Some Members noted that CCAMLR uses a scientific approach that incorporates uncertainty to provide a precautionary approach to management. The spatial overlap approach shows that a reduction in the catch of krill from the Bransfield Strait could be warranted. The recommendation of a rollover of CM 51-07, therefore, may not account for the best available science that has been developed, and potentially result in a less precautionary approach being applied for Bransfield Strait.

3.59 Some Members felt that the newly derived catch limits in Table 2 could be modified to form the basis of management advice for the 2022/23 fishing season but also noted the concerns that had been expressed by many Members who suggested that a new management strategy could be implemented with the following provisions:

(i) no revision to CM 51-01 to ensure that the overall catch limit for Subarea 48.1 remains under the trigger value (620 000 tonnes)

(ii) implement a 'staged approach' which could be accommodated by initially advising lower catch limits in some strata and increasing to the catch limits computed by WG-FSA through time

(iii) revise CM 51-07 for two fishing seasons as an interim measure to incentivise ongoing scientific work to address uncertainties

(iv) seasonal subdivisions of catch limits should be calculated in the same proportions as developed at WG-FSA (Table 2)

(v) CM 51-07 should include new paragraphs that commit Members to future research surveys and harmonisation with the D1MPA.

3.60 Some Members noted that modifying CM 51-07 on its own may alter current fishing patterns in a way that may lead to unexpected consequences. They noted that removing the ability to revise CM 51-01 as a means to keep the catch limit below the 620 000 tonnes trigger limit may not work as intended, if the revisions of CM 51-07 are not considered in tandem, as the conservation measures are inextricably linked.

3.61 The Scientific Committee noted that the revision/alteration of the conservation measures used to manage the krill fishery is a management discussion, and recommended that SC-CAMLR-41/12 should be forwarded to Commission for consideration.

3.62 The Scientific Committee noted that the development of the new krill management approach in the preceding three years has required the working groups to incorporate a range of uncertainties in their analyses. It further noted that during the meeting a range of concerns and uncertainties were raised related to the implementation of the revised krill catch limits, but they have not yet been fully articulated at this meeting, and there was insufficient time in the Scientific Committee this year to adequately address them.

3.63 The Scientific Committee also noted the following concerns:

(i) uncertainty in the biomass estimate from the conversion factor on the values of krill echoes to krill biomass density

(ii) uncertainty of average biomass estimates combining different surveys

(iii) the uncertainty in the estimation of by-catch rates on the finfish by-catch in the krill fishery

(iv) WG-FSA also noted the uncertainties in predator requirements, and information on critical areas for krill reproduction, as determined in the spatial overlap analysis.

3.64 The Scientific Committee recommended that these concerns and uncertainties should be clearly articulated by Members during the intersessional period for consideration within the working groups alongside recommendations as to how they should best be addressed.

3.65 The Scientific Committee noted that there are a range of spatial management initiatives within Subarea 48.1, including the ARK voluntary restricted zones and the D1MPA proposal. The Scientific Committee recognised the need to consider how the spatial redistribution of krill catch within strata be integrated with these other initiatives, noting there is a risk that a lack of integration could result in aggregation of catches, the issue that the new management approach was primarily designed to address. The Scientific Committee recommended that the issue of integration of different spatial management initiatives be considered by the Commission.

3.66 The Scientific Committee noted that increases in catch limits could be introduced in a staged manner.

Advice to the Commission

3.67 The Scientific Committee was unable to reach consensus as to whether the newly derived catch limits and spatial and temporal allocation of krill catch should be implemented in the 2022/23 season with commensurate changes to CMs 51-01 and 51-07.

3.68 Given the lack of consensus on a revision to CM 51-07, the Scientific Committee noted that some Members considered that a rollover of CM 51-07 would allow the scientific working groups to address some of the uncertainties raised in paragraphs 3.60 to 3.65.

3.69 Other Members considered that the Commission could use Tables 2 and 3 to form the basis of catch limits in management units within Subarea 48.1 (paragraphs 3.48 and 3.49 and Figure 1).

Observer views

3.70 ASOC noted the important discussions of the Scientific Committee regarding the need to apply a similar approach to the concept of using the best available science to the different working initiatives of the Scientific Committee. The scientific approach used, including the formulation of scientific questions, should be standardised for all issues before the Scientific Committee including the allocation of krill, catch limits for krill or toothfish, the review of Antarctic Specially Protected Area (ASPAs), and the important work of the committee in providing the science needed for the establishment of MPAs.

3.71 The ARK representative summarised SC-CAMLR-41/BG/09 and made the following intervention:

> *'ARK is pleased to see the significant advances in the development of the new management strategy that the different working groups had achieved this year. We now have a first template for implementing a progressive management of the krill fishery in Subarea 48.1. These results highlight what we already knew: that krill stock is abundant and that sustainable catch limits could be set at greater values than currently assigned.*

We also understand that the implementation of the new management strategy requires a greater amount of information and operational adjustments in order to progress. With this in mind, we would like to suggest to the Scientific Committee to consider recommendations outlined in SC-CAMLR-41-BG/09.

As mentioned, the new management strategy will require annual monitoring of the krill status in all strata agreed upon in Subarea 48.1, including new surveys during the winter period, which we consider necessary to understand spatio–temporal changes in krill distribution. ARK consider that this enormous task could be possible only if CCAMLR scientists and the fishing industry work together.

ARK also suggests implementing a daily catch and effort reporting system when the quota assigned or left within a specific stratum and period is below 30 000 tonnes, as suggested in WG-FSA-2022, paragraph 5.1.

Finally, while the new management strategy continues to be perfected, ARK suggests that a safeguard to land-based predators during the breeding season would be advised, in line with the current ARK voluntary restricted zones.'

3.72 ASOC introduced SC-CAMLR-41/BG/29 where a series of recommendations are provided in order to ensure precautionary management of the krill fishery, especially in light of the tremendous uncertainties facing the krill-based ecosystem and the increasing threats of climate change and ocean acidification.

3.73 ASOC recommended that the Scientific Committee complete the krill work plan and that the Commission agree on a new precautionary conservation measure this year to replace CM 51-07 for Subarea 48.1. In the case that CCAMLR is not able to agree to a new measure this year, ASOC recommended that CM 51-07 should be renewed until a new measure can be formulated. In addition, the Scientific Committee should continue to progress the science needed to manage the krill fishery at smaller spatial scales in Subareas 48.2 and 48.3, and keep the trigger level fixed until that time, as required by CM 51-01.

3.74 ASOC recommended that any increase in catch limits should be incremental and strongly supported by science that shows that a new measure will improve protection for krill and krill predators. Any increase in catch must only happen if accompanied by increased monitoring and mitigation of ecosystem impacts of the fishery. Specifically, this should include: regular science-based revisions of catch limits at least every five years; regular testing and evaluation of the Grym stock assessment if it is used to set catch limits; regular monitoring of the impacts of fishing on krill and predators including regular survey transects, which should be made mandatory for fishing vessels and a revision of the CEMP; 100% coverage by SISO; and scientific methods to mitigate mammal and seabird by-catch.

3.75 ASOC also noted that SC-CAMLR must devote serious attention to the foraging needs of cetaceans and how this may impact management of the krill fishery, since new research demonstrates that humpback and fin whales may consume more than 2.1 million tonnes in Subarea 48.1 in a single Antarctic summer. Finally, to secure the resilience of the ecosystem in the main krill fishing grounds around the Antarctic Peninsula, one of the fastest warming regions on earth, the D1MPA should be designated.

Fish resources

3.76 CCAMLR-41/BG/39 by Ecuador reported on *D. eleginoides* catches in Ecuadorian national waters.

3.77 The Scientific Committee welcomed this contribution and encouraged Ecuadorian scientists to participate in future working group meetings.

Icefish (*Champsocephalus gunnari*)

Assessment of *C. gunnari* in Subarea 48.3

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

3.79 The Scientific Committee noted that in recent years fishery effort has decreased in Subarea 48.3 (WG-FSA-2021/15, Figure 1).

3.80 The Scientific Committee noted a proposal for a combined trawl and acoustic survey of *C. gunnari* in Subarea 48.3 to estimate biomass for the length-based method to derive catch limit advice (SC-CAMLR-41/BG/26). The Scientific Committee noted that the current approach provides precautionary catch limit advice, but that it would be advantageous in understanding ecosystem relationships for biomass surveys of icefish to account for their semi-pelagic distribution during sampling. Progress towards the development of a combined trawl and acoustic survey could lead to more robust estimates of both demersal and pelagic components of icefish biomass (WG-FSA-2022, paragraphs 5.52 to 5.57). The Scientific Committee noted that icefish is an important part of the ecosystem in Area 48, as it is a krill predator and a prey for fur seals and penguins and encouraged Members and the relevant working groups to continue to improve the study of icefish.

Management advice

3.81 The Scientific Committee agreed that the catch limit for *C. gunnari* in Subarea 48.3 of 1 708 tonnes for 2022/23, as specified in CM 42-01, remain in place (Table 4).

Assessment of *C. gunnari* in Division 58.5.2

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

3.83 The Scientific Committee noted that WG-FSA reviewed an assessment of *C. gunnari* in Division 58.5.2 (WG-FSA-2022/08) that was based on the results of the annual randomised stratified trawl survey (WG-FSA-2022/07). Bootstrapped biomass estimates had a mean of 53 162 tonnes, with a one-sided lower 95% confidence bound of 26 434 tonnes, mainly comprised fish of age 3+ and 4+. Projecting forward the proportion of the one-sided lower 95th confidence bound of fish aged 1+ to 3+ (14 879 tonnes) gave yields of 2 616 tonnes for 2022/23 and 1 857 tonnes for 2023/24 that allow for 75% escapement and therefore satisfy the CCAMLR decision rules.

Management advice

3.84 The Scientific Committee recommended that the catch limit for *C. gunnari* in Division 58.5.2 should be set at 2 616 tonnes for 2022/23 and 1 857 tonnes for 2023/24 (Table 4).

Toothfish (*Dissostichus* spp.)

Workshop on Age Determination Methods (WS-ADM)

3.85 The Scientific Committee noted that the Workshop on Age Determination Methods (WS-ADM) was not able to be held in 2022 and recommended that it be conducted virtually in the intersessional period with the terms of reference as outlined in WG-FSA-2022, paragraph 4.20, and provide an adopted report of its recommendations to WG-FSA and SC-CAMLR in 2023.

3.86 The Scientific Committee noted, prior to WS-ADM, Members could exchange information on their ageing programs, undertake interlaboratory comparisons (see WG-FSA-02/51) and arrange visits for interested staff if feasible.

3.87 The Scientific Committee requested the Secretariat present an update on the CCAMLR image library and progress on the development of an age database to WS-ADM.

3.88 The Scientific Committee thanked Dr J. Devine (New Zealand) and Dr P. Hollyman (UK) for their offer to co-convene WS-ADM.

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

3.89 The Scientific Committee noted that WG-FSA reviewed updated estimates of growth and maturity for D. *eleginoides* in Subarea 48.3 (WG-FSA-2022/59) and a characterisation of the *D. eleginoides* fishery in Subarea 48.3 (WG-FSA-2022/56 Rev. 1) that described the dynamics of the fishery and the stock.

3.90 The Scientific Committee also noted that WG-FSA reviewed updates to the assessment for *D. eleginoides* in Subarea 48.3 that was presented to WG-SAM-2022 (WG-FSA-2022/57 Rev. 1 and 2022/58) and included data from the 2020/21 season and additional historic age information. The updated information did not result in a significant change to the assessment, and the current status of the stock was estimated to be 47% of B_0. The harvest rate estimated by the CASAL stock assessment was consistent with that estimated from the tag recapture rates.

3.91 Recalling WG-FSA-2022, paragraph 4.40, Dr Kasatkina noted the position of Russia that, since 2008/09, the *D. eleginoides* fishery in Subarea 48.3 has been based on the fishery removing fish less than 100 cm in length, an excessive number of immature *D. eleginoides* and those maturing for the first time (recruits) are currently being caught in Subarea 48.3. To Russia, this indicates a change in the size structure of spawning *D. eleginoides* and has been accompanied by decrease in the toothfish biomass. The *D. eleginoides* population in Subarea 48.3 requires protection and revision of the precautionary approach for the use of the *D. eleginoides* stock in the CCAMLR area (Subarea 48.3) as the current approach does not provide for the sustainable use of this living resource as rational use is not being ensured (SC-CAMLR-40/15; SC-CAMLR-40, paragraphs 3.47 and 3.48). Dr Kasatkina stated that, in her opinion, this is based on the best available data (CCAMLR papers, Fishery Reports, more than 100 articles by renowned scientists in peer-reviewed journals) and reflected in Russian documents submitted since 2018 to meetings of WG-SAM, SC-CAMLR and the Commission.

3.92 Recalling WG-FSA-2022, paragraph 4.41, Dr Kasatkina noted that the fishery performance (mean length, percent immature fish by year in catches) for the toothfish fishery in Subarea 48.3 cannot be compared with toothfish fishery for other CCAMLR areas (*D. eleginoides* fisheries in Subarea 58.6 and Divisions 58.5.1 and 58.5.2, and for the *D. mawsoni* fishery in Subarea 88.1 and small-scale research units (SSRUs) 882A−B) (WG-FSA-2019). *D. eleginoides* is the main target species in Subarea 48.3, while in other fisheries areas, the target species is the *D. mawsoni*, and *D. eleginoides* is taken as by-catch. These two species (*D. eleginoides* and *D. mawsoni*) differ in life cycle stages and behaviour, as well as the fishing areas themselves, primarily in terms of hydrological characteristics such as thermal regime, etc. Furthermore, the fishery for *D. eleginoides* in Subarea 48.3 has been ongoing since 1985, including over 25 years under CCAMLR management. The very high life expectancy of *D. eleginoides* of up to 50 years, its population should consist of a large number of length-age groups, the number of which on the histogram usually decreases quite smoothly in accordance with long life cycle of the fish, providing the basis of catches. Dr Kasatkina stated that this is exactly what is observed in the length histogram of *D. mawsoni* from the toothfish fishery in Subarea 88.1 (SC-CAMLR-40/15). The fishery for *D. eleginoides* in Subarea 48.3 was based on recruitment fish.

3.93 Recalling WG-FSA-2022, paragraph 4.42, Dr Kasatkina noted that the specific proposals from Russia regarding the regulation of the toothfish fishery in Subarea 48.3 in SC-CAMLR-XXXVII/14 Rev. 2 (limiting the length of *D. eleginoides* in catches; fishing only at depths of 1 000 m; reducing the catch limit to 500 tonnes, according to the fishing grounds with depths from 1 000 to 2 250 m; conducting an international survey to assess toothfish stock) had not been accepted. Dr Kasatkina noted that no scientifically substantiated documents have been submitted to CCAMLR meetings that contradict the Russian position on the management of the toothfish fishery in Subarea 48.3. Also, WG-FSA-2022/56 and 2022/57 also were not considered to provide new scientific data regarding issues of an irrational use of the *D. eleginoides* stock in Subarea 48.3 (Figures 5 and 13 in WG-FSA-2021/59, and Figure 13 in WG-FSA-2022/55).

3.94 Dr Kasatkina noted that the documents submitted to CCAMLR meetings for 2021 and 2022 show that, as before, fish from 5 to 7 years of age are involved in the toothfish fishery in

Subarea 48.3 and are actively caught. The basis of the toothfish fishery in Subarea 48.3 is immature fish 8–13 years old at all depths (WG-FSA-2021/59 and 2021/60; WG-FSA-2022/56 and 2022/57).

3.95 Dr Kasatkina noted that the precautionary catch limit calculated using the CCAMLR decision rules will be achieved by the catch of immature fish and emphasised the need to clarify how such a fishery responds to the rational use of *D. eleginoides* resources in Subarea 48.3.

3.96 Dr Kasatkina noted that Russia maintains its position that the *D. eleginoides* population in Subarea 48.3 needs to be protected and maintains the proposal that the precautionary approach to the use of the *D. eleginoides* stock in the Convention Area (Subarea 48.3) should be reviewed as the current approach does not ensure the sustainable and rational use of this *D. eleginoides* resource (SC-CAMLR-40/15; SC-CAMLR-40, paragraphs 3.47 and 3.48).

3.97 Dr Kasatkina noted that Russia proceeds from the principles and objectives of the Convention and considers it fundamentally important that the management of *D. eleginoides* resources in Subarea 48.3 be carried out on the basis of a balance between conservation and rational use (Article II of the Convention).

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

3.99 All other Members agreed that the statements made by Dr Kasatkina on behalf of Russia were the same as those made at WG-FSA in 2018, 2019, 2021 and 2022. All other Members noted that previous working groups had discussed Dr Kasatkina's statements (WG-FSA-18, paragraphs 3.16 to 3.20; WG-FSA-2019, paragraphs 3.50 to 3.68; WG-SAM-2019, paragraphs 3.12 to 3.19; SC-CAMLR-40, paragraphs 3.47 to 3.60; WG-FSA-2022, paragraphs 4.44 to 4.50) and had concluded that scientific evidence had not been provided that supported her statements. It was also noted that a large number of papers refuting statements made on behalf of Russia had been presented to the Scientific Committee and its working groups since 2018, that Russia has largely ignored evidence contrary to Dr Kasatkina's statements, and that there had been ample time to evaluate the hypothesis advanced by Russia during the in-person meeting of WG-FSA-2022. An updated listing of the scientific papers that had been submitted to support, update and constructively review data related to the toothfish fishery in Subarea 48.3 was presented in WG-FSA-2022, Table 4.

3.100 All other Members concluded that Russia's hypothesis about overexploitation of *D. eleginoides* in Subarea 48.3 has been disproven. Repeating several lines of evidence, all other Members rejected Dr Kasatkina's statements.

3.101 All other Members noted that evidence presented to WG-FSA had shown that the fishery in Subarea 48.3 selected multiple age classes and length classes of the population, not only immature fish. They further noted that over the past decade immature fish have remained a constant or declining proportion of the catch from Subarea 48.3 (WG-FSA-2022, Figure 2); the length at first maturity of *D. eleginoides* from Subarea 48.3 has remained constant (WG-FSA-2022, Figure 3); and the mean length of fish in the catch has been constant or increasing (WG-FSA-2022, Figure 4).

3.102 All other Members recalled that WG-SAM noted that the stock assessment process undertaken for Subarea 48.3 was the best available (paragraph 2.12; WG-FSA-2021, paragraph 3.34; SC-CAMLR-40, paragraph 3.61; WG-SAM-2022, paragraph 3.23 and WG-FSA-2022, paragraph 4.53).

3.103 All other Members noted that a diagnostic Kobe plot (Figure 2) for *D. eleginoides* in Subarea 48.3 showed that the population fluctuated about the target (50% B_0), and exploitation rates had been lower than that needed to achieve F_{MSY} in almost all years. All other Members also noted that three independent methods of estimating fishing mortality led to the same conclusion that the harvest rate in Subarea 48.3 is precautionary (WG-SAM-2022, paragraphs 3.48 and 3.54).

3.104 All other Members recalled that in 2019 the Scientific Committee noted that the stock assessment calculations for *D. eleginoides* in Subarea 48.3 and the application of the CCAMLR decision rules were in line with CCAMLR procedures, demonstrating there are no differences in characteristics between the biological characteristics, fishery selection and stock assessments for *D. eleginoides* in Subarea 48.3 and other CCAMLR areas (SC-CAMLR-38, paragraph 3.69), and resulting in advice consistent with CCAMLR's conservation objective and thus implicitly constituting rational use.

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

3.106 Many Members noted that Russia has been preventing the Scientific Committee from achieving consensus using best available science. Many Members noted that in their view Russia's position was based on a position that had no scientific justification and they had an approach of refusing to consider further science conducted on relevant issues.

Management advice

3.107 The Scientific Committee recalled that Article IX of the Convention and Resolution 31/XXVIII require the utilisation of the best science available in the formulation, adoption and revision of conservation measures.

3.108 In light of the position taken by Russia, the Scientific Committee recommended that an independent review of relevant data, the stock assessment, and application of CCAMLR decision rules, in the context of the assessment and management of all CCAMLR toothfish stocks, would enable a resolution of these issues. An independent review should not be considered if one or more Members are unwilling to accept the outcome of the review.

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

3.110 The Scientific Committee noted it had been unable to provide consensus advice on catch limits for *D. eleginoides* in Subarea 48.3.

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

3.111 The Scientific Committee noted that WG-FSA reviewed estimates of the vulnerable biomass of *D. mawsoni* in Subarea 48.4 from tagging returns presented in WG-FSA-2022/60. The five-year biomass average was estimated at 1 110 tonnes since 2018. Applying the CCAMLR-agreed precautionary assumption of a five-year average biomass, and harvest rate (gamma) of 0.038, a yield of 42 tonnes was determined for 2022/23.

Management advice

3.112 The Scientific Committee recommended that the catch limit for *D. mawsoni* in Subarea 48.4 should be set at 42 tonnes for 2022/23 (Table 4).

D. eleginoides in Division 58.5.2

Management advice

3.113 No new information was available on the state of fish stocks in Division 58.5.2 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 2022/23.

New and exploratory finfish fisheries

General issues

3.114 The Scientific Committee noted that there would be benefit in refining the requirements for research plans in exploratory fisheries conducted in accordance with CM 21-02, paragraph 6(iii) (paragraph 14.2). The paragraph states that research plans shall be reported in accordance with format 2 of CM 24-01, Annex 24-01/A.

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

3.116 The Scientific Committee recommended that a new annex (WG-FSA-2022, Appendix E) be added to CM 21-02 which outlines the format for research plans notified under CM 21-02, paragraph 6(iii). The Scientific Committee noted that this new format would also allow research plans in exploratory fisheries to be better aligned with the assessment tables used by working groups, as endorsed by CCAMLR in 2017 (CCAMLR-XXXVI, paragraph 5.26).

Biomass estimation for toothfish from trend analysis

3.117 The Scientific Committee recommended the use of the updated decision tree for the trend analysis (WG-FSA-2022, Figure 2), noting that it includes a new step for those research blocks where fishing occurred only in the most recent of the past five seasons.

3.118 The Scientific Committee recommended catch limits for research blocks in data-limited toothfish fisheries for the 2022/23 season as given in Table 4. The Scientific Committee also recommended updates to by-catch limits (Table 4).

3.119 The Scientific Committee endorsed plans to develop a management strategy evaluation (MSE) of the trend analysis (WG-FSA-2022, paragraphs 4.65 to 4.67) and requested that the Secretariat coordinate an intersessional subgroup of interested parties to progress the development of the MSE and assist Members with the development of relevant toothfish population simulation models.

Tagging

3.120 The Scientific Committee noted that CM 41-01 does not specify the area for which the tag-overlap statistic should be applied. The Scientific Committee recalled the discussion during WG-FSA, noting that the aim of the tag-overlap statistic is to ensure that the tags in each area are released in a similar proportion to the length composition of the overall catch, in order to not bias tag-based estimates of biomass.

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

3.122 The Scientific Committee recalled that a joint COLTO/CCAMLR toothfish tagging workshop had been planned for 2019/20 (SC-CAMLR-38, paragraph 13.1), but was delayed by the COVID pandemic. The Scientific Committee recommended that the workshop be held in March 2023 and COLTO reiterated its offer to support the workshop (paragraph 11.18).

Area 48

Subarea 48.6

3.123 The Scientific Committee noted that the research plan for Subarea 48.6 was in year two of a three-year plan and was therefore not required to be reviewed this year (CCAMLR-38, paragraph 5.64 and Table 7).

3.124 The Scientific Committee recommended that this exploratory fishery should proceed, and the catch limits, given in Table 4, should apply in Subarea 48.6.

Area 58

Divisions 58.4.1 and 58.4.2

3.125 The Scientific Committee recommended that the catch limits for the exploratory *D. mawsoni* fishery in Divisions 58.4.1 and 58.4.2 be based on the trend analysis (Table 4).

3.126 The Scientific Committee noted a new 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-2022/04). The research plan has been updated with relevant details for all notified vessels, and random depth-stratified sampling locations in all research.

3.127 The Scientific Committee recognised the quality and quantity of research that had been conducted in Divisions 58.4.1 and 58.4.2 by all proponents and recalled the Commission had encouraged multi-Member, multi-vessel research plans to be developed so as to increase the research capacity in data-limited exploratory fisheries (SC-CAMLR-XXXIV, paragraph 2.9).

3.128 The Scientific Committee recalled previous discussions on research plans in Divisions 58.4.1 and 58.4.2 and noted the continued lack of consensus in the case of Division 58.4.1 since 2018, in particular regarding the use of different longline types.

3.129 Dr Kasatkina stated that the research plan for Division 58.4.1 did not fulfil the requirements of CM 24-01 (Annex 24-01/A, format 2) as the vessels included in the proposal did not use standardised gear.

3.130 Dr Kasatkina noted that the use of different gear types and constructions for the implementation of the research plan for the *Dissostichus* spp. exploratory fishery in East Antarctica (Divisions 58.4.1 and 58.4.2) is a critical factor for efficiency and reliability of this research plan for data-limited fisheries. Dr Kasatkina noted the ongoing discussions in the Scientific Committee about the gear effect on the performance of the tagging program (SC-CAMLR-XXXVI, paragraph 3.75). Dr Kasatkina noted that using different gear has effects on performance of tag releases and recaptures associated with gear type and reminded that effective tag-survival rate varied strongly by gear type (SC-CAMLR-XXXVI, Annex 7, paragraph 3.71). It was noted that 5 509 fish were tagged and only 26 tagged fish were recaptured during the period 2011/12–2017/18 of the implementation of the research plan on East Antarctica.

3.131 The Scientific Committee recalled that effective tag-survival rate is also vessel/Member specific, and not necessarily related to gear configuration (SC-CAMLR-XXXVI, Annex 7, paragraph 3.72; WG-FSA-2018, paragraph 4.13).

3.132 Dr Kasatkina noted that the research plan for the *Dissostichus* spp. exploratory fishery in East Antarctica (Divisions 58.4.1 and 58.4.2) provided under CM 21-02 should fully comply with the requirements of CM 24-01 (Annex 24-01/A, format 2). There are no provisions in the Rules of Procedure of the Scientific Committee and the Commission for partial implementation of a CCAMLR conservation measure.

3.133 Most Members agreed that CM 24-01, Annex 24-01/A format 2, CM 21-02 and CM 41-01 do not specify that fishing gears used in multi-Member research plans must be standardised, nor the type of fishing gear that must be used (paragraph 14.2).

3.134 All Members except Russia noted that the use of CM 24-01, Annex 24-01/A, format 2, for exploratory fishery may have created a misunderstanding about requirements of standardised fishing gear in the exploratory fishery in Division 58.4.1. All Members except Russia noted that this issue will be addressed if a new annex is added to CM 21-02 (paragraph 3.114).

3.135 The Scientific Committee requested the Commission to consider the interpretation of the requirement for calibration and standardisation of sampling gears in category 3 (survey design, data collection and analysis) of CM 24-01, Annex 24-01/A, format 2.

3.136 The Scientific Committee endorsed the research plan for the exploratory fishery in Division 58.4.2, but was unable to reach consensus on how to proceed in the exploratory *D. mawsoni* fishery in Division 58.4.1.

Area 88

D. mawsoni in the Ross Sea region

Ross Sea shelf survey

3.137 The Scientific Committee noted the scientific value of the Ross Sea shelf survey, highlighting the important data it provided for the *D. mawsoni* stock assessment for the Ross Sea region and data relevant to the research and monitoring plan for the Ross Sea region marine protected area (RSRMPA).

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

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

3.139 The Scientific Committee recalled previous discussions on the allocation of catch for the Ross Sea shelf survey (SC-CAMLR-40, paragraph 3.92) and noted that two methods have been used in the past, with the catch either deducted from the Ross Sea region catch (2017/18 and 2018/19) or from the catch allocated to the RSRMPA special research zone (SRZ) (2019/20–2021/22).

3.140 The Scientific Committee considered a method for allocating of catch for the Ross Sea shelf survey, which is 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 SRZ (CM 91-05, paragraph 8). The allocation for the three methods is given in Table 5. The Scientific Committee requested the Commission consider the values given in updating the catch limits in the Ross Sea region.

Ross Sea data collection plan

3.141 The Scientific Committee noted the report of the Workshop on the Ross Sea Data Collection Plan 2022 (WG-FSA-2022, Appendix D) and welcomed the reformatted version of the proposed Ross Sea data collection plan (RSDCP) (WG-FSA-2022/46), with all proposed baseline data collection items separated into one table and all research items proposed to be undertaken in a voluntary manner in a second table.

3.142 The Scientific Committee recommended the adoption of the RSDCP to commence for the 2023/24 to 2027/28 fishing seasons, as outlined in WG-FSA-2022, Tables 1 and 2.

3.143 The Scientific Committee recommended that Members and the Secretariat work together intersessionally to finalise the required sampling protocols prior to WG-SAM-2023, to enable data collection under the RSDCP.

Subarea 88.2

3.144 The Scientific Committee considered mechanisms to revise the management of the fishery in SSRU 882H as outlined in WG-FSA-2022, Table 3.

3.145 The Scientific Committee recommended option 3 in Table 3 of WG-FSA-2022, where structured fishing with research hauls on minor seamounts would precede the Olympic fishery.

3.146 The Scientific Committee also recommended delaying the start of this fishery by two weeks, as this would increase the likelihood that sea-ice conditions would allow vessels to access an increased number of seamounts in this region, and so increase to value of data collected during research hauls in this SSRU.

Scientific research exemption

Icefish survey in Subarea 48.2

4.1 The Scientific Committee considered the proposal submitted under CM 24-01 for *C. gunnari* in Subarea 48.2 (WG-FSA-2022/17). The Scientific Committee noted that WG-FSA had reviewed the research proposal against the criteria (WG-FSA-2022, Table 6).

4.2 The Scientific Committee recommended that the survey should proceed for one year, with results presented at the subsequent meetings of WG-ASAM and WG-SAM-2023. It further recommended that the trawl sampling be randomised to better collect information that would lead to an estimate of biomass. To accommodate this, the Scientific Committee recommended that hauls should first be taken using oblique tows as opposed to targeted hauls for the primary survey of biomass.

4.3 The Scientific Committee thanked Australia who had offered to provide a 38 kHz transducer for the acoustic component of the survey that could be used for the next stage of this research.

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

4.5 The Scientific Committee recommended that the survey be both effort limited (as described in WG-FSA-2022, Appendix F), and catch limited, with a precautionary survey catch limit of 120 tonnes of *C. gunnari*.

4.6 The Scientific Committee agreed that any krill caught in the survey should be included in the total catch for krill in Subarea 48.2, and that the krill by-catch limit of 0.1% of the trigger level catch limits for krill allocated for Subarea 48.2 (279 000 tonnes), and the Scientific Committee recommended a by-catch limit for krill of 279 tonnes for this survey and that any krill by-catch be counted towards the overall catch limit for krill in this subarea.

D. mawsoni in Subarea 88.3

4.7 The Scientific Committee considered the proposal submitted under CM 24-01 for *D. mawsoni* in Subarea 88.3 (WG-FSA-2022/26). The Scientific Committee noted that WG-FSA had reviewed the research proposal against the criteria (WG-FSA-2022, Table 6).

4.8 The Scientific Committee recommended that the research plan for Subarea 88.3 continue and the catch limits 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

By-catch in krill fisheries

5.1 The Scientific Committee noted that the finfish by-catch (total weight) from the krill fishery using data reported from the fine-scale catch and effort (C1) data from 2010 to 2021 generally increased in recent years with increasing krill catch in Area 48 and in particular in the South Orkney West (SOW) and South Orkney North East (SONE) small-scale management units (SSMUs) in Subarea 48.2 (WG-FSA-2022, paragraph 6.1). The Scientific Committee noted that the increase in total by-catch and number of species recorded may be influenced by increased observer coverage and improvements in species identification in recent years.

5.2 The Scientific Committee recommended the inclusion of an additional field in the C1 data form to indicate whether the information on by-catch was collected by the fishing crew or the scientific observer on a haul-by-haul basis to enable evaluation of the influence of who collected by-catch data on quantity and diversity of by-catch identified in the krill fishery.

By-catch in toothfish fisheries

5.3 The Scientific Committee noted trends in performance indicators, including catches, fishing effort, catch rates, fish size, sex ratios and fish body condition, for the main by-catch species/species groups in the longline fishery targeting *D. mawsoni* in the Ross Sea region (WG-FSA-2022, paragraphs 6.9 and 6.10).

5.4 To support ongoing monitoring of by-catch species in the Ross Sea region toothfish fishery, the Scientific Committee recommended:

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

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

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

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

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

5.5 The Scientific Committee noted discussions on *Macrourus* by-catch in Subarea 48.6 and the Ross Sea region, as well as the work conducted on the improvement of handling guides on skate injury assessment.

5.6 The Scientific Committee recommended that the poster and the training video for skate handling and injury assessment (WG-FSA-2022/19) be made available on the CCAMLR website along with other SISO manuals. It also recommended that the proposed tagging workshop include discussions on skate tagging and handling practices to maximise skate survival after release.

5.7 The Scientific Committee requested that Members develop summaries and conduct analyses on population and catch information on key by-catch species across the Convention Area that can be compiled by WG-FSA with help from the Secretariat.

Incidental mortality of seabirds and marine mammals associated with fisheries

Review of incidental mortality in CCAMLR fisheries

5.8 The Scientific Committee reviewed advice from WG-IMAF (SC-CAMLR-41/07) presented by the Co-conveners Dr Favero and Mr Walker.

5.9 The Scientific Committee noted that this was the first meeting of WG-IMAF in 11 years, thanked the Co-conveners for conducting a successful meeting and noted the importance of WG-IMAF to address incidental mortality of seabirds and marine mammals associated with fisheries, especially in respect of any future increase in krill catch limits resulting from the revision of CM 51-07.

5.10 The Scientific Committee noted the work of WG-IMAF regarding seabird interactions with CCAMLR krill fisheries and noted discussions on the requirement of SISO observation protocols regarding warp strike observations.

5.11 The Scientific Committee endorsed the recommendation of WG-IMAF on the reintroduction of recording severity of warp strikes on krill vessels using the protocols for SISO observers on finfish trawl vessels.

5.12 The Scientific Committee noted discussions regarding the increase in the number of warp strike observations in order to reduce potential uncertainty in extrapolated warp strikes and estimated mortality. It noted that the current warp strikes observation effort is considered to be low (0.5% and 1.9% coverage for continuous and conventional trawl respectively).

5.13 The Scientific Committee noted the proposed increase to four warp observation periods per day increasing to a 2.1% of coverage of trawling time for continuous trawl and 7.7% for conventional trawl. The Scientific Committee discussed the implications and challenges associated with an increase in the number of warp strike observations for the observers' workload.

5.14 The Scientific Committee noted the considerable level of uncertainty on the extrapolation of total warp strikes and discussed the importance of developing further work on this issue and the implication in the implementation of changes in the level of coverage and sampling period, among other issues. It was noted that many of these topics such as the development of power analysis for recommended warp strike observation rates, observation protocols (spatial and temporal coverage) and the exploration of approaches to undertake stratified warp strike extrapolations are already included in the workflow for intersessional work that the group agreed during it meeting (WG-IMAF-2022, Table 1).

5.15 The Scientific Committee also noted WG-IMAF's request to the Secretariat to present warp strike rates (birds-per-unit of observed effort) subdivided by warp observation category (shooting, towing, hauling etc.), which would be required for intersessional work towards recommending sample size requirements for warp strike observing on trawl fisheries (WG-IMAF-2022, paragraph 3.2 and tasks 5.1 and 5.3 of Table 1).

5.16 The Scientific Committee also endorsed the WG-IMAF recommendation of the correction by the Secretariat of the SISO warp strike observation data from the Korean vessels *Adventure* and *Maestro* recorded in the 2011/12 season as it appears erroneous.

5.17 The Scientific Committee agreed that further research needs to be undertaken to refine the required numbers of 15-minute warp strike observation periods per day conducted by SISO observers in trawl fisheries to reduce the uncertainty in estimates of warp strikes.

5.18 The Scientific Committee noted the advice from ACAP on mitigation measures for demersal longline and trawl fisheries, and noted that the requirements under the current CCAMLR conservation measures for demersal longline fisheries match closely with ACAP best-practice guidelines.

5.19 The Scientific Committee welcomed news that the extrapolated number of seabird mortalities from provisional data resulting from CCAMLR longline fishing in 2022 was the lowest total on record. It was further recognised that the work towards decreasing seabird mortality to this historical low started during the past efforts of WG-IMAF.

Marine mammal incidental mortality

5.20 The Scientific Committee considered potential difficulties for krill trawl observers or vessels in accessing whale carcasses after entanglement events for the purposes of data and sample collection. It was further noted that members of the Scientific Committee of the International Whaling Commission (IWC-SC) Subcommittee on Non-deliberate Human Induced Mortality (the specialist group in studying whale entanglements) had assisted WG-IMAF in developing draft data collection protocols for entanglement events. An example was given of the guides for collecting photo-identification of killer whales to assist with depredation studies.

5.21 The Scientific Committee endorsed the recommendation of WG-IMAF that an e-group including experts from the IWC-SC intersessional group on whale entanglement in the Southern Ocean krill fishery, be tasked with developing a data collection template and accompanying instructions for vessels to report standardised data in the event of a whale mortality (WG-IMAF-2022, Table 1).

5.22 The Scientific Committee endorsed the WG-IMAF recommendation that the following data and samples, based on advice from the IWC, be collected (noting two tiers of data collection where i–iv: highest priority and v–vi: moderate priority) where possible:

(i) species and length

(ii) fishing operation (e.g. vessel and fishing gear specifications, time and location where a net was deployed, time and location where the entangled whale was discovered, average trawl depth)

(iii) photographic records

(iv) wound details following IWC entanglement response data form (detailed in Table 1 of WG-IMAF-2022/08)

(v) blubber thickness

(vi) tissue samples (e.g. skin, blubber, baleen plates); presence (and collection) of whale lice.

5.23 The Scientific Committee discussed the potential use of acoustic ‘pingers’ to alert cetaceans to the presence of nets, and of acoustic deterrent devices to scare whales away. It was noted that evidence of the effectiveness of acoustic pingers was ambiguous (WG-IMAF-2022, paragraph 4.30; WG-IMAF-2022/01 and 2022/08), and that acoustic deterrent devices may harm marine mammals.

5.24 The Scientific Committee also noted the potential use of new technologies, such as passive acoustics devices/sonars to detect the presence of cetaceans in the vicinity of krill trawl nets and recommended this observation process be considered in future work to investigate whale interactions with krill trawl nets (WG-IMAF-2022, Table 1, task 2.2).

5.25 The Scientific Committee recalled the observation (WG-FSA-2019/60, SC-CAMLR-38, paragraph 5.19) that in Subarea 48.3, fur seals were attracted to fishing trawl nets in years when krill availability was low, and when krill availability was high, fur seals seemed to be less interested in attending trawlers. The Scientific Committee also considered the question of whether there were any possible similarities between fur seal by-catch and humpback whale entanglement events, and whether this might point towards a mechanism for understanding whale and trawl net interactions.

5.26 The Scientific Committee endorsed the WG-IMAF recommendation that additional data on sex and total body length for incidental seal mortalities recovered onboard vessels be recorded by SISO observers, to determine if incidental fur seal mortalities in fisheries have adverse effects on particular sex or maturity cohorts of fur seal populations.

5.27 The Scientific Committee also endorsed the recommendation that supporting material should be developed and training provided to enable observers to perform tasks relating to recording of sex and total body length for incidental fur seal mortalities, and asked Members with expertise on the subject to contribute documents to that end for review by WG-IMAF (WG-IMAF-2022, Table 1).

5.28 The Scientific Committee endorsed the WG-IMAF recommendation that the Secretariat develop a library of the different exclusion devices used across different trawl vessels within the Convention Area in consultation with Members (WG-IMAF-2022, Table 1).

5.29 The Scientific Committee endorsed the WG-IMAF recommendation that the following advice be provided to krill trawling operators to minimise the risk of whale entanglement in krill trawling operations:

(i) consider adopting Norway’s modifications to the marine mammal exclusion device (MMED) for its continuous krill trawling nets (WG-IMAF-2022, Appendix D)

(ii) consider the development of technology to study how whales are interacting with krill trawling nets

(iii) further develop mitigation measures to decrease the risk of entanglement and by-catch of marine mammals, and present these to future meetings of WG-IMAF or WG-FSA for consideration.

Seabird incidental mortality

5.30 The Scientific Committee recommended that the Secretariat incorporate the ACAP guidelines for the safe handling and release of live-caught seabirds hooked or entangled in longline fishing gear into the SISO manuals and publish the guideline sheets on the CCAMLR website for Members to access (WG-IMAF-2022/05).

5.31 The Scientific Committee welcomed the news on the recovery of the white-chinned petrel (*Procellaria aequinoctialis*) population at Possession Island (Crozet Islands, Subarea 58.6), which had occurred through a combination of implementing effective seabird by-catch mitigation measures on fishing vessels, control of rats on land, and climatic conditions on foraging grounds. The Scientific Committee noted and welcomed the actions implemented to reduce IUU fishing in the Convention Area, which likely also contributed to this success.

Net monitoring cable trials

5.32 The Scientific Committee noted the outcomes of the net monitoring trials conducted by three vessels in the context of providing advice on the derogation of CM 21-03, Annex 25-03/A. The Scientific Committee recommended that the existing derogation on the use of net monitoring cables in CM 25-03 be extended under the following conditions:

(i) The three vessels (*Antarctic Endurance*, *Saga Sea* and *Antarctic Sea*) which use a net monitoring cable and have provided a detailed report of trials of mitigation devices as specified in CM 25-03, Annex 25-03/A, continue to utilise and refine current mitigation measures in use and achieve on-vessel observation coverage of at least 5% of total active fishing time. Such vessels should provide a report on the development and use of mitigation measures to WG-IMAF-2023.

(ii) For vessels which use a net monitoring cable and have not undergone trials of mitigation devices specified in CM 25-03, Annex 25-03/A, they must undertake a trial following these specifications, and report the results of this trial to the next meeting of WG-IMAF. These vessels should additionally provide advance notice to the Secretariat about any net monitoring mitigation technology or technique to be employed to reduce the risk of bird strikes, drawing upon the approaches identified from existing trials for reducing the risk of bird strikes, and outlining how it will respond to any operational difficulties arising during their use. Members with vessels participating in this trial should present specifications under which the net monitoring cable mitigation devices could be used effectively, for review by WG-IMAF.

5.33 The Scientific Committee congratulated the Co-conveners and participants of WG-IMAF, noting the importance of minimising incidental mortalities of non-target species to the conservation aim of the Convention. It was further noted that given the number of mitigation trials currently underway, WG-IMAF will need to meet again in 2023.

5.34 ASOC expressed its appreciation for the work of WG-IMAF, noting its aspiration to see incidental mortality in CCAMLR fisheries minimised or even eliminated. ASOC recognised the historical low in seabird mortalities in the longline fishery, but also noted the importance of marine mammal by-catch mitigation approaches given the observed increase in baleen whale abundances. Finally, ASOC noted the benefit of collaborating with other organisations in order provide expertise to develop the best advice for CCAMLR management decisions.

Collaboration with relevant organisations

5.35 The Scientific Committee highlighted the importance of incorporating the relevant expertise in its discussion of WG-IMAF and noted the valuable contributions made by experts intersessionally and during WG-IMAF-2022.

5.36 The Scientific Committee agreed that a standing invitation be provided to experts from ARK, COLTO, IWC and ACAP at future meetings of WG-IMAF.

Bottom fishing and vulnerable marine ecosystems

5.37 WG-EMM-2022/34 and 2022/46 presented proposals for eight new VMEs in Subarea 48.1 to be included in the CCAMLR VME registry based on high abundances of VME indicator taxa, which in many cases, exceeded abundances of previously registered VMEs (WG-EMM-2022, paragraphs 3.61 to 3.66).

5.38 The Scientific Committee endorsed the recommendation of WG-EMM-2022, paragraph 3.66, to include those proposed VME sites in the CCAMLR VME registry.

5.39 The Scientific Committee noted the discovery of an extensive nesting area of notothenioid icefish and the recommendation to consider a modification of CM 22-06 as a mechanism to protect these nesting areas when discovered (WG-EMM-2022, paragraphs 3.28 and 3.29; WG-FSA-2022, paragraph 6.26).

5.40 SC-CAMLR-41/BG/05 presented detailed information regarding the discovery of a fish nest aggregation of notothenioid icefish (*Neopagetopsis ionah* Nybelin 1947) in the southern Weddell Sea of unprecedented extent (WG-EMM-2022/15).

5.41 SC-CAMLR-41/BG/39 Rev. 1 proposed modifications in CM 22-06, including Annex 22-06/B, for including fish nest areas following the advice of WG-EMM-2022 and WG-FSA-2022 (WG-EMM-2022, paragraphs 3.28 and 3.29; WG-FSA-2022, paragraph 6.26). In addition, a completed Annex 22-06/B for *N. ionah* nest aggregation in the Weddell Sea was included for consideration by the Scientific Committee.

5.42 The Scientific Committee welcomed the documents and agreed on the importance of protecting those nesting areas. It agreed that an appropriate terminology to best capture those areas would be 'fish nest areas'.

5.43 The Scientific Committee further noted the importance of those areas for further studies and monitoring activities, and that at least one species from all five families of notothenioid fishes undertake parental care behaviour. It agreed that further research on such behaviour would be beneficial.

5.44 The Scientific Committee recommended the revision of CM 22-06 as follows:

(i) in the header the date is changed to 2022

(ii) in paragraph 3 'For the purposes of this measure, the term 'vulnerable marine ecosystems' in the context of CCAMLR includes seamounts, hydrothermal vents, cold water corals and sponge fields' is replaced by 'For the purposes of this measure, the term 'vulnerable marine ecosystems' in the context of CCAMLR includes seamounts, hydrothermal vents, cold water corals, sponge fields and fish nest areas'

(iii) because in the case of fish nest area density and absolute number of nests rather than taxa are used to indicate a VME, in CM 22-06, Annex 22-06/B, paragraph 6, the word 'taxa' is replaced by 'indicator'

(iv) for the same reason 'of organisms' is deleted in Annex 22-06/B, paragraph 6.

5.45 The Scientific Committee recommended that the fish nest area of *N. ionah* in the Weddell Sea, the coordinates of which are presented in SC-CAMLR-41/BG/39 Rev. 1 be included in the CCAMLR VME registry.

5.46 The Scientific Committee noted the revised VME Taxa Classification Guide (WG-FSA-2022, paragraphs 6.33 to 6.35), and that further work was needed in the intersessional period by taxonomic and benthic invertebrate specialists to further refine the guide. The Scientific Committee recommended that an interim translation table should be used to reconcile VME codes with e-logbook codes, and that this be developed by the Secretariat.

Marine debris

5.47 WG-FSA-2022/14 presented a report on the status of the CCAMLR marine debris monitoring program, and it showed that most debris are plastic items or fishing gear, and that the amount of debris observed each year is increasing (WG-FSA-2022, paragraphs 6.28 and 6.29). It was noted that more detailed information on marine debris sampling will be provided to the CEP in the future to facilitate collaboration between SC-CAMLR and the CEP and to communicate the impact of debris around Antarctica (WG-FSA-2022, paragraph 6.30).

5.48 The Scientific Committee endorsed the recommendations of WG-FSA-2022, paragraphs 6.31 and 6.32, that:

(i) marine debris and lost gear be summarised in the report by the Scientific Committee to the CEP

(ii) the 'Intersessional Correspondence Group on Marine Debris' be used to progress discussions, and that the Secretariat coordinate integration of the results from WG-FSA-2022/14 into the correspondence group's workplan.

5.49 The Scientific Committee noted that it would be important to look at causes and amount of lost gear, as well as the temporal distribution of lost gear, as more fishing gear is likely to be lost in the beginning of the Olympic fishing season when ice cover is more extensive and vessel crews are motivated to deploy fishing gear quickly. The Scientific Committee requested the Secretariat to undertake further analyses to examine temporal and spatial distribution of gear loss.

5.50 The Scientific Committee requested the Commission consider mechanisms to reduce gear loss and increase gear recovery.

5.51 The Scientific Committee noted that sampling of marine debris as part of CEMP could be helpful to increase marine debris reporting and recommended that the CEMP Workshop (WG-EMM-2022/18) include consideration of sampling of marine debris.

5.52 The Scientific Committee noted that the topic 'Marine debris impacts on seabirds and marine mammals' will also be included in the new terms of reference of WG-IMAF.

Spatial management of impacts on the Antarctic ecosystem

6.1 SC-CAMLR-41/15 summarised progress in mapping scientific research efforts in Domain 1 relevant to the priority elements for research and monitoring (PERMs) of the proposed D1MPA. Information was gathered through a broad literature review, workshops and surveys in Argentina and Chile, and an international survey of researchers that was shared through WG-EMM-2022, the D1MPA Expert Group, and through a CCAMLR circular. This identified a wide range of ongoing research activities involving significant international collaboration. The results of the study will be used in developing a research and monitoring plan (RMP) for the D1MPA proposal. The proponents invited colleagues who have not yet completed the survey to do so, and all stakeholders to continue to be involved in the development of the RMP.

6.2 The Scientific Committee noted that Domain 1 is one of the relatively data-rich regions in the Convention Area, and that the research activities identified in SC-CAMLR-41/15 could provide a firm basis and robust baseline data for developing an RMP for a D1MPA. The Scientific Committee noted that RMPs provide a framework for improving research collaborations and for cataloguing aspects of MPAs in the CCAMLR MPA Information Repository (CMIR). The Scientific Committee also noted that most Members agreed that the proposal has been developed based on the best available science (SC-CAMLR-37, paragraph 6.57).

6.3 China made the following statement:

> *'We appreciate the work Argentina and Chile conducted in gathering the information of research capabilities in Domain 1, and respect the endeavours from all Members carrying out research in this region. This paper further supported the idea that baseline data on key species and features in this area can be established even before the adoption of MPA. Following up on this, we further have 3 comments and suggestions:*
>
> *1) We highly encourage the Domain 1 MPA proposal to integrate the available data and findings from these research work, and update MPA proposal to support the assessment from Scientific Committee Members following the best science available guidelines.*
>
> *2) The PERM shall be an integral part of the MPA proposal to justify the proposed MPA, particularly its objectives, and the Scientific Committee shall provide scientific advice on the MPA proposal on the basis of the PERM, in accordance with CM 91-04, paragraph 3(iv). As we suggested in our paper CCAMLR-41/BG/24, considering applying SMART criteria in PERM of the MPA proposal. The priority elements including baseline data, translating and further unpack the conservation goals or general statements into specific, measurable, achievable, relevant or realistic and time-*

bound (SMART) management objectives, identifying with monitoring and evaluation indicators developed, as well as long-term monitoring plan to measure the state and trend, defining states of system or decision triggers, developing management actions in relation to decision triggers, are all critical to support the justification and transparency of the MPA proposal.

3) We hope to continue discussion on the improvement of PERMs of the D1MPA proposal in the Scientific Committee.'

6.4 Some Members noted that a dedicated RMP workshop, including for the D1MPA, would help to identify priority elements that are not currently matched by research activity and encourage Members willing to develop these activities, and to develop a roadmap to organise the research and monitoring needs. Such a meeting might be possible in conjunction with the Southern Ocean Observing System (SOOS) 2023 symposium in Hobart, Australia.

6.5 The Scientific Committee noted CCAMLR-41/41, which presented proposals for the designation and regulation of MPAs in the CCAMLR area. These proposals are: (i) to develop an agreed definition of a MPA; (ii) adoption of the MPA checklist introduced in CCAMLR-XXXIV/19 and inclusion of it in CM 91-04; (iii) that establishment of an MPA should be through approval of a series of necessary documents including a RMP; (iv) development of criteria for preparing RMPs and inclusion of these criteria in CM 91-04; and (v) revision of CM 91-04 to include a requirement for 'sufficient' data before an MPA can be established. As these were Commission matters, this paper was not considered.

6.6 The Scientific Committee noted CCAMLR-41/BG/24, which presented proposals for the development of RMPs in the development and management of MPAs in the CCAMLR area. The paper emphasised that an RMP is pivotal to the development and implementation of MPAs and noted that the Commission will adopt an RMP for an MPA on the basis of the advice of the Scientific Committee to inform the regular MPA review process. To develop a meaningful and functioning RMP that supports effective evaluation on whether the specific objectives of the proposed MPAs are met or not, priority elements should be included such as baseline data, translating conservation goals or general statements into specific, measurable, achievable, relevant or realistic and time-bound (SMART) management objectives, identifying indicators, defining states of system or decision triggers, developing management actions in relation to decision triggers, which is also critical to support the justification and transparency of the MPA proposal.

6.7 The Scientific Committee noted CCAMLR-41/BG/32, which considered CCAMLR MPAs in the context of marine spatial protection negotiations at a global scale and suggests that now is the time for CCAMLR to once again show global leadership by fulfilling its agreed goal to establish a representative system of MPAs in the Southern Ocean. CCAMLR's achievement in marine protection, the designation of the world's largest MPA in the Ross Sea, is an example of global leadership. However, the fact that the three MPA proposals under discussion have not been designated despite years of negotiations means that CCAMLR is failing its agreed mandate to deliver a network of MPAs in the Southern Ocean. The authors recommend that CCAMLR acts immediately to adopt current MPA proposals, approve the Ross Sea MPA RMP and make progress on MPA proposals in the remaining planning domains. As these were Commission matters, this paper was not considered.

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

6.8 The Scientific Committee noted the discussions of WG-EMM-2022 developing RMPs and welcomed the work (WG-EMM-2022, paragraphs 3.45 to 3.60).

6.9 The Scientific Committee noted SC-CAMLR-41/BG/17 by China with observation and comments on the scientific basis and draft RMP of the Weddell Sea MPA (WSMPA) phase 1 proposal. The authors mentioned that some substantial issues remain outstanding despite the engagement by China presented already in SC-CAMLR-38/BG/15 and SC-CAMLR-40/16. China proposed that there should be a simplification of the dual set of WSMPA objectives and proponents should provide more data for a better justification of objectives and further improvement of the draft RMP priority elements for consideration by the Scientific Committee.

6.10 The Scientific Committee noted SC-CAMLR-41/BG/18 by China with an example for collating and analysing a comprehensive and location-specific population data of emperor penguins (*Aptenodytes forsteri*) and Adélie penguins (*P. adeliae*) in the Ross Sea region, in the authors view which demonstrated that the breeding population of emperor penguins and Adélie penguins in the Ross Sea region has been increasing with fluctuation since 2000. The authors found it possible to update baseline data on key species such as the penguins through systematic literature analysis, and noted the urgency for the Scientific Committee to initiate its agreed work (SC-CAMLR-XXXVI, paragraph 5.45; SC-CAMLR-XXXVII, paragraph 6.37), including to take additional effort to further update and improve the penguin population dynamic data with the aim to establish a reliable baseline database, to develop scientifically measurable criteria and other scientific information to link the baseline data on penguins to the specific objectives of the RSRMPA within geographic locations listed in CM 91-05 as well as the specific management measures, and to facilitate the evaluation of the effectiveness of the RSRMPA.

6.11 The Scientific Committee noted the presentation by China of CCAMLR-41/BG/25, which proposed to improve the draft RMP of the RSRMPA in terms of translating broadly stated objectives into SMART management objectives, identifying measurable criteria and indicators to evaluate the performance of the MPA, establishing baseline data, and standardising methods for collection and analysis, etc. The paper noted that the lack of an RMP even five years after entry into force of the MPA has impeded the work of CCAMLR on MPAs, and called upon the proponents who have 'the best available scientific information' in support of the establishment of the MPA to take the responsibility to improve the draft RMP for the consideration of the Scientific Committee and then submit to the Commission.

6.12 Some Members noted that many of China's concerns about the RSRMPA RMP are addressed in CM 91-05, Annex 91-05/C, and in the RMP itself.

6.13 The Scientific Committee noted SC-CAMLR-41/BG/36 by the USA, New Zealand, Korea and Italy, which presented a compilation of Member activity reports related to the RSRMPA (2022). The paper summarised preliminary results from research projects related to the RSRMPA from those Members. All activities submitted to the CMIR counted in total 192 projects (26 active grants and 166 published studies) in the period from 2016 to 2022.

6.14 The Scientific Committee noted that the four Members that had provided reports on their activities relevant to the RSRMPA RMP had done so in compliance with the requirements in CM 91-05.

6.15 The Scientific Committee welcomed the large amount of work presented, and the collaborative efforts of 20 Members. The Scientific Committee noted the responsibility for the RMP lay with all Members, and invited all Members to collaborate to continue its refinement. The Scientific Committee noted the importance of the RMP for allowing scientists to plan their future work and many Members noted that the amount of scientific effort directed in the area of the RSRMPA is an indicator of the success of the RMP. The Scientific Committee encouraged Members to continue to refine the RMP and to submit relevant documents, including on ecosystem indicators on this matter to the appropriate working groups.

6.16 China noted that the RMP for the RSRMPA shall be adopted by the Commission on the basis of the advice of the Scientific Committee in accordance with CMs 91-04 and 91-05, and questioned whether the Scientific Committee has the right to endorse the RMP under such CCAMLR conservation measures. China also expressed concern on the relevance of the reported activities and the preliminary results to the objectives, measures and the evaluation of the effectiveness of the MPA, as well as how the Scientific Committee provides advice to the Commission in accordance with CM 91-05, paragraph 15, and Annex 91-05/B, paragraph 4.

6.17 Russia noted that that CM 91-05, Annex 91-05/C, paragraph 5, required the RMP to be organised geographically and recommended that the reports on activities relevant to the RMP include the geographic areas where the research was carried out.

6.18 The Scientific Committee noted that the Member reports on activities relevant to the RSRMPA RMP provided detail for each project on geographical area along with objectives, priority questions and outcomes and that this was summarised, for example, in WG-EMM-2022/37, Figure 5, summarising the CMIR records by area and work area.

6.19 The Scientific Committee recalled that some base level information contained by the CMIR is publicly available. The Scientific Committee requested that the Secretariat investigate whether all projects and linked data products in the CMIR could also be made public to further facilitate collaboration.

6.20 China noted that CM 91-05, paragraph 15, requested that activity reports shall be compiled by the Secretariat and provided to the Scientific Committee.

6.21 The Scientific Committee noted that the Secretariat had detailed the procedure that had been followed, with a call for activity reports through Scientific Committee circulars, and the submissions circulated through WG-EMM and the relevant e-group according to the required timescale.

Review of the scientific elements of proposals for new MPAs

6.22 The Scientific Committee noted SC-CAMLR-41/BG/30. The paper provided an updated review of the scientific literature showing the ongoing environmental changes that are stressing habitats and ecosystems in CCAMLR Domain 1, reinforcing the importance of adopting the proposal for the establishment of an MPA in this region. The information provided in this work highlights the relevance of protecting the ecosystems of the Western Antarctic Peninsula through the Domain 1 MPA (D1MPA) under a scenario of environmental changes and increased human presence.

Other spatial management

6.23 SC-CAMLR-41/BG/16 presented an update on Myctobase, which provides distribution data on mesopelagic fishes. The latest version of dataset has been made publicly available through the SCAR Antarctic biodiversity portal. CCAMLR Members are invited to further contribute to the Myctobase database.

6.24 The Scientific Committee noted the large value of this type of work which provides a repository of data that may inform many analyses, including spatial management efforts.

6.25 SC-CAMLR-41/BG/22 provided a report from the Workshop on Identifying Key Biodiversity Areas (KBAs) for the Southern Ocean using tracking data. Using the retrospective analysis of antarctic tracking data (RAATD), the KBA Standard was applied towards identifying potential KBA areas across sub-Antarctic and Antarctic waters. Working with the IUCN and SCAR's Ant-ICON Scientific Research Programme and the Expert Group on Birds and Marine Mammals (EG-BAMM), the authors held an expert workshop where they presented this work and solicited feedback and input. Overall, most participants viewed KBAs as an additional potential conservation planning tool that might inform Southern Ocean spatial management. Further, while the sub-Antarctic stands out in the KBA analysis, this is due to these areas being data heavy, while sufficient data was lacking for the higher-latitude areas. Details on the methods, preliminary results and summaries of the extensive workshop discussions can be found in the report. Analysis is currently being refined based on feedback, so all results, including maps, in the workshop report are preliminary and will likely change. Members were invited to stay involved by joining the listserv by emailing southernocean_kba@colorado.edu.

6.26 The Scientific Committee noted the large amount of work being undertaken by SCAR relevant to the Scientific Committee, and requested where possible, relevant papers also be submitted to the applicable working groups to enable more time for consideration in the development of advice by the Scientific Committee.

6.27 The Scientific Committee noted SC-CAMLR-41/BG/04 which reported on a collaborative analysis of 30 years of scientific data contributed by more than 50 research groups. The report is a first to highlight the growing importance of marine connectivity conservation, outlining how whales are encountering multiple and growing threats along their migration routes, or 'blue corridors', and their breeding and feeding habitats. The report calls for a new conservation approach to address these mounting threats and safeguard whales, through enhanced multilateral cooperation from local to regional to international levels. Of particular urgency is the importance of the commitment to implement a comprehensive and representative networks of MPAs by CCAMLR. The authors noted several of the areas presented in this report are within some MPA proposals (for instance, the Antarctic Peninsula in Domain 1) highlighting the importance of protecting those areas.

6.28 SC-CAMLR-41/BG/27 presented the initial results of Lagrangian particle modelling to characterise connectivity of Antarctic krill at a circum-Antarctic scale. Preliminary model results indicated that in an area where sea ice is created and advected off the continental shelf (e.g. the Ross Sea), krill pathways can be less constrained to stay on the continental shelf. Future work will focus on using this modelling framework to characterise connectivity between spawning grounds and nursery grounds for Antarctic krill and expand this approach to toothfish species.

6.29 SC-CAMLR-41/BG/31 presented an update on recent activities of the SCAR Antarctic Biodiversity Portal, including an invitation to contribute data papers to the *Biodiversity Data Journal* topical collection 'Antarctic and Southern Ocean biodiversity'. The paper highlighted key published datasets, and request input through participation in an online user survey (https://forms.gle/ANPWgfTfJuCfp7NKA) to help identify additional services and priorities for the Antarctic Biodiversity Portal that would be of benefit to Members.

6.30 CCAMLR-41/BG/29 responded to a request by WG-EMM-2021 to communicate results of the considerable amount of scientific research conducted within ASPA Nos 152 and 153 over the past four decades. Research has been conducted on the composition, structure, and dynamics of marine benthic communities, with a focus on fish species. The areas are recognised as important spawning grounds for several fish species, including the rockcod *Notothenia coriiceps* and the icefish *Chaenocephalus aceratus*. Scientific research is also being undertaken on the benthic faunal communities. This paper lists research highlights in several areas of study, followed by a selected bibliography for further information.

6.31 WG-EMM-2022/45 presented the outcomes of a comprehensive review of ASPA No. 152 Western Bransfield Strait and ASPA No. 153 Eastern Dallmann Bay including a recommendation to merge the management plans for these ASPAs based on shared common purposes, aims, objectives and management policies and the considerable benefit to having a single management plan for both sites. The paper requested that, consistent with Decision 9 (2005) at the Antarctic Treaty Consultative Meeting (ATCM), which states that for the purpose of the implementation of Article 6.2 of the Environmental Protocol, draft management plans that contain marine areas which require a prior approval of CCAMLR are those: (a) in which there is actual harvesting or potential capability of harvesting of marine living resources which might be affected by site designation; or (b) for which there are provisions specified in a draft management plan which might prevent or restrict CCAMLR-related activities.

6.32 The Scientific Committee considered the request to approve the revised management plan, noting the earlier discussions in WG-EMM-2022, including the request for the justification for these changes and reporting of scientific studies conducted in ASPAs (WG-EMM-2022, paragraphs 3.1 and 3.2).

6.33 The Scientific Committee noted that WG-EMM supported the revised management plan for ASPA Nos 152 and 153 (WG-EMM-2022, paragraph 3.3).

6.34 China pointed out that the proposed expansion of ASPA Nos 152 and 153 is not a minor change, and that the requested scientific information justifying the proposed changes and the revised management plan had not been provided to the Scientific Committee and WG-EMM-2022 for evaluation and therefore it was unable to join consensus to approve the updated management plan. China encouraged the proponent to submit the scientific justification on the expansion and the revised management plan to the Scientific Committee for review in the next meeting.

6.35 All other Members noted that further scientific justification for the merging of the two management plans was available in the revised management plan and presented at the Scientific Committee.

6.36 Many Members disagreed that additional scientific justification for revised ASPA management is required, noting that scientific justification had been provided to the Scientific Committee and that there was no requirement under Decision 9 of the ATCM for WG-EMM to review ASPA management plans.

6.37 Dr Penhale clarified that the ASPAs have been in place for over 40 years, and had previously been approved by CCAMLR, and that under this proposal, the management plans were to be merged, with the boundaries of ASPA Nos 152 and 153 remaining separate and being redesignated Site A and Site B respectively, and that this distinction was made clear in the revised management plan along with the justification for the adjustments in the ASPA boundaries. She stated that her presentation of the paper contained sufficient explanation as to the reasons for the merged plan with the minor changes in the size of the sub-units, including the scientific justification for those changes. She noted that non-approval of the management plan will result in a two-year delay for adoption by the ATCM, due to the sequence of approvals and meetings and thus will negatively impact the work of the CEP in its area protection mandate.

6.38 ASOC noted that Annex V of the Protocol states any area, including any marine area, may be designated as an ASPA or Antarctic Specially Managed Area (ASMA). The merits of ASPAs and ASMAs should be considered based on their management objectives. In ASOC's view the Scientific Committee should consider scientific aspects relevant to the criteria outlined in ATCM Decision 9 (2005), as appropriate. This process should not unnecessarily delay or complicate the adoption of new or revised management plans for ASPAs or ASMAs.

6.39 The Scientific Committee did not reach consensus to approve the revised management plan for ASPAs Nos 152 and 153.

6.40 The Scientific Committee supported the revised management plan proposal for ASPA No. 145.

6.41 The Scientific Committee noted the information coming from the Marine Ecosystem Assessment of the Southern Ocean (MEASO, paragraph 7.15; SC-CAMLR-41/BG/25) and noted that such information would prove useful in considering scientific issues related to spatial management.

Climate change

7.1 CCAMLR-41/29 noted that the Southern Ocean plays a globally important role in climate regulation, removing carbon dioxide from the atmosphere and storing some of this 'blue carbon' in the bodies of marine organisms and in biogenic sediments on the seabed for centuries or millennia. Protection of carbon-exporting species and carbon-rich habitats is necessary to maintain these climate regulation functions. The paper summarised current understanding of the roles played by Antarctic krill and continental shelf benthic ecosystems in carbon export and storage and introduced an initiative to map carbon storage hotspots. The authors recommended that Members:

(i) recognise the important contribution of Antarctic marine living resources and their habitats to the processes of carbon export and storage and consider actions to ensure their protection

(ii) note the new British Antarctic Survey (BAS) and the World Wide Fund for Nature (WWF)-UK blue carbon project, the results of which will be presented to CCAMLR in due course

(iii) support further research on blue carbon processes, particularly in relation to the contribution of krill and the potential impacts that krill fishing may have on these processes

(iv) consider the protection of important blue carbon habitats and species, including through the delivery of the commitment to establish a system of MPAs around Antarctica.

7.2 The Scientific Committee thanked the authors for highlighting this important area of research and noted that the subject should be considered in future discussions. The Scientific Committee recognised the importance of the Southern Ocean in the global carbon cycle and noted that a better understanding of how climate change will affect the physical and biological capacity for the uptake of carbon dioxide and long-term storage of carbon is needed.

7.3 The Scientific Committee noted that understanding the role of carbon cycling in Southern Ocean ecosystems was important and relevant to the Scientific Committee in its advice on rational use. The Scientific Committee looked forward with interest to discussing the results of the joint BAS and WWF-UK research project.

7.4 The authors of CCAMLR-41/31 Rev. 1 highlighted that evaluating the effects of climate change on Southern Ocean marine living resources is a priority topic for CCAMLR identified in the Performance Review (CCAMLR-41/06). In 2021, the Scientific Committee proposed a workshop on climate change, and this workshop was also highlighted during the Scientific Committee Symposium (SC-CAMLR-41/10). Following discussions at WG-EMM-2022, paragraphs 4.1 to 4.9, and WG-FSA-2022, paragraphs 6.44 to 6.46, and recognising that a focused workshop would enable progress to be made on integrating climate change and ecosystem interactions into CCAMLR's science work program, CCAMLR-41/31 Rev. 1 set out draft terms of reference together with other key elements required to develop the workshop, with objectives including: (i) establishing a common understanding about the effects of climate change in the CCAMLR context; (ii) identifying priority issues; and (iii) developing mechanisms to improve the integration of relevant scientific information on climate change into CCAMLR's work. The authors highlighted that it is important to consider the carbon footprint of the workshop and suggested that holding the meeting in a hybrid format, with regional in-person meeting hubs, would allow wider participation of CCAMLR scientists and invited experts.

7.5 The Scientific Committee noted the proposal for a joint CEP–CCAMLR climate change workshop in CCAMLR-41/BG/11 and recognised that there could be some overlap in objectives which should be considered in developing terms of reference of both the CEP and the workshop outlined in CCAMLR-41/31 Rev. 1. The Scientific Committee discussed the synergies and difference between the objectives of the two workshops and also the requirements for providing advice to the Scientific Committee.

7.6 The CEP noted that it was very supportive of the Scientific Committee climate change workshop but that the timeline for agreeing and scheduling a CEP workshop would result in the workshop not taking place until 2024. Consequently, the Scientific Committee agreed that holding a Scientific Committee Southern Ocean climate change workshop in 2023, before the CEP workshop, would be preferable. Outcomes could then be fed to the CEP workshop.

7.7 ASOC noted the need to incorporate the impacts of climate change into the Scientific Committee deliberations regarding fisheries management and in the context of establishing MPA is an issue of high importance to the organisation. Similarly, the need to adapt and improve CEMP to keep up with the necessary monitoring in the development of a new management system for the krill fishery has also been a priority of ASOC for many years. ASOC expressed interest in identifying ways in which it can contribute to the organisation of both workshops.

7.8 The Scientific Committee noted that discussions have been occurring in the Scientific Committee as to how to integrate climate change considerations into its analysis and advice. Some working groups are already including climate change considerations; noting previous comments in Scientific Committee documents:

(i) SC-CAMLR-XXXVI, Annex 9, paragraphs 2.28 to 2.31, collaborate to develop methods to assess changes over time, that can be used to evaluate the importance of observed changes on resulting advice using sensitivity analyses and simulations

(ii) SC-CAMLR-XXXVII, paragraph 3.51 and SC-CAMLR-38, paragraph 9.4, changes in model parameters and productivity assumptions could be a useful way to highlight issues related to climate change in management advice for CCAMLR stocks

(iii) SC-CAMLR-41, paragraph 2.17, discussion on how alternative decision rules for managing stocks could be restructured to account for climate change.

7.9 The Scientific Committee agreed to the timeliness of organising this workshop, particularly given the recent increase in ice-shelf collapse events and increasing evidence of climate change impacting the ecosystems in the Southern Ocean. It encouraged using a hybrid format with regional hubs as this will reduce climate impact but also allow more inclusive participation across the world.

7.10 The Scientific Committee agreed to hold a climate change workshop in the first half of 2023. The Scientific Committee considered that the workshop would be held in regional hubs with virtual access, and an online plenary session involving all regional hubs and sought co-conveners to plan and coordinate the delivery. Dr R. Cavanagh (UK) agreed to begin planning the workshop and a New Zealand representative offered to co-convene the workshop.

7.11 Dr Van de Putte noted that with respect to the proposed workshop on incorporating climate change and ecosystem interactions in the work of SC-CAMLR, it would be useful to have relevant experts, including from ICED-MEASO, SCAR and SOOS networks invited to this workshop.

7.12 SCAR indicated to the Scientific Committee that it would be prepared to provide experts to the workshop.

7.13 The Scientific Committee discussed and agreed terms of reference for the workshop which are detailed in Annex 10.

7.14 The Scientific Committee also agreed that climate change should be included in the revision of the Scientific Committee terms of reference for its working groups (paragraph 11.2).

7.15 SC-CAMLR-41/BG/25 introduced the MEASO, which identified strategies for considering and managing the impacts of climate change. MEASO also identified priorities for improving assessments in the future, including coordinated circumpolar studies on sea-ice systems, coordinated monitoring of sentinel species and the further development of food-web models throughout the Southern Ocean, especially coupled to Earth System models to support short- to medium-term assessments of change.

7.16 In SC-CAMLR-41/BG/21, SCAR noted that in 2009, it published a landmark Antarctic Climate Change and the Environment (ACCE) Report. SCAR published a further update to the ACCE Report in 2014, and since then has delivered information to CCAMLR about climate change and its impacts on a regular basis. A major update by SCAR to the ACCE report has now been compiled based largely on the findings of the Intergovernmental Panel on Climate Change's (IPCC) Sixth Assessment Reports. The full ACCE Decadal Synopsis is available to download from the SCAR website. SC-CAMLR-41/BG/21 provided a summary of key findings from the ACCE Decadal Synopsis, and a series of recommendations derived from the evidence-base presented in the synopsis – these were also the basis for the SCAR lecture which the Commission received on the first day of the meeting. SCAR noted that CCAMLR Members are among those best placed to be the voice of the state of the environment of the southern polar regions. The messages, informed by research in the Antarctic, are clear. The CAMLR Convention Area, the Antarctic continent's physical environments, and the biodiversity the region supports are changing rapidly as a consequence of global climate change. This climate change is the consequence largely of anthropogenic greenhouse gas emissions. Urgent action is needed to mitigate global greenhouse gas emissions, and to include considerations of climate change in the conservation and management of Antarctic systems and marine living resources. SCAR thanked CCAMLR for the opportunity to present a lecture on this work this year and would be happy to do so again in the future. The SCAR community stands ready to support CCAMLR in these endeavours.

7.17 The Scientific Committee considered SC-CAMLR-41/BG/14 and BG/15, submitted by SCOR. The papers summarised recent activities by SOOS, including improvements to SOOSmap and DueSouth, and the release of its Science and Implementation Plan for 2021–2025. SCOR notified the Scientific Committee of the upcoming first SOOS symposium, entitled 'The Southern Ocean in a Changing World', to be held in August 2023 in Hobart and welcomed CCAMLR scientists to participate. The Scientific Committee thanked SCOR for the papers and noted the importance of the work conducted, particularly the tools provided.

7.18 SC-CAMLR-41/BG/13 was presented by SCAR on behalf of Oceanites. Oceanites continues to examine the interactive effects of climate change vis-à-vis human activities and other causes that might help explain penguin population changes being detected. Oceanites noted that their latest State of Antarctic Penguins 2022 report summarises the present status – population size and population trends – of Antarctica's five penguin species, continent-wide and in key regions. The report highlighted that the five Antarctic penguin species total an estimated 6.12 million breeding pairs nesting at 740 sites across the Antarctic continent, an overall increase of 3.05% that, in large part, reflects new breeding sites recently added to Oceanites continent-wide penguin database known as MAPPPD. Excluding these newly added sites and focusing solely on previously known sites, Oceanites noted that:

(i) chinstrap penguins continue to decline in the Antarctic Peninsula (Subarea 48.1) and the South Orkney Islands (Subarea 48.2)

(ii) Adélie penguins continue to decline in the Antarctic Peninsula (Subarea 48.1)

(iii) gentoo penguins continue to increase in the Antarctic Peninsula (Subarea 48.1)

(iv) Adélie penguins are increasing in the Ross Sea region (Subarea 88.1) and Eastern Antarctica (Divisions 58.4.1 and 58.4.2).

7.19 Oceanites also noted that its analyses of the interactive effects of climate change vis-à-vis human activities continue and that Oceanites is examining a suite of potential causal factors, including: krill availability and a potentially shifting or shrinking krill stock; the amount of krill fishing and higher exposure by penguins to fishing interference during the penguin breeding season; competition for krill with whales and seals; the location of krill fishing vis-à-vis the foraging range of juvenile penguins post-breeding season; penguins' winter foraging ranges; other potential non-breeding season impacts; and rising temperatures, increased precipitation, and retreating sea ice due to global warming.

7.20 The Scientific Committee thanked Oceanites for its valued contributions to the research on penguin populations in the Antarctic region. Its data collection and research program is complimentary to CEMP and its annual reports contribute valuable supplementary information on the dynamics of the Southern Ocean penguin population, particularly in the Antarctic Peninsula.

7.21 The Scientific Committee noted the large amounts of information contained in papers on climate change submitted to the Scientific Committee. It encouraged the submission of papers detailing the analyses and datasets used to the working groups of the Scientific Committee to enable their incorporation in formulating advice.

7.22 ARK noted that regarding concerns over the overlapping of penguin foraging range and fishing in Subarea 48.1, ARK had introduced the voluntary restricted zones since the 2018/19 fishing season and that there is no fishing in the summer season. It would therefore be useful to compare the potential effect of the removal of fishing activity during the penguin breeding season using data collated by Oceanites.

7.23 The Scientific Committee noted that statistically separating any effects of the buffer zones in the voluntary restricted zones, which remove fishing from coastal regions from environmental variation can be challenging. As the period of time over which fishing has been relocated increases, any impact should become more apparent and data such as that collected by Oceanites, may be able to distinguish the consequences.

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

8.1 The Scientific Committee noted the discussions held at WG-FSA-2022 in relation to illegal, unreported and unregulated (IUU) fishing (WG-FSA-2022, paragraphs 3.7 to 3.9). The Working Group had welcomed the summary of information held by the Secretariat in relation to IUU fishing in 2021/22 relevant to CCAMLR as well as unidentified gear retrieved from October 2021 to August 2022, including proposed updates, amendments, inclusions and removals from IUU vessel lists (CCAMLR-41/16 Rev. 2). The Working Group had also noted the limited ability to identify IUU fishing activities in the Convention Area, especially in areas where no directed fishing has taken place for some years, such as in Division 58.4.1, where numerous historical reports of suspected IUU fishing activities had taken place.

8.2 The Scientific Committee agreed that estimating removals due to IUU fishing was critical to the provision of scientific advice, and that options to better estimate and assess IUU fishing activity should be explored. It is important to ascertain whether gear found belonged to the legal fishery, for example, by marking of fishing gear using radio-frequency identification tags.

8.3 The Scientific Committee endorsed the request of WG-FSA-2022 for the Secretariat to reinitiate efforts to develop improved methods of gear marking, including renewed use of the 'Unidentified fishing gear in the Convention Area' e-group and encouraged Members to participate in discussions on this topic in the e-group.

CCAMLR Scheme of International Scientific Observation

9.1 The Scientific Committee noted the Workshop on Conversion Factors for Toothfish, held in April 2022, and thanked the Co-conveners, Mr Walker and Mr Gasco, for a successful meeting providing useful information and advice to the Scientific Committee.

9.2 The Scientific Committee noted the krill observer workshop, to be held in China, terms of reference as outlined in SC-CAMLR-41/16 Rev. 2. The Scientific Committee considered that data collected by SISO observers is crucial for managing the direct and indirect effects of this fishery. The Scientific Committee recalled that the krill workplan had been discussed in WG-EMM-2022, paragraphs 2.7 and 5.18, and WG-FSA-2022, paragraphs 8.1 to 8.3. It also noted WG-EMM-2022/39 which outlined specific issues in Table 1 that have been identified for consideration by the Scientific Committee and its working groups, processes to address these, a timeline for changes to forms and instructions, and implementing outcomes.

9.3 The Scientific Committee further noted that proposed tasks to be discussed in the data collection plan for the krill fishery are diverse and that it would be useful to identify the specific tasks undertaken by observers, vessel crews and national programs. The Scientific Committee considered that these issues, and balancing observer tasking workloads, were important items to be discussed in the proposed krill observer workshop.

9.4 The Scientific Committee also noted that sampling numbers and sampling frequency of the krill size structure in the catch should be based on statistical analysis (see WG-SAM-16/39). The Scientific Committee also noted that there may be more frequent sampling required when vessels move to new grounds as opposed to when vessels fish on the same grounds.

9.5 Noting the relatively low and variable observation rate of krill biological sampling, fish by-catch sampling and warp strike observations in krill fisheries (WG-FSA-2022, paragraphs 8.22 and 8.25) and the need to build improved knowledge about the krill fishery (paragraph 3.11), the Scientific Committee noted the need for dedicated international SISO observers in the krill fishery.

9.6 The Scientific Committee recalled previous work by the Ad Hoc Technical Group for At-Sea Operations (TASO) could be useful to inform observer tasking requirements and technical issues.

9.7 The Scientific Committee noted that use of a data collection plan for the krill fishery could provide a roadmap in future for of the krill management plan, consistent with other data collection plans in CCAMLR fisheries.

9.8 The Scientific Committee endorsed the revised term of reference and the budget (paragraph 3.15) of the proposed krill observer workshop, to be held in China.

9.9 SC-CAMLR-41/17 reported on a workshop for training Russian scientific observers and inspectors working in the CAMLR Convention Area. The workshop program covered a wide range of aspects related to scientific observation and inspection in CCAMLR fisheries for krill, toothfish and crab.

9.10 The Scientific Committee encouraged Russia to continue to this work.

9.11 Russia welcomed the involvement of other Members and the Secretariat in future workshops.

9.12 The Scientific Committee noted SC-CAMLR-41/BG/32 on the application of electronic monitoring systems in CCAMLR fisheries. The paper highlighted how electronic monitoring could be used to enhance the work of observers and considered specific data collection requirements for each of the working groups and the Standing Committee on Implementation and Compliance. The paper also discussed the value of electronic monitoring in improving observer safety by allowing remote monitoring to mitigate potentially dangerous tasks (WG-FSA-2022, paragraphs 8.4 to 8.8).

9.13 The Scientific Committee noted the additional value of electronic monitoring in collecting data that could be subsequently analysed ashore, enabling more effective use of SISO observers when aboard. In addition, the Scientific Committee noted the increasing development and availability of portable recording equipment such as high-resolution cameras and environmental sampling equipment which may provide additional data collection opportunities.

9.14 The Scientific Committee considered how to harmonise the implementation of electronic monitoring across CCAMLR fisheries, and requested that Members liaise with fishing industry bodies such as COLTO and ARK to progress this. The Scientific Committee noted that the 10th International Fisheries Observer and Monitoring Conference, to be held in Hobart, Australia, from 6 to 10 March 2023, will provide a useful forum for electronic monitoring discussions.

9.15 Mr R. Arangio (COLTO) announced the winners of the annual CCAMLR toothfish tag return lottery for the 2021/22 season. First place went to the UK-flagged vessel *Argos Helena*, second place went to the Korean-flagged vessel *Hong Jin No. 701*, and third place went to the Spanish-flagged vessel *Tronio*. COLTO noted that these Antarctic toothfish had been recaptured between 6 and 55 km from their release points and thanked crew and SISO observers for their continued at-sea efforts to support CCAMLR tagging operations.

9.16 The Scientific Committee thanked COLTO for continuing to support the CCAMLR tag return lottery and additionally thanked COLTO for contributing to the planned tagging workshop in 2023.

Cooperation with other organisations

Cooperation within the Antarctic Treaty System

Committee for Environmental Protection

10.1 The Scientific Committee noted SC-CAMLR-41/BG/10 which presented the annual report of the CEP to the Scientific Committee of CCAMLR. The report summarised the discussions at CEP XXIV, hosted by Germany from 23 to 27 May 2022, on the five themes (climate change, biodiversity and non-native species, species requiring special protection, spatial management and area protection and ecosystem and environmental monitoring) agreed to be of common interest with SC-CAMLR.

10.2 SCAR presented SC-CAMLR-41/BG/20 which provided background information that may be useful for CCAMLR Members on avian influenza. Additional work is underway through SCAR, with the International Association of Antarctica Tour Operators (IAATO) and the Council of Managers of National Antarctic Programs (COMNAP), to develop practical advice to identify suspected cases and to eliminate risk associated with direct human contact. It may also be timely for the Scientific Committee to consider revising CEMP Standard Methods protocols on collection of samples in the event of disease.

Scientific Committee for Antarctic Research

10.3 The Scientific Committee noted SC-CAMLR-41/BG/19 in which SCAR presented recent and future activities of relevance to CCAMLR from its Annual Report 2021/2022, especially the SCAR's Antarctic Environments Portal ('the Portal' www.environments.aq) which provides a web-based source of independent and objective scientific information to support the work of decision makers in the Antarctic Treaty System, of which CCAMLR is an integral part. SCAR Ant-ICON will announce a fellowship scheme later this year to enable an early to mid-career researcher to be mentored to participate in ATCM/CEP or CCAMLR as part of the SCAR delegation.

10.4 The Scientific Committee noted the SCAR Krill Action Group (SKAG) has now transitioned to SCAR Krill Expert Group (SKEG). It further noted the krill and krill fishery summary in Antarctic environments portal (Kawaguchi et al., 2022) and the recent editorial on krill in the journal *Science* (Meyer and Kawaguchi, 2022) were both co-authored by members of SKEG, and made a significant contribution to raising awareness of the importance of krill management in CCAMLR. The support that CCAMLR provided for the creation of SKAG and SKAG's outreach and nurturing of early career scientists was acknowledged.

10.5 The Scientific Committee noted SC-CAMLR-41/BG/24 in which the relevant recent and planned research and activities of the multidisciplinary program Integrating Climate and Ecosystem Dynamics in the Southern Ocean (ICED) relevant to CCAMLR are summarised.

ICED promotes, addresses and identifies high-priority research, delivering workshops, conference sessions and stakeholder-engagement activities, involving individual scientists and national programs.

Reports of observers from other international organisations

10.6 The Scientific Committee noted SC-CAMLR-41/BG/31 which highlighted ASOC and its member organisations' intersessional activities in support of Antarctic conservation, such as funding scientific research, facilitating opportunities for discussion between CCAMLR stakeholders, and organising numerous educational and outreach activities.

10.7 The Scientific Committee further noted SC-CAMLR-41/BG/04 on protecting blue corridors, showing the importance of a collaborative international approach and highlighting the challenges and solutions for migratory whales navigating national and international seas, the importance of Antarctica for those animals, and the relevance of protecting the areas used by them.

10.8 The Scientific Committee noted SC-CAMLR-41/BG/07 which reported on the activities by ARK in the 2021/22 krill fishing season. The Scientific Committee further noted the existing beneficial cooperation between scientists and the fishing industry in providing scientific information to support the Scientific Committee advice.

10.9 The Scientific Committee noted SC-CAMLR-41/BG/08 which presented ARK's recommendations to the Scientific Committee and the Commission to improve transparency and safety across the entire fishery and not limited to voluntary actions. ARK suggested CCAMLR review and adopt these measures, making necessary changes to existing regulations and safety standards across the fleet.

10.10 ARK acknowledged the significant progress achieved at the different working groups in advancing the new management strategy for the krill fishery. In this regard, ARK will continue supporting this new management strategy as demonstrated by the ongoing collaborations between its members and scientists from China, Norway and the UK to conduct surveys in Subareas 48.1, 48.2 and 48.3 to provide baseline information for implementing the new management strategy. ARK members feel confident that the fishing fleet will be able to support the increasing data demands that the operationalisation of the new management strategy implies. As such, ARK supported the principle that all companies participating in the fishery should collect information necessary for management and would welcome to be included in the discussions that the Scientific Committee will undertake for the prompt development of data collection plans for krill fishing vessels. It appreciated the discussions around WG-FSA advice during this year's meeting but sought further clarification regarding what preconditions are needed to take this advice further by the Scientific Committee. Finally, while the new management strategy continues to be perfected, it suggested that a safeguard to land-based predators during the breeding season would be advised, in line with the current ARK voluntary restricted zones.

Reports of representatives at meetings of other international organisations

10.11 The Scientific Committee noted CCAMLR-41/BG/06 which summarises the key elements of the 35th meeting of the FAO Committee on Fisheries (COFI) and the 9th meeting of the Regional Fishery Bodies Secretariats' Network (RSN). The Scientific Committee noted the 2022 FAO publication on the State of World Fisheries and Aquaculture (SOFIA-2022) which reports that in 2020 the Antarctic krill fishery was the largest single-species crustacean fishery globally. The Scientific Committee further noted that FAO is revising and expanding the number of stocks for the calculation of the long-running sustainability index, and will liaise with the Secretariat to include krill and finfish data on the calculation of that index.

10.12 The Scientific Committee considered SC-CAMLR-41/BG/34, which summarised the activities of the IWC-SC of interest to SC-CAMLR for the years 2019–2022 such as assessments of baleen whale population recovery, cetacean abundance estimates (which would aid in consumption rate estimates for future spatial overlap analyses), non-deliberate human-induced mortality of whales, including entanglement, and ecosystem modelling. The Scientific Committee endorsed Dr Kelly as SC-CAMLR's observer to IWC-SC.

Future cooperation

10.13 The Scientific Committee considered CCAMLR-41/11 Rev. 1, which describes cooperation under the formal Arrangements and Memorandums of Understanding (MOUs) that CCAMLR has signed with other regional organisations.

10.14 The Scientific Committee noted the increasing level and importance of cooperation with these regional organisations. It further noted that the Arrangement with CCSBT came to an end in January 2022. The Scientific Committee endorsed the extension of the Arrangement with CCSBT for an additional three years.

10.15 The Scientific Committee noted CCAMLR-41/BG/23, which described the Southern Ocean Action Plan published in April 2022 providing an initial roadmap to strengthen links between science, industry and policy in order to address existing gaps in our knowledge and data coverage. CCAMLR Members are encouraged to further participate in Southern Ocean Decade activities.

Scientific Committee activities

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

11.1 SC-CAMLR-41/10 presented the Report of the Chair of the Scientific Committee on the CCAMLR Scientific Committee Symposium, noting that it was a well-attended symposium that provided a forum on the business of the Scientific Committee including progress over the past five years, an outlook for the upcoming five years, and examination of cross cutting issues.

11.2 The Chair further noted that an important result of the symposium was the review of the terms of reference for all working groups. Future work plans and terms of reference for the working groups were revised during each working group and further developed by the Scientific

Committee (Tables 6 to 10, Annex 11). The Scientific Committee suggested the Secretariat develop web pages for each working group as well as for the Scientific Committee where this information could be stored for tracking progress of the plan.

11.3 The Scientific Committee recommended annexing the Report of the Chair of the Scientific Committee on the CCAMLR Scientific Committee Symposium to the Scientific Committee report as a record of the important discussions (Annex 4).

11.4 The Scientific Committee endorsed the recommendation that progress reports be prepared every two years to track items identified as high-priority scientific issues during the 2023–2027 period (SC-CAMLR-41/10, Table 1). The Scientific Committee noted that these reports will be prepared by the Chair and the conveners and will provide a transparent record of progress.

11.5 The Scientific Committee endorsed the proposal from the Scientific Committee Chair to change the structure of its report to the Commission to use spatial areas rather than administrative topics to streamline the advice from working groups.

11.6 The Scientific Committee reviewed and endorsed proposed workshops for 2023 (Table 11) and the compilation of Secretariat tasks from the working groups and the Scientific Committee (Table 12).

Second Performance Review

11.7 CCAMLR-41/06 presented an update on the progress on the actions taken by CCAMLR in response to the Second Performance Review.

11.8 The Scientific Committee noted the summary of outcomes of the Second Performance Review and that in the last five-year period most actions identified as being the responsibility of the Scientific Committee were either completed or ongoing. The Scientific Committee further noted that the implementation of the five-year Strategic Plan enabled a mechanism to track progress internally. The Scientific Committee considered it appropriate to initiate a new external performance review when the current five-year period lapses.

11.9 The Scientific Committee recommended the Performance Review results be updated on the CCAMLR website to provide a transparent record of progress. The Scientific Committee noted that its Strategic Plan (Annex 4) will also be used to evaluate progress in the future.

CCAMLR Scientific Scholarship Scheme

11.10 Dr A. Makhado (South Africa) announced that the CCAMLR Scientific Scholarship review panel had only one application submitted for 2022, but that this was an excellent scholarship candidate. He announced the laureate of the 2022 scholarship: Mauricio Mardones (Chile), from Universidad de Magallanes, who will analyse the population dynamics and exploitation status of Antarctic krill near the Antarctic Peninsula through integrated stock assessment models. He will visit his mentors Dr George Watters and Dr Christian Reiss at

NOAA Fisheries, La Jolla, USA, as well as Dr César Cárdenas at Instituto Antártico Chileno (INACH), Punta Arenas, Chile, and will attend the WG-EMM-2024 and WG-FSA-2024 meetings to present his results.

11.11 The Scientific Committee congratulated Mr Mardones on his scholarship and noted that the planned work was relevant to advancing our understanding of krill. The Scientific Committee further noted that the ability to participate in online meetings had increased Mr Mardones integration within CCAMLR and the productivity of the CCAMLR scholarship scheme.

11.12 The Scientific Committee noted that the scholarships awarded during the COVID-19 pandemic had been extended for two years resulting in six continuing scholarships for 2022/23 in addition to the new scholarship. The Scientific Committee further noted that a significant portion of scholarship funding is contingent on attending an in-person CCAMLR meeting as well as meeting with mentors, and the ability to do this had been curtailed for the last two years.

Capacity building

11.13 The Ukrainian recipient of travel assistance from the General Capacity Building Fund, Larysa Samchyshyna, presented a summary of her research activities in SC-CAMLR-41/BG/06. Ms Samchyshyna thanked the Scientific Committee for the support from the CCAMLR General Capacity Building Fund for her research activities.

11.14 The Scientific Committee thanked China for providing the China Fund which will support two new international internships to work on science- or compliance-related tasks in the coming year. The Secretariat will publish the details of the internships on the CCAMLR website.

CEMP Special Fund

11.15 The Chair of the CEMP Fund Management Panel, Dr Makhado, reported that no new applications were received in 2022. Four ongoing projects received funding from the CEMP Special Fund in 2022. The Scientific Committee noted that the recipients of the four proposals since 2019 submitted progress reports detailed in SC-CAMLR-41/BG/03.

11.16 The Scientific Committee welcomed the nomination of a new junior CEMP Fund Management Panel member for 2022/2023, Dr Ghigliotti from the National Research Council of Italy.

11.17 Dr Lowther noted that the award of external funding by the Antarctic Wildlife Research Fund (AWR) to a project which will provide complementary data to a CEMP-funded project demonstrates well how the CEMP Special Fund can also be used by Members as leverage for other funding opportunities.

General Science Capacity Fund

11.18 The Scientific Committee recalled the endorsement of a joint COLTO–CCAMLR Workshop on tagging procedures in 2019 (SC-CAMLR-38, paragraph 4.8) which was delayed due to the pandemic. The objective of the proposed joint workshop is to develop best-practice guidelines for tagging of toothfish in CCAMLR longline fisheries, and to use these best practices to support the training of all involved in at-sea tagging operations. Since the 2019 discussions, the scope of this workshop was expanded to include skate tagging best practices. The workshop is anticipated to be held in Hobart, Australia, in the first week in March 2023 for four days (Table 12). Funding for meeting operations and venue will be provided by COLTO.

11.19 The Scientific Committee requested A$25 000 to cover travel- and accommodation-related costs for invited experts outside of CCAMLR, and an additional A$25 000 to support travel costs for CCAMLR Members to attend.

11.20 The Scientific Committee recommended that the funding could be provided through the General Science Capacity Fund by creating a new Special Activity for scientific workshops.

11.21 The Workshop Co-conveners (Dr Jones and Mr Arangio) detailed intersessional work to support the tagging workshop, including:

(i) consideration of issues with breaking tags (storage, replacement of needles or cleaning of tagging guns)

(ii) developing training material for observers/crew based on videos of good behaviour (e.g. WG-FSA-2022/19). This will be refined at the workshop, and serve as one of the outputs of the workshop

(iii) develop improved fish handling approaches to maximise survival (possibly an engineering project)

(iv) analysis to consider factors that lead to maximal survival

(v) examine improvement of tagging guidelines and translation into multiple languages.

11.22 The Secretariat presented SC-CAMLR-41/08 regarding the alignment of CCAMLR Special Fund procedures. The Scientific Committee endorsed the following recommendations:

(i) travel support be provided for working group conveners, provided that the General Science Capacity Fund has sufficient funds, and up to a maximum of A$20 000 per year per convener. In addition, the cap on the length of time a convener can be supported, is removed

(ii) continuation of funding the scholarship scheme at the level of A$30 000 per award and to award up to two scholarships each year

(iii) the management panels for the Special Funds be designated as per Table 1 in SC-CAMLR-41/08. The Secretariat additionally proposed that a quorum or decision-making for review panels can be defined as half plus one member present in the discussion to be consistent with the General Capacity Building Fund

(iv) that CEMP Special Fund applications be limited to three years duration with a limit of A$50 000 per year. The Fund would have a maximum expenditure of A$150 000 per year. These terms would be reviewed every five years to adapt to inflation. The Secretariat additionally noted that the Standing Committee on Administration and Finance (SCAF) budget has been adjusted to account for projected inflation but that the amounts can be re-evaluated as needed

(v) that annual progress reports should be submitted for each project (CEMP Special Fund and General Science Capacity Fund awards) to the relevant review panel and summarised for the Scientific Committee

(vi) fund advertising and application schedules be adopted as detailed in Table 2 in SC-CAMLR-41/08 Rev. 1.

CCAMLR science publication policy

11.23 CAMLR-41/10 presented potential improvements to the document access policy to allow documents to be identified as never release, release on request, or freely available for download and that all documents would receive a digital object identifier (DOI). It further recommended that all papers submitted to CCAMLR meetings could be marked 'available for download' if 22 or more years have elapsed since the year in which the relevant meeting took place, unless the delegation responsible for release indicates that access should remain restricted.

11.24 The Scientific Committee endorsed the proposal that all documents submitted to CCAMLR meetings will receive a DOI assigned using the infrastructure provided by the Australian Research Data Commons (ARDC) system and will receive an accessibility category chosen by the submitting Member.

11.25 The Scientific Committee noted that the website should specify that all papers should be read in the context of the working group meeting to which they were submitted.

11.26 The Secretariat presented SC-CAMLR-41/01, which detailed a review of the publication policy with respect to the purpose of *CCAMLR Science* (as requested by SC-CAMLR-40, paragraph 8.2), and presented options to increase the visibility and transparency of science conducted by CCAMLR, including the use of DOIs.

11.27 The Scientific Committee recommended a tiered approach for communicating its science, which included:

(i) making individual papers submitted to working groups available for download by Members at submission (CCAMLR-41/10)

(ii) encouraging papers, groups of papers, or works that journals are typically reluctant to publish to be progressed as a CCAMLR publication (and still called *CCAMLR Science*) which:

(a) would accommodate any number of contributions on an annual basis (including zero)

(b) allow potential submissions identified by Members at any time

(c) require agreement by the Scientific Committee Bureau (*CCAMLR Science* Editorial Board) that the work is key for the Scientific Committee to make available to the wider scientific community

(iii) encouraging more general promotion of CCAMLR's science through publication which can be accomplished through the regular publication strategy managed by the Secretariat.

11.28 SC-CAMLR-41/14 presented a proposal that a series of 15 papers led by Prof. P. Koubbi (France) could use the publication framework outlined in SC-CAMLR-41/01 as a special edition of *CCAMLR Science*.

11.29 The Scientific Committee requested that the papers be submitted to WG-EMM to begin evaluating the publication process.

Data Service Advisory Group (DSAG) activities

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

11.31 The Scientific Committee noted the recommendation of WG-FSA-2022, paragraph 9.11, that:

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

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

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

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

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

11.32 The Scientific Committee noted that while data are requested for the preparation of documents for consideration of the Scientific Committee and its working groups, for many of those requests, there is no paragraph in the Scientific Committee report which endorses the work and justifies releasing data following paragraph 2(a) of the Rules.

11.33 The Scientific Committee reflected whether changing the current data request procedure, which considers the absence of reply within a three-week period as consent to release the data, would affect the availability of data to prepare documents for the consideration by the Scientific Committee and its working groups.

11.34 The Scientific Committee noted that the rules for data access were complex and the implication for some of the changes recommended by the working groups required further consideration, including by the Commission.

11.35 The Scientific Committee requested that the Secretariat provide a simple process diagram to outline the workflow for data requests to more easily communicate how the rules function and where constraints or improvements could be made and to coordinate a discussion through the DSAG e-group.

11.36 The Scientific Committee welcomed the nominations of Dr Okuda and Dr Van de Putte as Co-conveners of DSAG.

Next meetings

11.37 The Chair noted that in accordance with the Scientific Committee Rules of Procedure, the Scientific Committee may seek the advice of other scientists and experts as may be required on an ad hoc basis. Such scientists and experts may submit documents and participate in discussions on the questions for which they were invited, but do not participate in the taking of decisions. In cases when an invitation to such scientists and experts has financial implications for the Commission not provided for in its budget, such an invitation should require approval of the Commission. The Scientific Committee encouraged Members to add external experts into their delegations to enable them to attend CCAMLR workshops. The Scientific Committee noted the agreement that designated observers could be invited to participate in WG-IMAF (paragraph 5.36).

11.38 The next meeting of the Scientific Committee will be held at the CCAMLR Headquarters building (181 Macquarie Street) in Hobart, Australia, from 16 to 20 October 2023 (CCAMLR-38, paragraph 13.9):

(i) WG-ASAM – To be hosted in Japan from 29 May to 2 June 2023, provisionally Yokohama or Tokyo

(ii) WG-SAM – To be hosted in Kochi, India, 26 to 30 June 2023

(iii) WG-EMM – To be hosted in Kochi, India from 3 July to 14 July 2023

(iv) WG-IMAF – To be hosted in Hobart from 7 October to 10 October 2023 (Saturday to Tuesday)

(v) WG-FSA – To be hosted in Hobart, Australia, from 2 to 13 October 2023.

11.39 All intersessional meetings and workshops are detailed in Table 11.

Secretariat supported activities

12.1 The Scientific Committee considered CAMLR-41/05 which summarised the Executive Secretary's report and the forth-year implementation report for the Secretariat's Strategic Plan. The Scientific Committee noted the extraordinary workload put on the Secretariat during 2022 and thanked the Secretariat for its commitment to securing the efficient work of CCAMLR under challenging conditions.

12.2 The Scientific Committee noted that the return to in-person meetings had greatly assisted its ability to resolve and progress its advice and requested that the Secretariat maintain the current format of in-person meetings that are supplemented with online access. The Scientific Committee noted that this format facilitated access to the discussions of a wide range of Member experts, while reducing travel costs for Members.

12.3 The Scientific Committee noted the progress made by the Secretariat on the tasks assigned to the Secretariat as outlined in SC-CAMLR-41/02 and its work with SIOFA to improve the toothfish tag release and recapture data for fish that have moved between the Convention Area and SIOFA areas.

12.4 The Scientific Committee endorsed the toothfish tag data sharing protocol with SIOFA given in SC-CAMLR-41/02, Annex 1.

12.5 The Scientific Committee requested that the Secretariat approach SPRFMO to discuss the establishment of a similar tag data sharing protocol.

12.6 The Scientific Committee noted the report of the Secretariat on its experience with the first year of issuing circulars from Observer organisations (SC-CAMLR-41/BG/02) and encouraged the Secretariat to continue this trial a further year. SCAR requested that the circulars are shared with all Observer organisations.

12.7 The Scientific Committee noted the progress made by the Secretariat in the management of CCAMLR data and its plans for further data-related work (SC-CAMLR-41/BG/37).

Budget

13.1 The Scientific Committee noted CCAMLR-41/01 Rev. 1 and CCAMLR-41/07, describing the Secretariat's Strategic Plan and the Staffing and Salary Strategy for 2023–2026. The papers described an ambitious workplan for the Secretariat, including an increase in staffing to implement the new Strategic Plan, enhance support for the Scientific Committee to implement its Strategic Plan, support growth and redevelopment of the website and increase administrative support.

13.2 The Scientific Committee welcomed the plan and looked forward to the further development of capacity within the Secretariat and its assistance in supporting the ambitious scientific work of the Committee in the coming four years.

Advice to SCIC and SCAF

14.1 The Chair of the Scientific Committee reported to SCIC on several topics, including that:

(i) improved gear marking would aid ascertain whether gear found belonged to the legal fishery and in the quantification of IUU fishing (paragraph 8.2)

(ii) the issues with catch reporting by the *Betanzos* and *Juvel* (SC-CAMLR-40, paragraph 3.5) have been resolved (WG-FSA-2022, paragraph 7.2)

(iii) the tagging rate, and tag-overlap statistic, be specified and applied to the smallest scale for which a catch limit is set (e.g. research block, SSRU, or management area) (paragraph 3.121).

14.2 The Chair also asked SCIC that if a proposal utilising CM 24-01, Annex 24-01/A, format 2, would be considered compliant if it did not address every item listed in the template. Feedback from SCIC indicated the evaluation of proposals which use the template was a scientific matter and that there was no compliance aspect of the template to consider, noting that there were items listed that were not appropriate for all proposals, for example 'trawl type' for proposals using longline gear.

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

(i) six existing scholarships have been delayed due to COVID-19, plus one new scholarship will result in a large expenditure on scholarships in 2022 and 2023. In addition, the Chair reported that the Scientific Committee recommended awarding up to two scholarships annually (paragraph11.12)

(ii) convener travel assistance should continue but with modified implementation rules and budget (paragraph 11.21i)

(iii) the Scientific Committee recommended the creation of a new Special Activity for the General Science Capacity Fund to support requests for funding related to scientific workshops, including two workshops in the coming year (paragraph 11.20)

(iv) the CEMP Fund anticipates camera maintenance expenses of A$16 765 in 2023 (paragraph 11.15)

(v) the Scientific Committee supported recommendations to further develop document access, including assigning DOIs (paragraph 11.24) and a tiered approach for *CCAMLR Science* publications (paragraph 11.27).

Election of Vice-Chair

15.1 The Scientific Committee elected the Vice-Chair in accordance with Rule 8 of its Rules of Procedure. Dr Makhado was elected Vice-Chair in 2019 for the 2020 and 2021 meetings, and was extended through the 2022 meeting due to the COVID-19 pandemic. Dr F. Schaafsma (Netherlands) was elected Vice-Chair in 2021 for the 2022 and 2023 meetings. For the 2023 period, Dr Schaafsma will assume the Senior Vice-Chair role, and a new Junior Vice-Chair was nominated.

15.2 The Scientific Committee endorsed the nomination of Dr Lowther as the Junior Vice-Chair of the Scientific Committee. Dr Lowther thanked the Scientific Committee and looked forward to learning the details of the role from Dr Makhado.

Other business

16.1 The Japanese training and research vessel, *Umitaka-Maru*, operated by the Tokyo University of Marine Science and Technology, has a research cruise planned in the East Antarctic area in January 2023. The main purpose of this research cruise is the ecological study of fish and squid larvae, and plankton. The main target is meso-pelagic fishes like lanternfish sampled by Matsuda-Oozeki-Hu trawl (MOHT) net. Unfortunately, there is no room for visiting researchers on the research cruise in 2023.

16.2 As the Ross Sea shelf survey has been approved to go ahead for another three years (paragraph 3.137) and now that pandemic travel restrictions and associated logistical challenges have eased, New Zealand is able to return to the previous practice of including an international scientist on the shelf survey. International scientists are invited to join the survey as a mechanism to share knowledge and experience across the CCAMLR science community. Dr Péron will join Dr Devine on the upcoming Ross Sea shelf survey starting in January 2023. Dr Péron thanked New Zealand for the offer and looked forward to participating in the survey.

Adoption of the report of the Forty-First Meeting

17.1 The report of the meeting was adopted.

Close of the meeting

18.1 At the close of the meeting Dr Welsford thanked all participants for their contributions to the significant progress made at this meeting, especially the on the development of the krill management approach. He thanked the Secretariat for support during the meeting and throughout the year, the interpreters and Congress Rental for meeting communication and AV support, the translators for their efficient work, as well as all the people who made the meeting a success through their work in catering, housekeeping and keeping participants safe.

18.2 On behalf of the Scientific Committee, Dr Darby thanked Dr Welsford for his hard work and reinforced the gratitude to all who made the first in-person meeting in three years a success.

18.3 Dr Darby also pointed out that Doro Fork, CCAMLR Communications Manager, is planning to retire before the next meeting of the Scientific Committee after providing 25 years of exemplary service. The Scientific Committee responded with a standing ovation.

References

Grant, S.M. C.L. Waller, S.A. Morley, K.A. Barnes, M.J. Brasier, M.C. Double, H.J. Griffiths, K.A. Hughes, J.A. Jackson, C.M. Waluda and A.J. Constable. 2021. Local drivers of change in Southern Ocean ecosystems: Human activities and policy implications. *Front. Ecol. Evol.*, 9: 624518, doi: https://doi.org/10.3389/fevo.2021.624518.

Kawaguchi, S., B. Meyer, J.A. Conroy, H. Zhang and E. Rombolá. 2022. Antarctic krill and its fishery: current status and challenges. *Antarctic Environments Portal*, doi: 10.48361/b1vp-mt19.

Meyer, B. and S. Kawaguchi. 2022. Antarctic marine life under pressure. *Science*, 378: 6617, doi: 10.1126/science.adf3606.

Table 1: Topics identified by the Scientific Committee and its working groups relating to data collection in the krill fishery, with steps identified to develop advice and implement outcomes for data collection requirements and protocols. Note that workshops may be combined if advice, forms and training materials for the appropriate participants are available. ToR – terms of reference, SISO – Scheme of International Scientific Observation.

Issue	Group for consideration	Advice to be developed	Advice implementation Phase 1		Advice implementation Phase 2	Notes and references
			Secretariat	Member consultation	Workshops (indicative timing)	
Krill observer data collection requirements and time allocation	WG-EMM-2022 and WG-SAM-2022	Update to SISO observer sampling instructions for length-frequency sampling	Adapt observer instructions	e-group Lead: Drs Zhu and Kawaguchi Observers and Scientists Time allocations and instructions for the krill observer data collection requirements and identify the training requirements for the preparation of the krill observer workshop 2023.	Krill observer workshop (2023 in Shanghai, China) Co-conveners: Drs Zhu and Kawaguchi	Revised ToR: WG-FSA-2022, Annex I. Financial implications: Seeking re-endorsement of financial support as outlined in SC-CAMLR-38/22 and endorsed by CCAMLR-38. Background: WG-EMM-2022, paragraphs 2.9 and 2.10. WG-FSA-2022, paragraphs 8.1 to 8.3
Krill length-weight relation	WG-SAM-2022	Methods for weight sampling to be defined and developed	Development of instructions for observers	Scientists and Observers Relevant Members submit work to WG-SAM-2023	Training workshop for weight sampling in 2023 or 2024 (TBA by WG-SAM-2023)	Background: WG-SAM-2022, paragraph 3.6, and WG-EMM-2022, paragraph 2.58. Workshop location, conveners, ToR, and financial implication for weight sampling WS: (TBA by WG-SAM-2023)
Fish by-catch sampling and reporting	WG-FSA-2022	Methods to be defined and developed	Development of instructions for vessels and observers	Members to undertake papers on results of power analysis to WG-SAM and WG-EMM-2023 to identify sampling requirements for fish by-catch. Discussion outcomes from the working groups will guide the development of observer data collection protocols at the krill observer workshop to be held in Shanghai (China) in 2023.	Training observer workshop will be included in Krill observer workshop	Background: WG-FSA-2022, paragraphs 8.21 to 8.28

(continued)

Table 1 (continued)

Issue	Group for consideration	Advice to be developed	Advice implementation Phase 1		Advice implementation Phase 2	Notes and references
			Secretariat	Member consultation	Workshops (indicative timing)	
Marine mammal interactions and sampling	WG-IMAF-2022	Methods and data collection requirements, including protocols for sampling mammals, to be developed	Development of instructions for vessels and observers	Intersessional group Lead: Dr Kelly Observers, IWC scientists, industry Refine design of additional data to be collected by observers and crew when whale entanglements occur (see list developed by WG-IMAF-2022) Report back to WG-IMAF-2023?	Observer Training Workshop TBA	WG-IMAF-2022 Report Table 8.1, Task 2.1 Workshop ToR to be refined
Bird warp strikes	WG-IMAF-2022	Update to SISO observer protocols	Adapt observer instructions	Intersessional group Lead: Dr Debski, with Secretariat support Redesign the warp strike observation protocols Report back to WG-IMAF 2023	Observer Training Workshop TBA Workshop ToR to be refined	WG-IMAF-2022 Report Table 8.1, Task 5.2 Workshop ToR to be refined
New C1 form	E-group	New C1 form design, including product weight field	Form design	Scientists, industry	Workshop (TBA)	New form to be endorsed by WG-EMM-2023

Table 2: Precautionary catch limits[1] allocated for the candidate management units in Subarea 48.1 (a map of the management units is shown in Figure 1) based on the 'alphas' from the 'AMLR strata new5' baseline scenario (WG-FSA-2021/16) and gamma = 0.0338. EI – Elephant Island, JI – Joinville, BS – Bransfield Strait, SSIW – South Shetland Islands West, GS – Gerlache Strait, DP – Drake Passage, PB – Powell Basin.

Management unit	Baseline (risk value, 0.46)				
	alpha		Catch limit (tonnes)		
	Summer (1 Oct – 31 Mar)	Winter (1 Apr – 30 Sept)	Summer (1 Oct – 31 Mar)	Winter (1 Apr – 30 Sept)	Total
Joinville (JI)	0.0008	0.0178	525	11 860	12 385
Elephant Island (EI)	0.0662	0.1097	44 253	73 298	117 552
Bransfield Strait (BS)	0.0061	0.1094	4 075	73 112	77 187
South Shetland Islands West (SSIW)	0.0549	0.0731	36 694	48 857	85 551
Gerlache Strait (GS)	0.0238	0.2116	15 921	141 378	157 300
Powell Basin (PB) +Drake passage (DP)	0.0450	0.2815	30 046	188 079	218 125
Total	0.1968	0.8032	131 515	536 585	668 101

1 The Scientific Committee was unable to reach consensus on catch limits in Subarea 48.1 (paragraph 3.67).

Table 3: Proposed catch limit[1] for each management unit as well as local biomass estimates, information related to fishing activities, research efforts and future research required in each stratum management unit. EI – Elephant Island, JI – Joinville, BS – Bransfield Strait, SSIW – South Shetland Islands West, GS – Gerlache Strait, DP – Drake Passage, PB – Powell Basin. CEMP – CCAMLR Ecosystem Monitoring Program.

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

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

[1] The Scientific Committee was unable to reach consensus on catch limits in Subarea 48.1 (paragraph 3.67).

Table 4: Proposed precautionary catch limits (tonnes) for finfish for consideration by the Commission for 2022/2023. AUS – Australia, CHL – Chile, CHI – China, ESP – Spain, FRA – France, GBR – United Kingdom, JPN – Japan, KOR – Republic of Korea, NOR – Norway, NZL – New Zealand, UKR – Ukraine, URY – Uruguay, ZAF – South Africa.

Subarea/ division	Fishing area	Target species	Catch limit		*Macrourus* spp.	Skates and rays	Other species	Conservation measure	Notified Members
			2021/22	2022/23					
48.2	48.2	*C. gunnari*	-	120			279 (krill)		UKR
48.3	483	*C. gunnari*	1 457	1708			See CM 33-01	33-01, 42-01	Not applicable
48.3[1]	483A	*D. eleginoides*	-	-	-	-	See CM 33-01		Not required
	483B	*D. eleginoides*	-	591	-	-	See CM 33-01		Not required
	483C	*D. eleginoides*	-	1379	-	-	See CM 33-01		Not required
	Total	*D. eleginoides*	-	1970	-	-	See CM 33-01		Not required
48.4	484_SSI	*D. eleginoides*	23	23				41-03	Not applicable
	484_SSI	*D. mawsoni*	50	42				41-03	Not applicable
48.6	486_2	*D. mawsoni*	134	123	19	6	19	33-03, 41-04	ESP, JPN, ZAF
	486_3	*D. mawsoni*	36	37	5	1	5	33-03, 41-04	ESP, JPN, ZAF
	486_4	*D. mawsoni*	196	157	25	7	25	33-03, 41-04	ESP, JPN, ZAF
	486_5	*D. mawsoni*	210	168	26	8	26	33-03, 41-04	ESP, JPN, ZAF
	Total	*D. mawsoni*	576	485					
58.4.1[1]	5841_1	*D. mawsoni*	138	138	22	6	22	33-03, 41-11	AUS, ESP, FRA, JPN, KOR
	5841_2	*D. mawsoni*	139	139	22	6	22	33-03, 41-11	AUS, ESP, FRA, JPN, KOR
	5841_3[2]	*D. mawsoni*	119	79	12	3	12	33-03, 41-11	AUS, ESP, FRA, JPN, KOR
	5841_4[2]	*D. mawsoni*	23	46	7	2	7	33-03, 41-11	AUS, ESP, FRA, JPN, KOR
	5841_5	*D. mawsoni*	60	60	10	3	10	33-03, 41-11	AUS, ESP, FRA, JPN, KOR
	5841_6	*D. mawsoni*	104	104	17	5	17	33-03, 41-11	AUS, ESP, FRA, JPN, KOR
	Total	*D. mawsoni*	583	566	-	-	-	33-03, 41-11	AUS, ESP, FRA, JPN, KOR
58.4.2	5842_1	*D. mawsoni*	72	86	13	4	13	33-03, 41-05	AUS, FRA
	5842_2	*D. mawsoni*	55	258	41	12	41	33-03, 41-05	AUS, FRA
	Total	*D. mawsoni*	127	344				33-03, 41-05	AUS, FRA
58.5.2	HIMI	*C. gunnari*	1 528	2616			See CM 33-02	42-02, 33-02	Not applicable
	HIMI	*D. eleginoides*	3 010	3010			See CM 33-02	41-08, 33-02	Not applicable

(continued)

Table 4 (continued)

Subarea/ division	Fishing area	Target species	Catch limit		*Macrourus* spp.	Skates and rays	Other species	Conservation measure	Notified Members
			2021/22	2022/23					
88.2	882_1	*D. mawsoni*	230	230	36	11	36	33-03, 41-10	AUS, ESP, GBR, JPN, KOR, NZL, UKR, URY
	882_2	*D. mawsoni*	223	268	42	13	42	33-03, 41-10	AUS, ESP, GBR, JPN, KOR, NZL, UKR, URY
	882_3	*D. mawsoni*	204	208	33	10	33	33-03, 41-10	AUS, ESP, GBR, JPN, KOR, NZL, UKR, URY
	882_4	*D. mawsoni*	154	185	29	9	29	33-03, 41-10	AUS, ESP, GBR, JPN, KOR, NZL, UKR, URY
	882H	*D. mawsoni*	102	122	19	6	19	33-03, 41-10	AUS, ESP, GBR, JPN, KOR, NZL, UKR, URY
	Total	*D. mawsoni*	913	1013	159	49	159		
88.3	883_1	*D. mawsoni*	16	16	2	0.8	2	24-05	KOR, UKR
	883_2	*D. mawsoni*	20	20	3	1	3	24-05	KOR, UKR
	883_3	*D. mawsoni*	60	48	7	2	7	24-05	KOR, UKR
	883_4	*D. mawsoni*	60	48	7	2	7	24-05	KOR, UKR
	883_5	*D. mawsoni*	8	8	1	0.4	1	24-05	KOR, UKR
	883_6	*D. mawsoni*	30	36	5	1	5	24-05	KOR, UKR
	883_7	*D. mawsoni*	30	36	5	1	5	24-05	KOR, UKR
	883_8	*D. mawsoni*	10	10	1	0.5	1	24-05	KOR, UKR
	883_9[3]	*D. mawsoni*	10	10	1	0.5	1	24-05	KOR, UKR
	883_10[3]	*D. mawsoni*	10	10	1	0.5	1	24-05	KOR, UKR
	Total	*D. mawsoni*	254	242					

1 Consensus could not be reached on catch limits for *D. eleginoides* in Subarea 48.3 and *D. mawsoni* in Division 58.4.1.
2 Catch limit for effort-limited research fishing as per WG-SAM-2022/04.
3 Catch limit for effort-limited research fishing as per WG-SAM-2022/05.

Table 5: Catch allocation options in the Ross Sea region. SRZ – special research zone.

Area		Method 1	Method 2	Method 3
		(a) New method as per CM 24-01 and CM 91-05	(b) Method used in 2017/18–2018/19	(c) Method used in 2019/20–2021/22
North of 70°S		642	645	664
South of 70°S		2 230	2 241	2 307
SRZ		524	510	425
Shelf Survey		99	99	99
Total		3 495	3 495	3 495
N70	Skates (5%)	32	32	33
	Macrourids (16%)	102	103	106
	Other (5%)	32	32	33
S70	Skates (5%)	111	112	115
	Macrourids (388 tonnes)	316	316	316
	Other (5%)	111	112	115
SRZ	Skates (5%)	26	25	21
	Macrourids (388 tonnes)	72	72	72
	Other (5%)	26	25	21
Total	Macrourids	490	491	494

Table 6: 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 (Annex 4). 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	2023	2024		
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		Dr Péron, Dr Miller, Dr Kasatkina	Yes
	(ii) Data collection – SISO and vessels					
	Task 4: Metric of vessel tagging performances			X	Dr Péron, Dr Miller, Mr Dunn, Dr Hoyle	Yes
	Conversion factors					
	Task 5: Develop protocol for conversion factors	short	X		Mr Gasco, Dr Massiot-Granier, Mr Walker	Yes
	(iii) Improve biomass estimation methods					
	Task 6: Optimise tag-based study (spatial overlap)				Dr Miller, Dr Péron, Dr Grüss	
	(d) Develop stock assessments to implement decision rules for finfish					
	(i) Research to develop new assessments					
	(1) Research plan evaluations:					
	Task 7: Research plan assessment	short			WG-SAM	
	48.2 Icefish		X	X		
	48.6 Patagonian toothfish		X			
	58.4.1–58.4.2 Antarctic toothfish		X			
	88.1 shelf survey Antarctic toothfish		X	X		
	88.3 Antarctic toothfish		X			

(continued)

Table 6 (continued)

Theme	Priority research topic	Timeframe			Contributors	Secretariat participation
	(ii) Develop new assessment tools					
	(1) CASAL2 development					
	Task 8: Online training + workshop at SAM	short	X		Mr Dunn, Dr Earl	
	Task 9: Toothfish growth modelling method (length bin sampling)	short		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:	medium				
	Task 10: Develop and agree on an operating model		X	X	Dr Ziegler, Mr Dunn,	Yes
	Task 11: MSE		X	X	Dr Darby, Dr Massiot-Granier, Dr Earl, Mr Somhlaba	Yes
	(ii) Development and testing of data-limited fishery decision rules	medium				
	Task 12: Develop and agree on an operating model		X	X	Dr Ziegler, Mr Dunn,	Yes
	Task 14: MSE (FSA-2022/53, WG-FSA-2022, paragraph 4.67)		X	X	Dr Darby, Dr Massiot-Granier, Dr Earl, Mr Somhlaba	Yes
	(iii) Finfish management strategies that are robust to climate change	medium	X	X	TBD	Yes
2. Ecosystem impacts	(a) Ecosystem monitoring (Second Performance Review, Recommendation 5) Structured ecosystem monitoring programs (CEMP, fishery)					
	Task 15: effective sample size for fish by-catch monitoring in the krill fishery	short	X		Dr Jones	
3. Adminis-trative topics	(b) Advise on quality control and assurance processes for data provided to and supplied by the Secretariat					
	Task 16: Inspect tag reconciliation issues	short		X		Yes
	(e) Communication of progress, internal and external:					
	Task 17: Diagnostic graphs on stock status	short		X	TBD	

Table 7: Intersessional work plan for WG-EMM. 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). Table 2 is the focus for this compilation. Numbers following level of urgency indicate the stated value in the box which replaced 'X', i.e. the year. 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	
		(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 Darby Dr Kawaguchi Dr Watters	
		(ii) Develop diagnostic tools Urgency: Medium	Medium		
		(iii) Develop ecosystem indicators to inform risk assessment framework Urgency: Low		Dr Warwick-Evans	

(continued)

Table 7 (continued)

Theme	Priority research topic	Priority research topic task	Timeframe	Contributors	Secretariat participation
		(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 Darby Dr Hill Dr Watters	
		(vii) Krill management strategies that are robust to climate change Urgency: Low	Long		
	(e) Management strategy evaluations for target species (Second Performance Review, Recommendation 8)	(iii) Finfish management strategies that are robust to climate change Urgency: Low			
2. Ecosystem impacts	(a) Ecosystem monitoring (Second Performance Review, Recommendation 5)	(i) Structured ecosystem monitoring programs (CEMP, fishery) (2) Fishery via SISO Urgency: Medium	Short/medium?	Dr Collins Dr Hinke Dr Lowther	
		(ii) Ecosystem modelling Urgency: Low	Long	Dr Schaafsma Dr Pinkerton	
		(iii) Invasive species Urgency: Low	Long		
		(iv) Marine debris monitoring Urgency: Low	Long	Dr Schaafsma	
	(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	

(continued)

Table 7 (continued)

Theme	Priority research topic	Priority research topic task	Timeframe	Contributors	Secretariat participation
		(ii) Research and monitoring plans Urgency: High			
	(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 Prof. Brey Australia 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			

(continued)

Table 7 (continued)

Theme	Priority research topic	Priority research topic task	Timeframe	Contributors	Secretariat participation
	(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) Urgency: Medium	Medium	Dr Schaafsma Dr Dahlgren	
	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			

Table 8: Intersessional work plan for WG-FSA. Timeframe periods are short = 1–2 years, medium = 3–5 years and long = 5+ years. Items tasked to WG-FSA from the Scientific Committee Strategic Plan (Annex 4) for Table 2. 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, FRA – France, JPN – Japan, KOR – Republic of Korea, NZ – New Zealand, US – USA.

Theme	Priority research topic	Priority research topic task	Timeframe	Contributors	Secretariat participation
1. Target species	(a) Develop methods to estimate fish by-catch for the krill fishery	(iii) Data collection – SISO, vessels Urgency: High	2023	Krill observer workshop, WG-SAM	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) Urgency: High (1) Subarea 48.1 (2023) Urgency: High (ii) Methods to account for uncertainty in stock status Urgency: Low (iii) Develop krill management approach as a multiannual cycle Urgency: High	2023	WG-ASAM-2023/ WG-SAM-2023/ WG-EMM-2023	Yes
		(iv) Krill management strategies that are robust to climate change Urgency: Low	2027	WG-SAM-2025/ WG-EMM-2025	Yes
	(c) Develop methods to estimate biomass for finfish	(i) Data collection – SISO and vessels Urgency: High			
		(1) Conversion factors Urgency: done	2023	Secretariat	Yes
		(2) Tagging protocols Urgency: High	2023	Dr Jones/Mr Arangio	Yes
		(3) Ross Sea data collection program Urgency: Low	2024–2028	All involved Members (NZ Lead)	Yes
		(ii) Modelling of spatial population structure Urgency: medium	2023–2025	Members	

(continued)

Table 8 (continued)

Theme	Priority research topic	Priority research topic task	Timeframe	Contributors	Secretariat participation
	(d) Develop stock assessments to implement decision rules for finfish	(i) Research to develop new assessments Urgency: Low		WG-SAM	
		(1) Research plan evaluations Urgency: High	2023–2025	WG-SAM/WG-FSA	Yes
		(2) Subarea 88.2 fishery structure Urgency: Medium	2023–2025	(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) Urgency: Low	2023–2027	JPN/NZ/CHN/KOR/US Members	Yes
		(ii) Develop new assessment tools			
		(1) CASAL2 development (done already, conduct a workshop) Urgency: done	2023–2025	NZ/All involved Members	
		(iii) Provide precautionary catch limits Urgency: High	Every year	WG-FSA regular updates	Yes
	(e) Management strategy evaluations for target species (Second Performance Review, Recommendation 8)	(ii) Development and testing of data-limited fishery decision rules Urgency: Medium	2023–2025	Interested Members (WG-FSA-2022, paragraph 4.67)	Yes
		(iii) Finfish management strategies that are robust to climate change Urgency: Low	2025	AUS/NZ/UK Interested Members	Yes
2. Ecosystem impacts	(a) Ecosystem monitoring (Second Performance Review, Recommendation 5)	(i) Structured ecosystem monitoring programs (CEMP, fishery)			
		(2) Fishery via SISO Urgency: Medium		Regular monitoring	Yes
		(3) Research surveys Urgency: Low		Members fishing under CM-24-01 Surveys	
		(iii) Invasive species Urgency: Low			

(continued)

Table 8 (continued)

Theme	Priority research topic	Priority research topic task	Timeframe	Contributors	Secretariat participation
	(c) By-catch risk assessment for krill and finfish fisheries	(i) Monitoring status and trends Urgency: High	Every year	Secretariat	
		(ii) By-catch species catch limits Urgency: High	2026	AUS/FRA/NZ/UK	
		(iii) By-catch mitigation methods Urgency: Low	2026	AUS/FRA/NZ/UK	
	(d) Habitat protection from fishing impacts	(i) Habitat classification, bio-regionalisation and monitoring Urgency: Low			
		(ii) VME identification and management Urgency: Low	2025	FRA/AUS	Yes
		(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 Urgency: Low (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	2024	Secretariat	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) Urgency: Medium			

(continued)

Table 8 (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		Every year	DSAG	Yes
	(b) Advise on quality control and assurance processes for data provided to and supplied by the Secretariat Urgency: High		Every year	DSAG	Yes
	(c) Refine the scheme of international scientific observation (SISO) across all fisheries Urgency: Medium				
	(d) Further develop data management systems Urgency: Medium	(1) Quality assurance Urgency: High	Every year	DSAG	Yes
		(2) DOI Urgency: Medium		DSAG	Yes
		(3) Data access Urgency: Low		DSAG	Yes
	(e) Communication of progress, internal and external Urgency: Medium		2023	Convener	Yes
	(f) Working group terms of reference Urgency: Done		2022	SC-CAMLR-41	Yes
	(g) Scientific Committee Symposium in 2027 (Include annual review) Urgency: Medium		2027	SC Chair	Yes

Table 9: Annotated table of WG-ASAM research priorities. 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 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	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		

(continued)

Table 9 (continued)

Theme	Topic/task	Timeframe	Contributors	Secretariat participation
	(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			
	(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	Annex 4, Table 2, 1.a.i		
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	2019		
	(g) Scientific Committee Symposium in 2027			

Table 10: 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 incident mortality	1.1	Development of a web-based tool to allow examination of interactions and incidental mortality data across CCAMLR fisheries and areas at a finer scale (spatial and temporal) (supplemental information in additional to Secretariat report to WG-IMAF)	Short	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 (2023)	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)	Medium	Dr Kelly, Dr Lowther and Dr Lindstrøm	-
	2.3	Development of protocols for pinniped sex and length sampling and training materials	Short	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	Refine design of marine mammal exclusion device, considering a convex shape to the exclusion mesh to deflect whales (and seals) away from the net mouth	Medium / Long	Dr Kelly, Dr Lowther and Dr Lindstrøm	-
	4.2	Develop specifications for MMED in use in CCAMLR trawl fisheries	Short / Medium	Mr Pardo	-
	4.3	Undertake experiments into effectiveness of different MMED designs (for various species)	Medium / Long	Dr Kelly, Dr Lowther and Dr Lindstrøm	-
5. Seabirds – incidental mortality	5.1	Power analysis of required observer sampling required for warp strikes	Short	Dr Kelly, Dr Hinke and Mr Walker	-
	5.2	Redesign the warp strike observation protocols	Short (2023)	Dr Debski	-
	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	

(continued)

Table 10 (continued)

Theme		Task	Timeframe	Contributors	Secretariat participation
7. Seabirds – mitigation	7.1	Improve design and develop specification of 'sock'	Short		-
	7.2	Consider performance of trawl warp/cable strike mitigation approaches utilised by continuous trawl vessels (including environmental conditions and other factors)	Short	Dr Debski and Dr Arata	-
	7.3	Review existing use of and consider mitigation requirements in conventional trawl vessels	Short	Dr Debski and Dr Arata	-
	7.4	Review developments in demersal longline mitigation (streamer lines etc.)	Short	Mr Barrington, Dr Debski and Mr Arangio/ Mr McNeill	-
8. Observer reports and data collection	8.1	Consider IMAF-related tasks for observers in the various CCAMLR fisheries	Medium	Mr Clark	Yes
	8.2	Consider use of EM and AI to add further data collection to aid observers	Medium / Long	Mr Clark	-
9. Marine debris effects on seabird and marine mammals	9.1	Review information on the effect of marine debris on marine mammals and seabirds in the Convention Area	Short	Mr Barrington	Yes
10. Light pollution effect on seabirds	10.1	Consider options for the management of light pollution for vessels fishing in the Convention Area	Short	Mr Barrington	-

Table 11: Workshops and e-groups proposed by Scientific Committee working groups. NZ – New Zealand.

Title of workshop	e-group	Context	Convener(s)/ Managers	Location	Date	Secretariat support	Reference (paragraph)	Funds required
COLTO/CCAMLR tagging workshop		Improve tagging performance in longline fisheries	Dr Jones Mr Arangio	Hobart	March	Yes	SC-40, 3.36 SC-41, 3.122	A$50 000 (SCAF approved A$30 000)
Workshop on age determination methods		Determine methods and criteria to pool toothfish age data among laboratories	Dr Devine and Dr Hollyman	Online		Yes	SC-40, 3.94 SC-41, 3.85	
Casal2 workshop	Casal2 development	Introduce and provide training to scientists on using Casal2 to conduct stock assessments	e-group: Mr Dunn Workshop: NZ	TBD	TBD	No	SAM-2022, 3.32 SC-41, 2.9	
Krill observer workshop	Krill length frequency	Progress development of the krill data collection workplan, identify the number and venues for the necessary workshops	e-group: Dr Cox, Dr Wang Workshop: Drs Zhu and Kawaguchi	e-group: Online, Shanghai	7–10 days post WG-EMM-2023 (SC-CAMLR-41/16 Rev. 2)	Yes	EMM-2019, 3.38, EMM-2022, 2.10, 5.18, and SC-41, 3.12–3.14	A$40 000
CEMP workshop	CCAMLR Ecosystem Monitoring Program (CEMP)	Develop terms of reference to scope and structure a workshop to update CEMP relative to the krill management approach	Dr Collins, Dr Waluda, Ms Van Werven	TBD	Focus topic at WG-EMM-2023, then virtual workshops, then WG-EMM-2024	Yes	EMM-2022, 2.97–2.99 SC-41, 5.52	
Climate change workshop	Climate change impacts and CCAMLR	Develop ecosystem indicators and integrate within CCAMLR's scientific work	Dr Cavanagh, TBD (NZ)	NZ plus other regional hubs, in person workshops. Virtual plenary	March – May 2023	Yes	EMM-2022, 4.2, 4.6–4.9 SC-41, 7.10	

Table 12: Secretariat support and tasks for the incoming intersessional period. See Annex 12 for the glossary of acronyms.

Meeting	Paragraphs	Task
WG-ASAM	2.14, 5.3, 5.4, 5.5	Acoustic surveys metadata repository and exploration tool
WG-SAM	3.29, Appendix D	Casal2 verifications
	3.50, 3.51	Trend analysis and MSE (see also WG-FSA-2022, 4.67)
	8.3	Data access rules (see also WG-EMM-2022, 5.13)
WG-EMM	2.23	Net diagrams and configuration measurements collation
	4.8	CEMP indicators development
WG-IMAF	3.2, 3.3	IMAF reporting
	3.15	Data changes (see also WG-FSA-2022, 7.2i)
	4.28, 5.4	IMAF exclusion devices and guidelines
	Table 1	Several tasks
WG-FSA	3.3	Gear type identification prior to 2017
	3.6	CDS reconciliation
	3.9	IUU/gear markings
	3.20, 3.23	Ross Sea Data Collection Plan protocols
	3.25, 4.20(i)(e), 4.21, 4.22	Age database
	4.10 to 4.13	Tag linking
	6.3, 6.7, 6.10(ii), 6.10(v), 9.15	By-catch analyses and reporting
	6.24	Thorn sampling protocols
	6.32	Marine debris
	6.35	VME code translation table
	8.18, 8.19	Conversion factors
	8.26	SISO observation rate analysis (krill fishery)
SC-CAMLR	2.28	Load acoustic survey metadata
	3.5(vi)	Load all metadata and data prior to WG-ASAM annually
	3.18	Collate krill trawl net diagrams into gear library
	3.2	Contact Peru for historic acoustic data (WG-EMM-2022, 3.29)
	3.87	Update otolith image library and age database
	3.119	Coordinate intersessional group on toothfish MSE
	3.143	Refine Sampling protocols for RSDCP
	5.4(ii)	Improve species-level bycatch identification
	5.4(v)	Improve by-catch summaries in Fishery Reports
	5.7	Summarise key bycatch species at Convention Area scale
	5.15	Present warp strike rate summaries
	5.16	Correct Korean warp strike data
	5.28	Develop gear library description of marine mammal exclusion devices used
	5.30	Incorporate ACAP guidelines into SISO manuals and website
	5.32(ii)	Receive notice about gear monitoring trials
	5.46	Develop translation table for VME codes for Observers
	5.48(ii)	Restart ICG on Marine Debris via an e-group
	5.49	Undertake further analysis of gear loss
	6.19	Make CMIR public
	8.3	Reinitiate discussion to improve gear marking
	10.11	Liaise with FAO on sustainability index
	11.2	Develop webpages for SC-CAMLR and working groups
	11.35	Workflow diagram of Data Access Rules
	12.2	Continue current supplementation of in-person meetings with online access
	12.5	Approach SPRFMO to establish tag data sharing protocol

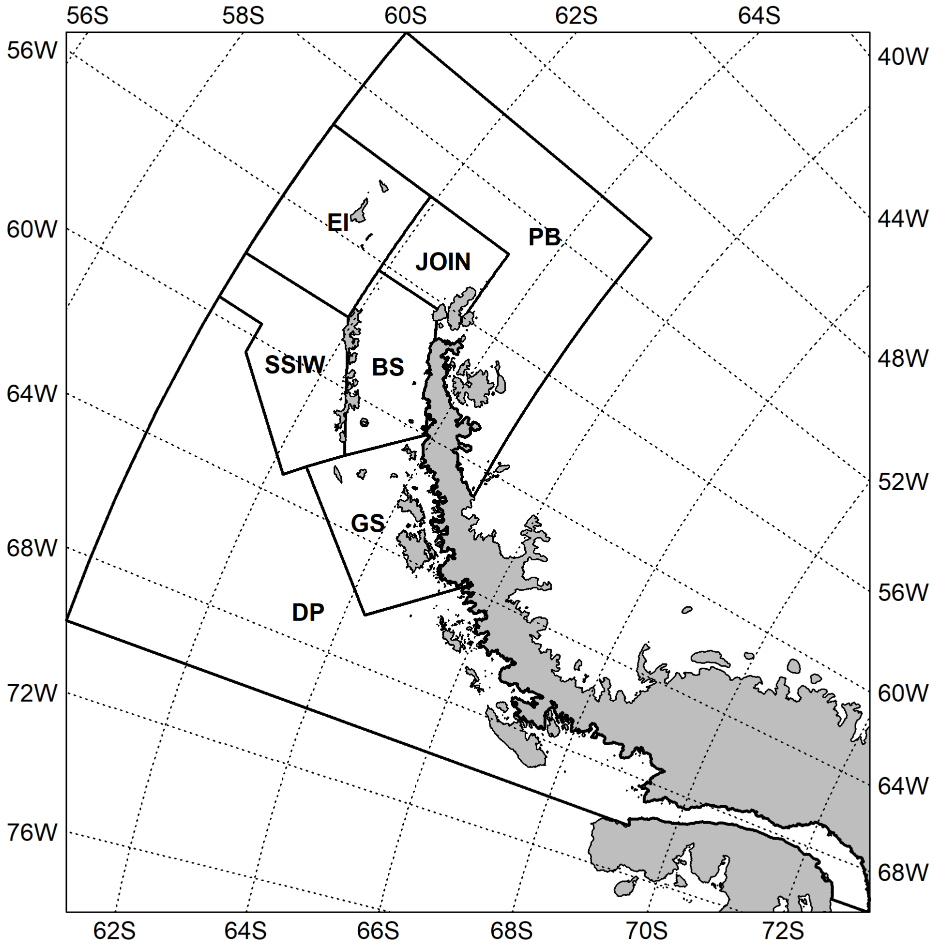


Figure 1: Krill management units in Subarea 48.1 EI – Elephant Island, JOIN – Joinville, BS – Bransfield Strait, SSIW – South Shetland Islands West, GS – Gerlache Strait, DP – Drake Passage, PB – Powell Basin.

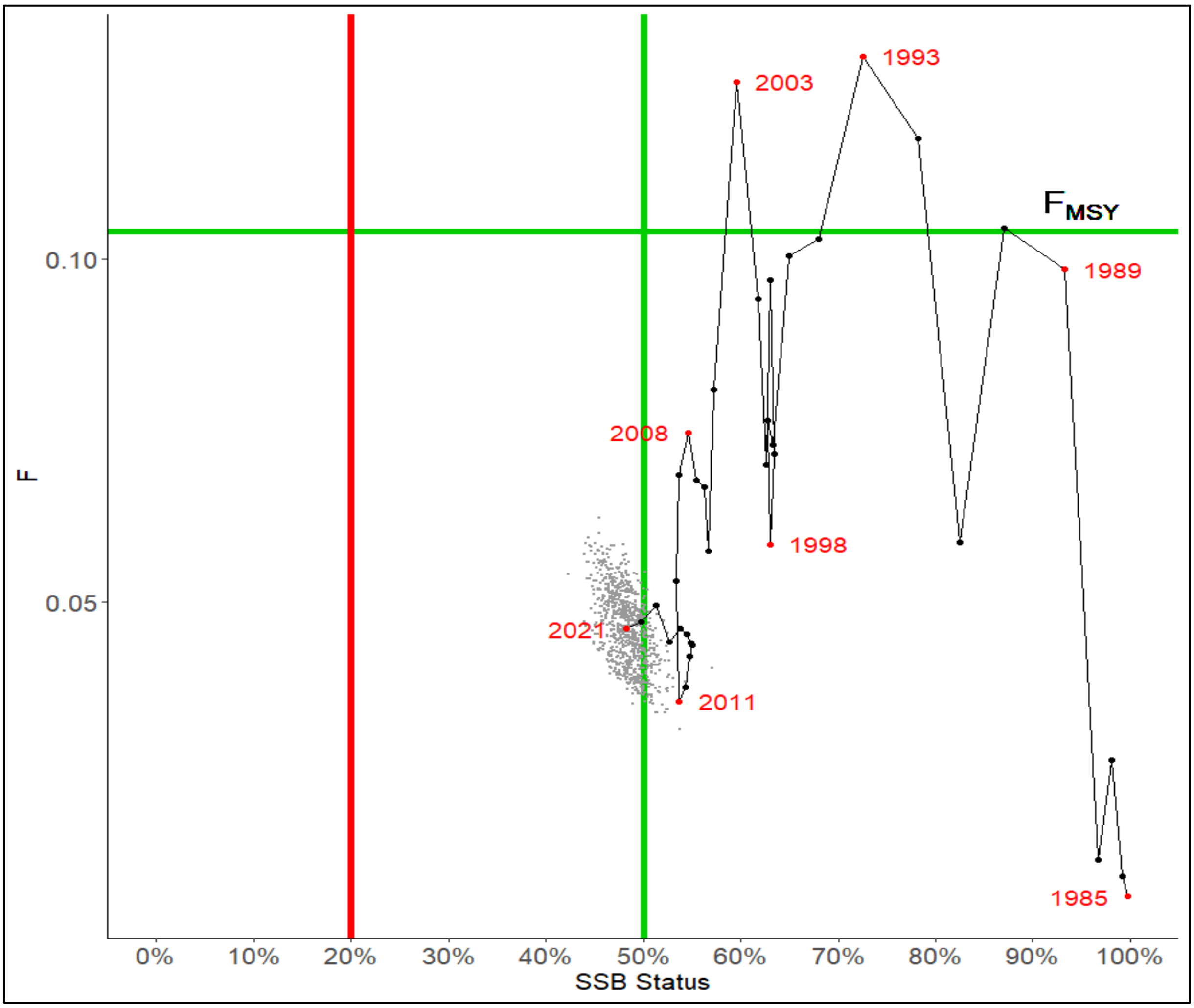


Figure 2: Markov chain Monte Carlo (MCMC) Kobe plot for *Dissostichus eleginoides* in Subarea 48.3 (lines) with the MCMC estimates of uncertainty around the 2021 estimate (points). The green and red vertical lines indicate the target (50% B_0) and limit (20% B_0) reference points respectively for toothfish under the CCAMLR decision rules, and the horizontal green line indicates the maximum sustainable yield (F_{MSY}) exploitation rate for the stock (~0.104 y^{-1}).

Annex 1

List of Registered Participants

List of Registered Participants

Chair, Scientific Committee		Dr Dirk Welsford Australian Antarctic Division, Department of Agriculture, Water and the Environment
Chair, Commission		Dr Jakob Granit Swedish Agency for Marine and Water Management
Argentina	Representative:	Dr Enrique Marschoff Instituto Antártico Argentino
	Alternate Representatives:	Mrs Marina Abas Argentine Ministry of Foreign Affairs, Trade and Worship
		Mr Máximo Gowland Ministry of Foreign Affairs, International Trade and Worship
		Mr Fausto Lopez Crozet Ministry of Foreign Affairs and Worship
		Ms Cynthia Mulville Ministerio de Relaciones Exteriores, Comercio Internacional y Culto
		Dr Emilce Florencia Rombolá Instituto Antártico Argentino
	Advisers:	Ms Andrea Capurro Private Consultant
		Mr Javier De Cicco Argentine Ministry of Foreign Affairs, Trade and Worship
		Dr Dolores Deregibus Instituto Antártico Argentino/CONICET
		Mr Darío Dziewezo Polski Embassy of Argentina in Australia
		Dr Marco Favero National Research Council (CONICET, Argentina)

		Mrs Paola Gucioni Ministerio de Relaciones Exteriores, Comercio Internacional y Culto
		Ms Marcela Mónica Libertelli Instituto Antártico Argentino
		Dr María Mercedes Santos Instituto Antártico Argentino
Australia	Representative:	Dr Philippe Ziegler Australian Antarctic Division, Department of Agriculture, Water and the Environment
	Alternate Representative:	Dr So Kawaguchi Australian Antarctic Division, Department of Agriculture, Water and the Environment
	Advisers:	Mr Nigel Abery Australian Fisheries Management Authority
		Ms Harriet Baillie Australian Antarctic Division
		Ms Sally Carney Australian Antarctic Division
		Ms Taha Cowen Australian Antarctic Division, Department of Climate Change, Energy, the Environment and Water
		Ms Emily Grilly WWF – Australia
		Dr Nat Kelly Australian Antarctic Division, Department of Agriculture, Water and the Environment
		Mr Dale Maschette Institute for Marine and Antarctic Studies (IMAS), University of Tasmania
		Mr Malcolm McNeill Australian Longline Pty Ltd

		Dr Cara Miller Australian Antarctic Division, Department of Climate Change, Energy, the Environment and Water
		Ms Gaia Puleston Australian Antarctic Divsion
		Ms Selina Stoute Australian Fisheries Management Authority
		Ms Claire Wallis Australian Fisheries Management Authority
		Prof. Nicole Webster Australian Antarctic Division
		Ms Anna Willock Australian Fisheries Management Authority
Belgium	Representative:	Dr Anton Van de Putte Royal Belgian Institute for Natural Sciences
	Alternate Representative:	Ms Stephanie Langerock FPS Health, DG Environment, Multilateral & Strategic Affairs
	Adviser:	Ms Zephyr Sylvester University of Colorado Boulder
Brazil	Alternate Representative:	Mrs Christiana Lamazière Ministry of External Relations of Brazil - Brazilian Embassy in Australia
Chile	Representative:	Dr César Cárdenas Instituto Antártico Chileno (INACH)
	Alternate Representatives:	Dr Lucas Krüger Instituto Antártico Chileno (INACH)
		Mr Mauricio Mardones Instituto de Fomento Pesquero
		Mr Sebastián Molina Ministerio de Relaciones Exteriores
		Dr Juan-Carlos Quiroz Instituto de Fomento Pesquero

		Mr Marcos Troncoso Valenzuela Subsecretaría de Pesca y Acuicultura
	Advisers:	Mrs Aurora Guerrero Subsecretaría de Pesca y Acuicultura
		Dr Lorena Rebolledo Instituto Antártico Chileno (INACH)
		Ms Jacqueline Salas Undersecretariat for Fisheries and Aquaculture
		Mr Francisco Santa Cruz Instituto Antartico Chileno (INACH)
China	Representative:	Dr Xianyong Zhao Yellow Sea Fisheries Research Institute, Chinese Academy of Fishery Science
	Alternate Representatives:	Dr Le Li MARA of China
		Mr Lei Yang Chinese Arctic and Antarctic Administration
		Prof. Guoping Zhu Shanghai Ocean University
	Advisers:	Mr Gangzhou Fan Yellow Sea Fisheries Research Institute
		Mr Hongliang Huang East China Sea Fisheries Research Institute, Chinese Academy of Fishery Science
		Mr Linlin Li Ministry of Foreign Affairs of China
		Dr Lu Liu Yellow Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences
		Mr Yuhao Tang Ministry of Foreign Affairs
		Mr Wan yong Wang Jiangsu Sunline Deep Sea Fishery Co. Ltd.

Dr Xinliang Wang
Yellow Sea Fisheries Research Institute,
Chinese Academy of Fishery Science

Dr Yi-Ping Ying
Yellow Sea Fisheries Research Institute

Mr Han Yu
Liaoning Pelagic Fisheries Co., Ltd

Dr Di Zhang
Polar Research Institute of China

Ms Haiting Zhang
Shanghai Ocean University, IMAS,
University of Tasmania

Mr Jichang Zhang
Yellow Sea Fisheries Research Institute

Mr Yang Zhang
Ministry of Foreign Affairs

Dr Yunxia Zhao
Yellow Sea Fisheries Research Institute

Ms Yingqin Zheng
Shanghai Institutes for International Studies

Ecuador	Representative:	Mr Andrés Arens Viceministry of Aquaculture and Fisheries Resources
	Alternate Representative:	Mr Alejandro Moya Subsecretaría de Recursos Pesqueros
	Advisers:	Mr Jose Isidro Andrade Vera Ministry of Production, Foreign Trade, Investments and Fisheries
		Mrs Mildred Barzola Reyes Instituto Oceanográfico y Antártico de la Armada del Ecuador
		Mr Fausto Bustos Ministerio de Relaciones Exteriores y Movilidad Humana

		Mr Santiago Coral Instituto Oceanográfico y Antártico de la Armada (INOCAR)
		Mr Jorge Costain Transmarina S.A.
		Mrs Rebeca Espinoza Bernal Ministerio de Producción, Comercio Exterior, Inversiones y Pesca
		Mrs Manuela Rosalía Fernández de Córdova Ministerio de Relaciones Exteriores y Movilidad Humana
		Mrs Mónica Riofrío Instituto Oceanográfico y Antártico de la Armada (INOCAR)
European Union	Representative:	Dr Sebastián Rodríguez Alfaro European Union
France	Representative:	Dr Marc Eléaume Muséum national d'Histoire naturelle
	Advisers:	Dr Pierre Feutry CSIRO
		Ms Maude Jolly Ministère de la Transition Ecologique
		Prof. Philippe Koubbi Sorbonne Université
		Dr Clara Péron Muséum national d'Histoire naturelle
		Dr Yan Ropert-Coudert IPEV
Germany	Representative:	Prof. Thomas Brey Alfred Wegener Institute for Polar and Marine Research
	Alternate Representative:	Prof. Bettina Meyer Alfred Wegener Institute for Polar and Marine Research

	Advisers:	Ms Patricia Brtnik German Oceanographic Museum
		Dr Jilda Caccavo Institute Pierre-Simon Laplace
		Mrs Sharlene Fechter Helmholtz Institute for Functional Marine Biodiversity
		Dr Stefan Hain Alfred Wegener Institute for Polar and Marine Research
		Dr Heike Herata 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
		Mr Julian Wilckens Project Management Juelich – German Federal Ministry of Education and Research
India	Representative:	Mr Saravanane Narayanane Centre for Marine Living Resources and Ecology
	Alternate Representative:	Dr GVM Gupta Ministry of Earth Sciences Govt. of India
	Adviser:	Dr Anoop Kumar Tiwari National Centre for Polar and Ocean Research, Ministry of Earth Sciences, Government of India
Italy	Representative:	Dr Marino Vacchi IAS – CNR
	Alternate Representatives:	Dr Maurizio Azzaro Institute of Polar Sciences

		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)
	Advisers:	Dr Anna Maria Fioretti Italian Ministry of Foreign Affairs
		Dr Silvia Olmastroni Museo Nazionale dell'Antartide
		Dr Carla Ubaldi ENEA – Antarctic Technical Unit
Japan	Representative:	Dr Taro Ichii Fisheries Resources Institute, Japan Fisheries Research and Education Agency
	Alternate Representative:	Dr Takehiro Okuda Fisheries Resources Institute, Japan Fisheries Research and Education Agency
	Advisers:	Mr Naohiko Akimoto Japanese Overseas Fishing Association
		Mr Masahiro Akiyama Fisheries Agency of Japan
		Dr Nobuo Kokubun National Institute of Polar Research
		Mr Naohisa Miyagawa Taiyo A & F Co. Ltd.
		Prof. Joji Morishita Special Adviser to the Minister of Agriculture, Forestry and Fisheries
		Mr Takeshi Shibata Taiyo A & F Co. Ltd.
		Dr Akinori Takahashi National Institute of Polar Research
		Mr Kyo Uehara Taiyo A&F Co. Ltd.

Korea, Republic of	Representative:	Dr Jaebong Lee National Institute of Fisheries Science (NIFS)
	Alternate Representative:	Dr Sangdeok Chung National Institute of Fisheries Science (NIFS)
	Advisers:	Mr Gap-Joo Bae Hong Jin Corporation
		Mr Yang-Sik Cho TNS Industries Inc.
		Mr DongHwan Choe Korea Overseas Fisheries Association
		Mr Hyun Joong Choi TNS Industries Inc.
		Mr Sang-jin Choi Korea Overseas Fisheries Association
		Mr Kunwoong Ji Jeong Il Corporation
		Mr Taebin Jung TNS Industries
		Dr Eunhee Kim Citizens’ Institute for Environmental Studies
		Dr Jeong-Hoon Kim Korea Polar Research Institute (KOPRI)
		Mr Yoonhyung Kim Dongwon Industries
		Mr Hae Jun Lee Hongjin Company
		Mr Kanghwi Park Jeong Il Corporation
		Mr Sang Gyu Shin National Institute of Fisheries Science (NIFS)
Netherlands, Kingdom of the	Representative:	Dr Fokje Schaafsma Wageningen Marine Research

New Zealand	Representative:	Mr Nathan Walker Ministry for Primary Industries
	Alternate Representative:	Mr Enrique Pardo Department of Conservation
	Advisers:	Dr Clare Adams Ministry for Primary Industries
		Mr Adam Berry Ministry for Primary Industries
		Dr Nancy Bertler Antarctica New Zealand
		Dr Jennifer Devine National Institute of Water and Atmospheric Research Ltd. (NIWA)
		Mr Alistair Dunn Ocean Environmental
		Mr Jack Fenaughty Silvifish Resources Ltd
		Prof. Ian Hawes Antarctic Science Platform
		Ms Alexandra Macdonald Department of Conservation
		Mr Darryn Shaw Sanford Ltd
		Mr Andy Smith Self
		Mr Barry Weeber ECO Aotearoa
Norway	Representative:	Dr Bjørn Krafft Institute of Marine Research
	Alternate Representative:	Dr Andrew Lowther Norwegian Polar Institute
	Advisers:	Dr Gary Griffith Norwegian Polar Institute

		Ms Birgit Njåstad Norwegian Polar Institute
		Dr Cecilie von Quillfeldt Norwegian Polar Institute
Poland	Representative:	Mr Michal Szymanski National Marine Fisheries Research Institute in Gdynia, Department of Logistics & Monitoring
	Alternate Representative:	Mrs Jolanta Mosor Ministry of Agriculture and Rural Development
Russian Federation	Representative:	Dr Svetlana Kasatkina AtlantNIRO
	Adviser:	Dr Andrey Petrov Federal Agency for Fisheries
South Africa	Representative:	Dr Azwianewi Makhado Department of Environmental Affairs
	Alternate Representatives:	Mr Sobahle Somhlaba Department of Agriculture, Forestry and Fisheries
		Mrs Melanie Williamson CapMarine Environmental
Spain	Representative:	Mr Roberto Sarralde Vizuete Instituto Español de Oceanografía
	Alternate Representative:	Mrs Elena Consuegra Ministerio de Agricultura, Pesca y Alimentación
	Advisers:	Dr Takaya Namba Pesquerias Georgia, S.L
		Mr Joost Pompert Pesquerias Georgia, S.L
Sweden	Representative:	Dr Thomas Dahlgren University of Gothenburg

	Alternate Representatives:	Dr Pia Norling Swedish Agency for Marine and Water Management Mr Frank Zhang Swedish Agency for Marine and Water Management
Ukraine	Representative:	Dr Kostiantyn Demianenko Institute of Fisheries and Marine Ecology (IFME) of the State Agency of Melioration and Fisheries of Ukraine
	Alternate Representative:	Dr Leonid Pshenichnov Institute of Fisheries and Marine Ecology (IFME) of the State Agency of Fisheries of Ukraine
	Advisers:	Mr Andrii Chuklin IKF LLC Mr Andrii Fedchuk National Antarctic Scientific Center of Ukraine Dr Larysa Samchyshyna Institute of Fisheries and Marine Ecology, Institute of Fisheries, NAAS Mr Vitalii Tsymbaliuk Ministry of Foreign Affairs of Ukraine
United Kingdom	Representative:	Dr Chris Darby Centre for Environment, Fisheries and Aquaculture Science (Cefas)
	Alternate Representative:	Dr Martin Collins British Antarctic Survey
	Advisers:	Ms Kylie Bamford Foreign, Commonwealth and Development Office Dr Mark Belchier British Antarctic Survey Dr Rachel Cavanagh 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

Ms Sue Gregory
Foreign and Commonwealth Office

Dr Simeon Hill
British Antarctic Survey

Dr Oliver Hogg
Centre for Environment, Fisheries and Aquaculture Science (Cefas)

Mrs Rhona Kent
WWF UK

Ms Lisa Readdy
Centre for Environment, Fisheries and Aquaculture Sciences (Cefas)

Ms Georgia Robson
Centre for Environment, Fisheries and Aquaculture Science (Cefas)

Mr Peter Thomson
Argos Froyanes

Dr Claire Waluda
British Antarctic Survey

United States of America

Representative: Dr George Watters
National Marine Fisheries Service, Southwest Fisheries Science Center

Alternate Representative: Dr Christopher Jones
National Oceanographic and Atmospheric Administration (NOAA)

Advisers: Ms Nicole Bransome
The Pew Charitable Trusts

		Dr Jefferson Hinke National Marine Fisheries Service, Southwest Fisheries Science Center
		Dr Polly A. Penhale National Science Foundation, Division of Polar Programs
		Ms Elizabeth Phelps US Department of State
		Dr Andrew Titmus National Science Foundation
Uruguay	Representative:	Prof. Oscar Pin Direccion Nacional de Recursos Acuaticos (DINARA)
	Alternate Representatives:	Dr Yamandú Marín Direccion Nacional de Recursos Acuaticos (DINARA)
		Ambassador Gustavo Miguel Vanerio Balbela Ministry of Foreign Affairs

Observers – Acceding States

Canada	Representative:	Ms Maya Gold Fisheries and Oceans Canada
	Advisers:	Mr Alain Dupuis Fisheries and Oceans Canada
		Ms Katharine Ferri Fisheries and Oceans Canada
		Ms Olivia Lassaline Fisheries and Oceans Canada
Finland	Representative:	Ambassador Satu Mattila-Budich Embassy of Finland in Canberra
Mauritius	Representative:	Mr Devanand Bolaky Ministry of Blue Economy, Marine Resources, Fisheries and Shipping
Panama	Representative:	Mr Alcibiades Guerra Campos Autoridad de los Recursos Acuáticos de Panamá

	Alternate Representative:	Mr Robert Duarte Autoridad de los Recursos Acuáticos de Panamá
Peru	Representative:	Ambassador Vitaliano Gaspar Gallardo Valencia Embassy of Peru
	Advisers:	Mr Diego Gago Embassy of Peru Mr Ivan Silva Embassy of Peru

Observers – Non-Contracting Parties

Luxembourg	Representative:	Dr Pierre Gallego Ministry of Environment

Observers – International Organisations

ACAP	Representative:	Dr Christine Bogle Secretariat of the Agreement on the Conservation of Albatrosses and Petrels
	Advisers:	Dr Igor Debski ACAP Seabird Bycatch Working Group (SBWG) Dr Wiesława Misiak Secretariat to the Agreement on the Conservation of Albatrosses and Petrels
Antarctic Treaty Secretariat	Representative:	Mr Albert Alexander Lluberas Bonaba Secretariat of the Antarctic Treaty
CEP	Representative:	Dr Polly A. Penhale National Science Foundation, Division of Polar Programs
IUCN	Representative:	Ms Minna Epps Global Marine & Polar Programme, IUCN
	Alternate Representative:	Dr Aurélie Spadone Ocean Team, Centre for Conservation Action, IUCN

SCAR	Representative:	Prof. Mary-Anne Lea Institute for Marine and Antarctic Studies (IMAS)
	Alternate Representative:	Prof. Cassandra Brooks University of Colorado Boulder
	Advisers:	Prof. Steven Chown Monash University, School of Biological Sciences
		Dr Susie Grant British Antarctic Survey
		Dr Yeadong Kim Korea Polar Research Institute
		Dr Chandrika Nath Scientific Committee on Antarctic Research
		Dr Keith Reid Antarctic Environments Portal
SCOR	Representative:	Dr Delphine Lannuzel University of Tasmania
	Adviser:	Dr Alyce Hancock Southern Ocean Observing System (SOOS)
SIOFA	Representative:	Dr Marco Milardi Southern Indian Ocean Fisheries Agreement
SPRFMO	Representative:	Dr Tiffany Vidal South Pacific Regional Fisheries Management Organisation
WCPFC	Representative:	Mr Tim Jones Western and Central Pacific Fisheries Commission

Observers – Non-Governmental Organisations

ARK	Representative:	Dr Javier Arata Association of Responsible Krill harvesting companies (ARK) Inc.
	Alternate Representative:	Mr Pål Einar Skogrand Aker BioMarine

	Advisers:	Mrs Valeria Carvajal Federación Industrias Pesqueras del Sur Austral (FIPES)
		Mr Xu Gao CNFC
		Mr Enrique Gutierrez Pesca Chile
		Mr Sang-Yong Lee Jeong-Il Corporation
		Mr Jun Rong Luo Fujian Zhengguan Fishery Development Co., Ltd.
		Ms Genevieve Tanner ARK Secretariat
		Ms Hong Zhang China National Fisheries Corporation (CNFC)
ASOC	Representative:	Dr Rodolfo Werner The Pew Charitable Trusts & Antarctic and Southern Ocean Coalition
	Advisers:	Ms Kimberly Aiken Antarctic and Southern Ocean Coalition
		Ms Olive Andrews Antarctic and Southern Ocean Coalition
		Mr Jiliang Chen Greenovation Hub
		Ms Claire Christian Antarctic and Southern Ocean Coalition
		Ms Barbara Cvrkel The Pew Charitable Trusts
		Ms Ruth Davis University of Wollongong
		Mr Yutian Ding Greenovation: Hub

		Mr Emil Dediu The Pew Charitable Trusts
		Ms Lyn Goldsworthy Institute for Marine and Antarctic Studies, University of Tasmania
		Ms Andrea Kavanagh The Pew Charitable Trusts
		Mr Nicholas Kirkham The Pew Charitable Trusts
		Dr Susanne Lockhart Southern Benthics
		Dr Laura Meller Greenpeace Norden
		Dr Ricardo Roura Antarctic and Southern Ocean Coalition
		Ms Meike Schuetzek Antarctic and Southern Ocean Coalition
		Dr Masha Vorontsova Antarctic and Southern Ocean Coalition
		Ms Lena Zharkova Antarctic and Southern Ocean Coalition.
		Ms Wei Zhou Greenpeace
		Mr Zhengguang Zhu WWF-China
COLTO	Representative:	Mr John Alexander Reid Polar Seafish Ltd
	Alternate Representative:	Mr Rhys Arangio Coalition of Legal Toothfish Operators
	Advisers:	Mr Richard Ball SA Patagonian Toothfish Industry Association
		Mr Jason Bryan Archipelago

		Ms Delphine Ciolek Syndicat des armements réunionnais de palangriers congélateurs (SARPC)
		Dr Deborah Davidson Argos Ltd
		Mr Brad Milic Australian Longline Fishing
		Mr Andrew Newman Argos Froyanes Ltd
		Ms Brodie Plum Talley's Ltd
		Mr James Ragg Argos Froyanes Limited
		Mrs Emilie Richard Comata-Scapêche
Oceanites	Representative:	Mr Ron Naveen Oceanites, Inc.
	Advisers:	Mr Steven Forrest Oceanites, Inc.
		Dr Grant Humphries Black Bawks Data Science
		Prof. Philip Trathan Oceanites, Inc.

Secretariat

Executive Secretary	Dr David Agnew
Science	
Science Manager	Dr Steve Parker
Fisheries and Observer Reporting Coordinator	Isaac Forster
Science Data Officer	Daphnis De Pooter
Fisheries and Ecosystems Analyst	Dr Stephane Thanassekos
Fisheries Monitoring and Compliance	
Fisheries Monitoring and Compliance Manager	Todd Dubois
Compliance Officer	Eldene O'Shea
Fisheries Monitoring and Compliance Data Officer	Henrique Anatole
Research, Monitoring and Compliance Analyst	Claire van Werven
Data Administration Officer	Alison Potter
Finance, Administration and Human Resources	
Finance, Administration Manager and Human Resources	Deborah Jenner
Finance Support Officer	Christine Thomas
Human Resources Officer	Angie McMahon
Administrative Services Officer	Amelia Stoneham
Administration Support	Rebecca Stride
Communications	
Communications Manager	Doro Forck
Publications Officer	Belinda Blackburn
French Translator/Team Coordinator	Floride Pavlovic
French Translator	Marie Lecomte
French Translator	Bénédicte Graham
Russian Translator/Team Coordinator	Olga Kozyrevitch
Russian Translator	Anar Umerkhanova
Russian Translator	Blair Denholm
Spanish Translator/Team Coordinator	Jesús Martínez
Spanish Translator	Facundo Alvarez
Spanish Translator	Alejandra Sycz
Data and Information Systems	
Data and Information Systems Manager	Gary Dewhurst
Database Administrator/Technical Analyst	Thomas Williams
Systems Analyst	Ian Meredith
IT Support Officer	James Eisenhower
Software Developer	Mingyun Qie
Technical Business Analyst	Mitchell John
Web Project Officer	Dane Cavanagh

Interpreters (ONCALL Conference Interpreters)

Ms Cecilia Alal
Mr Andrey Efimenko
Ms Claire Garteiser
Ms Evgenia Ignatova
Ms Camille Lapierre
Ms Silvia Martinez
Ms Elena Mikhailik
Dr Marc Orlando
Ms Rebeca Parades-Nieto

Annex 2

List of Documents

List of Documents

SC-CAMLR-41/01	Communicating the science of CCAMLR CCAMLR Secretariat
SC-CAMLR-41/02	Secretariat science support for the Scientific Committee in 2022 CCAMLR Secretariat
SC-CAMLR-41/03	Report of the Working Group on Ecosystem Monitoring and Management (Virtual meeting, 4 to 11 July 2022)
SC-CAMLR-41/04	Report of the Working Group on Fish Stock Assessment (Hobart, Australia, 10 to 20 October 2022)
SC-CAMLR-41/05	Report of the Working Group on Statistics, Assessments and Modelling (Virtual meeting, 27 June to 1 July 2022)
SC-CAMLR-41/06	Report of the Working Group on Acoustic Survey and Analysis Methods (Virtual meeting, 30 May to 3 June 2022)
SC-CAMLR-41/07	Report of the Working Group on Incidental Mortality Associated with Fishing (Hobart, Australia, 10 to 14 October 2022)
SC-CAMLR-41/08 Rev. 1	Alignment of SC-CAMLR Special Fund procedures CCAMLR Secretariat
SC-CAMLR-41/09	Requirements for vessel-based acoustic surveys of krill in Subarea 48.1 Delegation of the USA
SC-CAMLR-41/10	Report of the Chair of the Scientific Committee on the CCAMLR Scientific Committee Symposium (Virtual Meeting, 8 and 10 February 2022) Chair of the Scientific Committee
SC-CAMLR-41/11	Scientific scholarship review panel recommendations in 2022 Scientific scholarship review panel
SC-CAMLR-41/12	Proposals for the interim revision of CM 51-01 and CM 51-07 as a first trail of the new krill management approach in 2022 Delegation of the People's Republic of China

SC-CAMLR-41/13	Summary on the scientific progresses to facilitate the revision of CM 51-07 in 2022 Delegation of the People's Republic of China
SC-CAMLR-41/14	Project of a *CCAMLR Science* special issue on the 'Biogeography of plankton and mesopelagic fish between Crozet, Kerguelen and St Paul and New Amsterdam' P. Koubbi
SC-CAMLR-41/15	Mapping of scientific research capabilities of CCAMLR Members in Domain 1, with a focus on the D1MPA Research and Monitoring Plan Delegations of Argentina and Chile
SC-CAMLR-41/16 Rev. 2	Proposed workplan for developing and implementing data collection needs for CCAMLR krill fisheries, and re-scoping of the Krill Fishery Observer Workshop S. Kawaguchi and G. Zhu (Co-conveners of the proposed Krill Fishery Observer Workshop)
SC-CAMLR-41/17	Information about a Workshop for Training Russian Scientific Observers and Inspectors (2022) Delegation of the Russian Federation
SC-CAMLR-41/18 Rev. 1	Comments and proposals on the development of management strategy for krill fishery: Risk assessment framework to allocate catch in Subarea 48.1 Delegation of the Russian Federation
SC-CAMLR-41/19	Proposals and comments on developing a krill resource management strategy for Area 48 in revising krill fisheries management in Subarea 48.1 Delegation of the Russian Federation
	************
SC-CAMLR-41/BG/01	Catches of target species in the Convention Area Secretariat
SC-CAMLR-41/BG/02	Circulars from Observers –update after the first year Secretariat
SC-CAMLR-41/BG/03	CEMP Special Fund activities 2022 CEMP Special Fund Management Panel

SC-CAMLR-41/BG/04	Protecting Blue Corridors – a collaborative international report highlighting the challenges and solutions for migratory whales navigating national and international seas Delegations of Chile and WWF
SC-CAMLR-41/BG/05	Icefish spawning aggregation in the southern Weddell Sea including discussions and recommendations from WG-EMM-2022 Delegations of Germany and France
SC-CAMLR-41/BG/06	Ukrainian specific research activities assisted by the CCAMLR General Capacity Building Fund: Increase of effectiveness through the research staff expertise strengthen and international cooperation capabilities: improvement of Ukrainian obligations under the Convention L. Samchyshyna, E. Pakhomov, P. Zabroda, I. Slypko, T. Pestovskyi, K. Demianenko and L. Pshenichnov
SC-CAMLR-41/BG/07	2022 Report to SC-CAMLR-41 and CCAMLR-41 by the Association of Responsible Krill harvesting companies (ARK) Submitted by ARK
SC-CAMLR-41/BG/08	ARK recommendations for improving transparency and safety in the CCAMLR krill fishery Submitted by ARK
SC-CAMLR-41/BG/09	Moving forward with the new krill management strategy Submitted by ARK
SC-CAMLR-41/BG/10	Committee for Environmental Protection XXIV: 2022 Annual Report to the Scientific Committee of CCAMLR CEP Observer to SC-CAMLR
SC-CAMLR-41/BG/11	Review of progress in the implementation of the recommendations identified at the Joint CEP/SC-CAMLR Workshop on Climate Change and Monitoring (2016) Submitted by CEP
SC-CAMLR-41/BG/12	State and results of *Pygoscelis* penguin population monitoring at CEMP sites by time-lapse cameras in the Vernadsky station area in 2021/22 season O. Savenko, V. Tkachenko, G. Milinevsky, A. Simon and L. Pshenichnov
SC-CAMLR-41/BG/13	Report to CCAMLR by Oceanites, Inc. — State of Antarctic Penguins 2022 Submitted by Oceanites

SC-CAMLR-41/BG/14	Networks and tools to enhance collaboration and coordination of observational activities Submitted by SCOR
SC-CAMLR-41/BG/15	The Southern Ocean Observing System (SOOS) Science and Implementation Plan (2021–2025) – Providing Observations for Environmental Monitoring
SC-CAMLR-41/BG/16	Myctobase: Toward a circumpolar database of mesopelagic fishes for new insights into mesopelagic prey fields B.L. Woods, R. Trebilco, A. Walters, M. Hindell, G. Duhamel, H. Flores, M. Moteki, P. Pruvost, C. Reiss, R.A. Saunders, C. Sutton, Y.-M. Gan and A. Van de Putte
SC-CAMLR-41/BG/17	Observation and comments on the scientific basis and draft RMP of the WSMPA Proposal Delegation of the People's Republic of China
SC-CAMLR-41/BG/18	Obtaining and updating baseline data through systematic literature analysis Delegation of the People's Republic of China
SC-CAMLR-41/BG/19	The Scientific Committee on Antarctic Research (SCAR) Annual Report to CCAMLR 2021/2022 Submitted by SCAR
SC-CAMLR-41/BG/20	Heightened risk of avian influenza in the Southern Ocean Submitted by SCAR and IAATO
SC-CAMLR-41/BG/21	Antarctic Climate Change and the Environment: A Decadal Synopsis Submitted by SCAR
SC-CAMLR-41/BG/22	Workshop on Identifying Key Biodiversity Areas for the Southern Ocean Using Tracking Data Submitted by SCAR and IUCN
SC-CAMLR-41/BG/23	The Southern Ocean contribution to the United Nations Decade of Ocean Science for Sustainable Development Submitted by SCAR, SCOR, IAATO, The Netherlands and Belgium
SC-CAMLR-41/BG/24	Recent highlights and future plans of the Integrating Climate and Ecosystem Dynamics in the Southern Ocean (ICED) Programme Submitted by SCAR

SC-CAMLR-41/BG/25	Marine Ecosystem Assessment for the Southern Ocean (MEASO): Progress, key outcomes to date, and next steps Submitted by SCAR
SC-CAMLR-41/BG/26	Proposal for complex acoustic and trawl surveys for the mackerel icefish (*Champsocephalus gunnari*) estimates in the CCAMLR Statistical Subarea 48.3 S. Kasatkina
SC-CAMLR-41/BG/27	Connectivity of toothfish and krill in the Southern Ocean Submitted by ASOC
SC-CAMLR-41/BG/28	Resource support for conducting scientific programs in the Ross Sea region MPA: comments and proposals Delegation of the Russian Federation
SC-CAMLR-41/BG/29	Finer-scale krill fishery management, enhanced monitoring and additional measures to protect the krill-based ecosystem Submitted by ASOC
SC-CAMLR-41/BG/30	Ongoing environmental changes and the continuity of stressors acting over ecosystems along the Domain 1: the need for the adoption of the D1MPA proposal Delegations of Argentina and Chile
SC-CAMLR-41/BG/31	The SCAR Antarctic Biodiversity Portal, update 2022 Delegation of Belgium
SC-CAMLR-41/BG/32	The application of electronic monitoring in CCAMLR fisheries Delegation of the United Kingdom
SC-CAMLR-41/BG/33	Proposal for a Workshop to enhance the CCAMLR Ecosystem Monitoring Program (CEMP) C. Waluda, M. Collins, M. Korczak-Abshire, J.-H. Kim, G. Milinevsky, A. Kato and S. Olmastroni
SC-CAMLR-41/BG/34	Southern Ocean-focused activities of the Scientific Committee of the International Whaling Commission 2019–2022 N. Kelly
SC-CAMLR-41/BG/35	Multiple indicators suggest a scarcity of krill (Eupha*usia superba*) at South Georgia in 2021 Delegation of the United Kingdom

SC-CAMLR-41/BG/36	Compilation of Member Activity Reports related to the Ross Sea Region Marine Protected Area, 2022 Delegations of the USA, New Zealand, the Republic of Korea and Italy
SC-CAMLR-41/BG/37	Update on Secretariat data-related progress and future work Secretariat
SC-CAMLR-41/BG/38	Chair's Guide to the schedule and annotated agenda Chair of the Scientific Committee
SC-CAMLR-41/BG/39 Rev. 1	Modifications of CM 22-06 and Annex 22-06/B for including fish nest areas and filled proforma for the case of the icefish *Neopagetopsis ionah* nest aggregation Delegations of Germany and France

****

Other Documents

CCAMLR-41/01 Rev. 1	CCAMLR Secretariat Strategic Plan 2023–2026 Executive Secretary
CCAMLR-41/04	Review of the 2022 Budget, Draft 2023 Budget and Forecast Budget for 2024 Executive Secretary
CCAMLR-41/05	Executive Secretary's Report, 2022, including the Fourth Year Implementation Report for the Secretariat's Strategic Plan (2019–2022) Executive Secretary
CCAMLR-41/06	Performance Review 2 – summary of outcomes Secretariat
CCAMLR-41/07	CCAMLR Staffing and Salary Strategy (2023–2026) Executive Secretary
CCAMLR-41/08	Review of the Rules for Access and Use of CCAMLR Data Chair of the Data Services Advisory Group (DSAG)
CCAMLR-41/10	Access to meeting documents Secretariat
CCAMLR-41/11 Rev. 1	Arrangements for cooperation with other organisations Secretariat
CCAMLR-41/29	Antarctic Blue Carbon Delegation of the United Kingdom

CCAMLR-41/31 Rev. 1	Proposed workshop on integrating climate change and ecosystem interactions into CCAMLR science Delegations of the United Kingdom, Australia, France, New Zealand, Norway, Sweden and the USA
CCAMLR-41/37	Comments on the revision of Conservation Measure (CM) 51-07 Delegation of the Russian Federation
CCAMLR-41/41	Comments and proposals by the Russian Federation on regulating unified criteria for establishing MPAs in the CCAMLR Convention Area Delegation of the Russian Federation
CCAMLR-41/BG/06	Report of the CCAMLR Observer to the 35th meeting of FAO Committee on Fisheries (COFI) and the 9th meeting of the Regional Fishery Bodies Secretariats' Network (RSN) Executive Secretary
CCAMLR-41/BG/24	The development of Research and Monitoring Plan for CCAMLR MPAs Delegation of the People's Republic of China
CCAMLR-41/BG/25	Proposal to improve the draft Research and Monitoring Plan for the Ross Sea region Marine Protected Area Delegation of the People's Republic of China
CCAMLR-41/BG/29	ASPAs 152/153: Western Bransfield Strait and Dallmann Bay: Highlights of scientific research results Delegation of the USA
CCAMLR-41/BG/31	ASOC Report to CCAMLR Submitted by ASOC
CCAMLR-41/BG/32	Marine protected areas: A global and regional imperative for CCAMLR Submitted by ASOC
CCAMLR-41/BG/39	Reporte de pesca de investigación de bacalao de profundidad en aguas de jurisdicción nacional Delegación de Ecuador
WG-EMM-2022/45	ASPA No. XXX Western Bransfield Strait and Eastern Dallmann Bay for Review by CCAMLR P. Penhale
WG-FSA-2022/35	Alternative proportional recruitment estimates for Subarea 48.1 based on reanalysis of the US AMLR data series Y. Ying and X. Zhao

**Agenda for the Forty-first Meeting
of the Scientific Committee**

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

1. Opening of the meeting

    1.1 Adoption of the agenda
    1.2 Chair's report

2. Advances in statistics, assessments, modelling, acoustics and survey methods

    2.1 Statistics, assessments and modelling
        2.1.1 Advice to the Commission
    2.2 Acoustic survey and analysis methods
        2.2.1 Advice to the Commission

3. Harvested species

    3.1 Krill resources
        3.1.1 Progress towards acoustic biomass estimates
        3.1.2 Progress towards a stock assessment
        3.1.3 Progress towards a spatial overlap assessment
        3.1.4 Ecosystem effects in the krill fishery
        3.1.5 Advice to the Commission

    3.2 Fish resources
        3.2.1 Status and trends
        3.2.2 Assessment of fish resources
            3.2.2.1 Advice to the Commission

        3.2.3 New and exploratory finfish fisheries
            3.2.3.1 Progress towards assessments
            3.2.3.2 Advice to the Commission

4. Scientific research exemption

    4.1 Advice to the Commission

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

    5.1 Fish and invertebrate by-catch
    5.2 Incidental mortality of seabirds and marine mammals associated with fisheries
    5.3 Bottom fishing and vulnerable marine ecosystems
    5.4 Marine debris
    5.5 Advice to the Commission

6. Spatial management of impacts on the Antarctic ecosystem

    6.1 Marine protected areas (MPAs)
        6.1.1 Review of scientific analysis relevant to existing MPAs, including research and monitoring plans for MPAs
        6.1.2 Review of the scientific elements of proposals for new MPAs

    6.2 Other spatial management issues

    6.3 Advice to the Commission

7. Climate change

    7.1 Advice to the Commission

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

9. CCAMLR Scheme of International Scientific Observation

    9.1 Advice to the Commission

10. Cooperation with other organisations

    10.1 Cooperation within the Antarctic Treaty System
        10.1.1 Committee for Environmental Protection
        10.1.2 Scientific Committee for Antarctic Research

    10.2 Reports of observers from other international organisations

    10.3 Reports of representatives at meetings of other international organisations

    10.4 Future cooperation

11. Scientific Committee activities

    11.1 Priorities for work of the Scientific Committee and its working groups
    11.2 Second Performance Review
    11.3 CCAMLR Scientific Scholarships Scheme
    11.4 CEMP Special Fund
    11.5 CCAMLR publication policy
    11.6 Other administrative items
    11.7 Invitation of experts and observers to meetings of working groups
    11.8 Next meeting

12. Secretariat supported activities

13. Budget for 2022/23

14. Advice to SCIC and SCAF

15. Election of Vice-Chair

16. Other business

17. Adoption of report of the Forty-first Meeting

18. Close of meeting.

Report of the Chair of the Scientific Committee on the CCAMLR Scientific Committee Symposium

(Virtual Meeting, 8 and 10 February 2022)

Report of the Chair of the Scientific Committee on the CCAMLR Scientific Committee Symposium

(Virtual Meeting, 8 and 10 February 2022)

Abstract

The Chair's report on the Scientific Committee Symposium was developed following the meeting and submitted for comment to the intersessional working groups (WG-ASAM-2022, WG-SAM-2022 and WG-EMM-2022). Due to the time constraints of virtual meetings the comment period was extended to the Scientific Committee Symposium e-group. This report does not include comments from WG-IMAF-2022 or WG-FSA-2022 as these will be provided by those working groups directly to the Scientific Committee. The next steps identified in Section 6 were completed. Comments received are included in this revised version of the report directly and in Appendix A. We look forward to SC-CAMLR reviewing this paper and drawing from it to adopt its second 5-year strategic workplan at SC-CAMLR 41.

1. Opening of the meeting and rationale

1.1 The CCAMLR Scientific Committee Symposium met virtually using the Interprefy platform on 8 and 10 October 2022, and was chaired by Dr D. Welsford (Australia) and supported by the CCAMLR Secretariat. Scientists from 22 Members, one Acceding State, and Observers from the Association of Responsible Krill harvesting companies (ARK), the Antarctic and Southern Ocean Coalition (ASOC), the Coalition of Legal Toothfish Operators (COLTO), the International Union for the Conservation of Nature (IUCN), the Scientific Committee on Antarctic Research (SCAR), and the Scientific Committee on Oceanic Research (SCOR) attended the Symposium.

1.2 At the opening of the meeting, Dr Welsford welcomed and acknowledged more than 124 attendees and noted that this meeting was an informal meeting to discuss progress and outcomes from the first CCAMLR Scientific Committee's workplan (SC-CAMLR-XXXVI/BG/40). The meeting was also to provide an opportunity for participants to propose long-term priorities and strategies to inform the development of the next five-year strategic plan of the Scientific Committee (2023–2027). Accordingly, this report is not an adopted report, but is a summary by the Chair for the consideration of the working groups and the Scientific Committee. The intent is that the recommendations and plans outlined below will be refined during the intersessional period and agreed at SC-CAMLR-41 according to the Scientific Committee Rules of Procedure.

1.3 The Chair introduced the rationale and scope of the symposium as outlined in SC CIRC 22/13 to review and develop priority work items for the 2023–2027 period, and noted that the Symposium was arranged into the following agenda items to facilitate discussion:

(i) Review of implementation of the Scientific Committee's 2017–2021 five-year Strategic Plan
(ii) Priorities for scientific research and advice over the next five years (2023–2027)
(iii) Processes and mechanisms to deliver strategic work and advice
(iv) Next steps.

2. Review of implementation of the Scientific Committee's 2017–2021 five-year Strategic Plan

2.1 The participants considered SC-Symposium-2022/05 and welcomed this collation of the Scientific Committee's tasks over the last five years by the Secretariat, the Scientific Committee Chair and the working group conveners. It was acknowledged that a considerable body of the workplan included within SC-CAMLR-XXXVI/BG/40 has been achieved across all six themes identified in the first five-year plan. While most tasks had been completed or progressed, about 20% of these were judged by the authors to have made little to no progress. Symposium attendees identified diverse factors that contributed to hindering progress on these tasks, including:

(i) the large list of tasks

(ii) the scope required to address particular issues (e.g. some felt that the large amount of time and effort invested in the krill management procedure had come at the expense of other areas of work, such as the review of the CCAMLR Ecosystem Management Program (CEMP))

(iii) a lack of criteria for evaluating the effectiveness of the implementation tasks/topics

(iv) a lack of clear requirements for formation of tasks/topics outcomes

(v) a lack of clear identification of who was facilitating a particular work stream

(vi) the prioritisation of more time-critical topics including ad-hoc requests from the Commission

(vii) effects of the Covid-19 pandemic.

2.2 The Symposium noted that the lack of progress on some tasks may hinder the progress on others. In looking to the future, an approach that prioritised addressing tasks that had high level of interdependency with other parts of the work plan could avoid delaying progress in other areas.

2.3 It was further noted that as is typical with scientific research, various items in the workplan had evolved from their original scope, with the need for new tasks and outputs being identified as work progressed. (e.g. the relatively swift progress towards using krill fishing vessels as monitoring platforms meant that some tasks identified in the 2017–2021 workplan became redundant). Given this dynamic approach, participants endorsed the need to ensure that future workplans are 'living documents' that allow for regular updating, evaluation and refinement as scientific progress and management requirements evolve. Some noted that there is still a lack of standardisation in data collection and processing, and most notably in krill surveys. It was also noted that some achievements were not utilised to progress other parts of the workplan (e.g. recommendations of the Scientific Committee on Antarctic Research (SCAR) Krill Action Group (SKAG), 2019; the Integrating Climate and Ecosystem Dynamics in the Southern Ocean (ICED) workshop April 2018).

2.4 Noting that reviewing past performance was beneficial for future planning, the Symposium considered the possibility of SC-CAMLR establishing a process to conduct more regular reviews of its strategic plan. This would allow the Scientific Committee to take the most current information into account when discussing future work.

2.5 Participants noted the invaluable role of the SC Bureau since its inception and re-endorsed the coordination process carried out by this group. They agreed that it could have a role in conducting annual progress reviews. They also noted the need to balance the frequency of reviews, which could take resources away from actually addressing priority work, and the benefits of having plans updated more regularly.

2.6 The Symposium noted that such periodic reviews were valuable for internal planning and review purposes, but also for communicating the work conducted by the Scientific Committee to the Commission and other external bodies. It was also noted that such reviews could also assist Members with explaining to research institutions and funding agencies what CCAMLR priorities were, and where and when they might best contribute, and hence increase the likelihood of Members being able to find additional resources to address these priorities.

2.7 The Symposium considered the importance of maintaining regular review and tracking on programs which contribute both to internal CCAMLR procedures (Scheme of International Scientific Observation (SISO), tagging), as well as those that also have an external focus (CEMP, marine debris).

2.8 Participants also recognised the value of contracting an external party to undertake performance reviews of SC-CAMLR (similar to the performance reviews of the CAMLR Commission, but with a focus on delivery of scientific advice) and/or programs of scientific work conducted by the Scientific Committee (particularly noted for SISO). It was noted that external reviews would foster accountability in the Scientific Committee to its agreed priorities and procedures, potentially introduce innovative approaches, and increase transparency.

3. Priorities for scientific research and advice (2023–2027)

3.1 Papers and SC CIRCs submitted to the meeting identified a number of high-priority work topics to progress as well as mechanisms to assist in the implementation of the strategic plan (SC-Symposium-2022/01, /03, /04, /06 and /08 and SC CIRCs 22/09 and 22/15). The Symposium identified strategic work topics to progress in Table 1 focusing on further development of an ecosystems approach to fisheries and themes which would improve the processes for developing the work of the Scientific Committee.

3.2 The discussion focussed on two types of needed planning. Firstly, defining detailed tasks for the working groups to prioritise in order for the Scientific Committee to provide advice that contributes towards achieving CCAMLR’s objective. These items are compiled in Table 2, with the working groups involved indicated. Secondly, cross-cutting themes were identified that the Scientific Committee could implement to improve its processes and therefore speed up progress.

4. Cross-cutting themes

4.1 While considering the cross-cutting topics listed in Table 1, the Symposium discussions were along three general themes:

(a) Improving science capacity and capability

(i) *Budgeting*. The Symposium noted the need for discussions with the Commission regarding the allocation of funds to support the work of the Scientific Committee. Resources available to conduct SC-CAMLR science are limited and decreasing and were unlikely to substantially increase over the next five years unless new mechanisms to build capacity and find/fund further resources are developed. It discussed the need for a routine allocation of funds to SC-CAMLR to enable it to plan for longer-term and more strategic tasks. It noted that the current practise of annual requests for funds to the Commission, where decisions are made after the Scientific Committee has concluded it business, can lead to delays in implementing agreed initiatives. For example, after being agreed in the Scientific Committee, the Commission may request more information or discussion of alternatives, leading to at least a one-year delay.

(ii) *Secretariat support*. The Symposium noted that to support the large and growing information and technical needs of the Scientific Committee in the coming period, the Secretariat may need to hire more staff or seek mechanisms to acquire additional capacity to support priority work such as managing acoustic datasets.

(iii) *Mentoring newcomers to CCAMLR*. The Symposium discussed the possibility of establishing a process to facilitate the introduction of new scientists to the complex CCAMLR world (e.g. goal-oriented mentoring by experienced CCAMLR scientists, assigning them as working group conveners' support, or with mentors prior to and during meetings).

(iv) *Science communication*. The Symposium identified several actions to improve communication both internally and externally, including:

(a) creation of a repository of CCAMLR scientists (a 'who's who', with names, expertise, bibliography) to facilitate communication between CCAMLR scientists and external scientists

(b) development of scientific syntheses across SC-CMALR work such as an Intergovernmental Panel on Climate Change (IPCC)-style report on the 'State of the ecosystem' in the Convention Area, which would benefit from collaboration with the International Union for the Conservation of Nature and Natural Resources (IUCN) and SCAR

(c) development of webpages for each working group on the new website to help organise and communicate their work to Members and interested public

(d) development of ways to improving science communication in general to provide transparency, attract new scientists and improve the integrity of SC-CAMLR's processes and advice.

(v) *Coordination with related organisations*. The Symposium noted the value in collaboration and targeted communication of CCAMLR science into other forums involved in ocean conservation and the Antarctic region. For example, it recalled the role played by SKAG in bringing in the expertise of krill scientists not typically engaged in SC-CAMLR in developing revised krill management approaches, and the work with the Committee for Environmental Protection (CEP) and SCAR to better understand climate change implication for the Antarctic ecosystem.

The Symposium considered SC-Symposium-2022/07, which described the importance of cetacean science to the work of CCAMLR, and the importance of CCAMLR working with the scientific expertise in the International Whaling Commission (IWC), particular to help understand the impacts of direct whale interactions with CCAMLR fisheries, as well as the implications of changing whale populations for conserving krill. It noted key topics for collaboration which applied across multiple working groups and the need to ensure the appropriate expertise was available for topics such as developing the krill management approach, minimising incidental mortality, the development of ecosystem models, and understanding the role of climate change on marine mammals.

The Symposium noted that the elements that had led to the success of previous collaborations between SC-CAMLR and the IWC could be generalised to other collaborations, including:

(a) identifying specific individuals for the task of facilitating collaboration

(b) SC-CAMLR providing clear guidance on the focus for the collaborative work.

The Symposium noted that clarity on SC-CAMLR priorities, and clear pathways for engaging with SC-CAMLR, were essential for improving coordination and integration with external organisations.

(vi) *Diversity and inclusion*. The Symposium recognised the benefits of diversity and inclusion in improving representation, perspectives, experiences and cultural contributions to the work of the Scientific Committee and encouraged Members to further support and develop this aspect of their scientific capabilities, and bring forward suggestions for improving diversity and inclusion in all aspects of SC-CAMLR work.

(vii) *Career development*. The Symposium noted the benefits of providing scholarship and integration opportunities for early- and mid-career scientists in the work of the Scientific Committee and recommended to continue developing and expanding these opportunities through internships, scholarships, funding grants for high-priority work topics, and involvement of CCAMLR scientists in communication and outreach activities.

(b) Communication with the Commission

(i) *Communicating differences in scientific opinions*. The Symposium agreed that it was an issue of great concern that was hindering scientific progress. Addressing it was of crucial importance to ensure scientific independence and effective provision of scientific advice to the Commission. It noted that 'scientific opinion' was a problematic concept, that the Scientific Committee needed to focus primarily on articulating and resolving differing 'scientific interpretations'. It was noted that this issue was not unique to SC-CAMLR, and that other forums had shown that this could be addressed through a process involving external expert review of the scientific method, data and analysis that had been undertaken to arrive at a particular scientific interpretation. The Symposium noted that devising a clear and effective process was urgently needed, as impasse in the Scientific Committee increased the risk of failure to achieve the objective of the Convention.

(ii) *Regulatory framework review*. The Symposium noted the need for clear descriptions of fishery classifications to initiate a framework review and considered it an urgent matter. It was noted that the Commission had tasked the Scientific Committee Chair and the Commission Chair to undertake a review, however, noted that SC-CAMLR should be focused on the scientific elements of the regulatory framework, such as what assessment methods and data are needed to determine the status and risks to fished stocks and dependant and related species.

(iii) *Climate change and spatial management*. The Symposium noted that climate change and spatial management are cross-cutting themes and considered that a joint Scientific Committee–Commission symposium may be a useful venue for discussion to progress these issues.

(c) Coordinating information from the working groups

(i) *Facilitators*. The Symposium noted the importance of assigning a facilitator to certain tasks (SC-Symposium-2022/04), noting the success of such a defined role in regard to, inter alia, the krill management approach. The default facilitator would be one of the Scientific Committee Representatives, and any such roles would need to be clearly defined and behave according to the Scientific Committee's Rules of Procedure. For long-term tasks such as reporting on CEMP, the Symposium noted that the Secretariat may be a suitable facilitator to ensure consistency through time. It also noted that tasks requiring coordination across working groups would benefit the most from a facilitator (e.g. climate change program) working together with the CCAMLR Secretariat and the SC Bureau to implement the Scientific Committee Strategic Plan.

(ii) *Terms of reference for working groups*. The Symposium noted the need to review the terms of reference of working groups (SC-Symposium-2022/06, Annex II), particularly the less recent ones as they needed updating to realign with current priorities and practices. It noted that such a task could be usefully undertaken by the working groups this year when considering the draft strategic workplan.

(iii) *Project management*. The Symposium considered the need for establishing objective criteria or metrics to measure task progression (SC-Symposium-2022/01). The Symposium noted the need to track and review progress on tasks within and between working groups, as well as within CCAMLR data collection programs, and the potential role of the SC Bureau or external reviewers in coordinating this process (see also above). The clear description of expected outcomes and tracking progress of completing tasks was also deemed important for the communication of the Scientific Committee's work.

(iv) *Performance of data collection programs*. Considering the main CCAMLR science programs (CEMP, SISO, tagging, marine debris), the Symposium noted that while progress had been made on some of these programs, more effort was required to keep the Scientific Committee informed on their current performance (in particular regarding CEMP given its potential utility in the krill management approach). Therefore, the need for a review of CEMP's standard monitoring objectives and methods was highlighted, especially given the importance of non-CEMP species such as fish and whales, in the krill management approach.

(v) *Performance review*. The Symposium noted the need to address remaining recommendations from the second performance review (CCAMLR-XXXVI/01; SC-CAMLR-XXXVII, paragraph 13.16; SC-Symposium-2022/06, Annex III), noting that some of the recommendations above would assist in this regard.

5. Rules for data access and use

5.1 The Symposium considered SC-Symposium-2022/02 and noted that while the Rules for Access and Use of CCAMLR Data (hereafter 'the Rules') apply to 'All data submitted to the CCAMLR Secretariat, and maintained by the CCAMLR Data Centre', it is unclear whether data shared between Members through the e-groups or the marine protected area (MPA) baseline data which are shared through the CCAMLR MPA Information Repository (CMIR https://cmir.ccamlr.org/) are governed by the Rules. It noted that CCAMLR's approach to data accessibility should be 'as open as possible but as closed as necessary'. It therefore noted that it may be useful to identify different categories of data held by CCAMLR, and that the rules of access could be more or less strict depending on the sensitivity of the data holding (e.g. vessel monitoring system (VMS) or fine-scale catch and effort data may need more conditions for release as opposed to other data).

5.2 The Symposium considered whether the current data request procedure in which the absence of a reply after a three-week period is taken as consent to release data is in accordance with the Rules and noted that the Rules need to be updated to allow for efficient use of data for CCAMLR purposes. It further reflected that if the length of the data request procedure would be reduced to two weeks, a system of redundancy should be established to allow an Alternative Scientific Committee Representative to approve data releases when the Scientific Committee Representative is not available.

5.3 The Symposium noted that it could be beneficial for CCAMLR to establish a metadata catalogue to help researchers understand the types of data held or used by CCAMLR. This would aim to document all datasets maintained by the CCAMLR Secretariat as well additional datasets which may be useful for CCAMLR work, but are not maintained by the Secretariat. Datasets in this catalogue could be identified with a DOI and the catalogue could specify for each dataset how they can be accessed, and which rules apply to them. The Symposium considered whether the level of access and the expected use of data should be specified at a record level inside the CCAMLR database and welcomed collaboration with Members on how this could be developed.

5.4 The Symposium reflected that while there are good reasons that recent data and papers should be confidential, those reasons may no longer apply after a certain number of years. Noting that CCAMLR is now 40 years old, in many cases longer than the careers of CCAMLR scientists, there was considerable merit in developing a rule to release papers that are older than, say, 25 years.

5.5 The Symposium reflected on whether CCAMLR data should be made available solely for work conducted by the working groups and the Scientific Committee and noted the increasing number of requests to use CCAMLR data for analyses to be published in peer-reviewed journals, without being presented to the working groups. The Symposium noted that the Rules allow the data owners and requesters to agree conditions under which data would be released and for the data owner to refuse publication in the public domain if they feel those conditions have not been adhered to. The Symposium considered whether it should instate a procedure to detect and address lack of compliance with the Rules.

5.6 The Symposium noted that Observers attending e-groups and potentially other forums have access to some confidential data and papers during meetings and considered options to address this in the Rules.

5.7 The Symposium noted that the Rules should be reviewed by the working groups, the Scientific Committee and the Commission. It requested the Data Services Advisory Group (DSAG) to prepare a revised version of paper SC-Symposium-2022/02 for consideration during 2022.

6. Next steps

6.1 This summary document provides potential tasks for working group efforts and actions the Scientific Committee could progress during the next five years. Each working group is invited to:

(i) review their terms of reference as provided in Annex III of SC-Symposium-2022/06 and suggest revisions to simplify and streamline their work

(ii) comment on the report and cross-cutting themes

(iii) identify the tasks within their remit from Annex II of SC-Symposium-2022/06 and develop a sequence for addressing the topics, facilitators for the major topics and mechanisms to track progress on tasks.

6.2 The Scientific Committee Chair will collate comments from Members and the working groups and present a revised Draft Strategic Plan of the Scientific Committee, 2023–2027 to the 2022 meeting of the Scientific Committee for consideration.

6.3 The Symposium noted that tracking and review was critical in implementing the strategic plan. The Scientific Committee Chair recommends that in addition to annual reporting through the working group conveners on progress on the identified topics, the Scientific Committee should look forward to another Symposium in the 2026/27 season to allow a new strategic plan to be developed for agreement during the 2027 Scientific Committee meeting.

6.4 The Scientific Committee Chair thanked all participants for their contributions and the Secretariat, interpreters, stenographer, and Interprefy staff for their support of the Scientific Committee Symposium. Many participants noted the lack of formality had contributed to a very open and honest dialogue and thanked the Scientific Committee Chair for guiding the Symposium.

Table 1: High-priority scientific issues for the Scientific Committee to progress 2023–2027.

Providing the scientific advice that underpins an integrated, ecosystem-based approach to fisheries	1. Develop the new krill management approach for all subareas in Area 48 2. Review krill and finfish management approaches and decision rules to ensure they are consistent with Article II 3. Develop data collection plans to inform and support refined management approaches 4. Develop research to inform and support more robust assessment approaches for lower information fisheries 5. Develop methods to detect ecosystem changes and provide advice on adaptive management (e.g. through CEMP and WG-IMAF) 6. Develop scientific approaches for conservation of Antarctic marine ecosystems, including spatial management 7. Ensure the effects of fishing on by-catch, dependent, or related species are consistent with Article II 8. Provide scientific advice on CCAMLR's regulatory framework for fisheries.
Addressing cross-cutting scientific topics	1. Develop a process to objectively address differences in scientific interpretation 2. Improve integrated approaches to fund and build science capacity within CCAMLR, including linkages with external organisations 3. Develop policies to communicate the science generated by CCAMLR to the wider scientific community 4. Review performance of CEMP and SISO data collection programs relative to the strategic plan 5. Collaborate with other organisations (e.g. CEP, SCAR) to provide a synthesis of the state and trajectory of Antarctic marine living resources.

Table 2: Priority research topics for the working groups and the Scientific Committee arranged by relationship to Article II of the Convention and the working group(s) charged with leading the work. Urgency is coded as High, Medium, or Low. ASAM – Working Group on Acoustic Survey and Analysis Methods; SAM – Working Group on Statistics, Assessments and Modelling; EMM – Working Group on Ecosystem Monitoring and Management; IMAF – Working Group on Incidental Mortality Associated with Fishing; FSA – Working Group on Fish Stock Assessment; SISO – Scheme of International Scientific Observation; CEMP – CCAMLR Ecosystem Monitoring Program; MPA – marine protected area; DSAG – Data Services Advisory Group. X indicates annual work on this topic. Number indicates the year of focussed work. Hyphens indicates additional work in the following year. Sec – Secretariat; AUS – Australia.

	Urgency	ASAM	SAM	EMM	IMAF	FSA	Workshop	e-group	Facilitator
1. Target species									
(a) Develop methods to estimate biomass for **krill**									
(i) Survey design standards for regional and synoptic surveys	H	X	23						
(ii) Develop methods to use fishing fleets as monitoring platforms	H	X							
(iii) Data collection – SISO and vessels and CEMP	H	X		X		X	X	X	Sec
(1) Implement standardised surveys		X							
(2) Develop diagnostic approaches for data quality	H		23–	X	X				
(iv) Acoustic data storage and processing	H	X							
(1) Automated data processing of acoustic data from fishing vessels, including frequency of updates to biomass estimates	L	23							
(2) Standardised procedures to check and verify acoustic data	M	23							Sec
(3) Develop the use of krill length frequency data in the estimation of target strength, and krill weight for biomass estimates	H	23		X				X	AUS
(4) Submission of acoustic data and the inclusion of metadata by Members in the repository held by the Secretariat	L	22							Sec
(5) Develop statistical approaches to acoustic data emerging from new acoustic observation platforms	L								
(v) Biomass estimation methods	H	X							
(1) Establish Grym parameters for krill stock assessments in Areas 48 and 58	H			X					
(2) Krill age interlaboratory comparisons	L						22		
(3) Grym Training	L						22		

(continued)

Table 2 (continued)

	Urgency	ASAM	SAM	EMM	IMAF	FSA	Workshop	e-group	Facilitator
(4) Krill biomass estimate in Division 58.4.1	L	X							
(5) Krill biomass estimate in Division 58.4.2	L	X							
(vi) Account for spatial structure of krill	M	X		X					
(b) Develop stock assessments to implement decision rules for **krill**									
(i) Krill management approach (synthesis of krill recruitment, spatial scale, biomass estimates, predator risk)	H	X	X	X	X	X	X	X	
(1) Subarea 48.1 (2022)	H	X		X		X			
(2) Subareas 48.2, etc… (2023/24)	L	X		X		X			
(ii) Develop diagnostic tools	L	X	24–	X					
(iii) Develop ecosystem indicators to inform risk assessment framework	L	X		X					
(iv) Methods to account for uncertainty in stock status	L	X	24–	X		X			
(1) Movement of krill (flux)	L	X							
(2) Spatial structure within subareas	H	X		X	X				
(3) Interannual variability	L	X		X					
(v) Develop krill management approach as a multiannual cycle	H		25–	X		X			
(vi) Generate precautionary spatial catch limits for krill	H						X		
(vii) Krill management strategies that are robust to climate change	L		25–	X		X			
(c) Develop methods to estimate biomass for **finfish**									
(i) Survey design	H		23						
(ii) Data collection – SISO and vessels	H		23			X		X	Sec
(1) Conversion factors	H					X	22		Sec
(2) Tagging protocols	L					X	22		Sec
(3) Ross Sea data collection program	L					X	22		
(iii) Improve biomass estimation methods	M		23–						Sec
(iv) Gear standardisation analyses	H		X						

(continued)

Table 2 (continued)

	Urgency	ASAM	SAM	EMM	IMAF	FSA	Workshop	e-group	Facilitator
(v) Modelling of spatial population structure	L		24–			X			
(vi) Review regulatory framework	L							X	
(d) Develop stock assessments to implement decision rules for **finfish**									
(i) Research to develop new assessments	M		X			X			
(1) Research plan evaluations	L		X			X			
(2) Subarea 88.2 fishery structure	L		23			X		22	
(3) Stock structure and connectivity	L		23–			X			
(ii) Develop new assessment tools	M		23–					X	
(1) Casal2 development	L		22			X			
(2) Toothfish age interlaboratory comparisons	L		23–				22		
(iii) Provide precautionary catch limits	H					X			Sec
(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	H		23–						
(ii) Development and testing of data-limited fishery decision rules	M		23–			X			
(iii) Finfish management strategies that are robust to climate change	L		24–	X		X			
2. Ecosystem impacts									
(a) Ecosystem monitoring (Second Performance Review, Recommendation 5)				X					
(i) Structured ecosystem monitoring programs (CEMP, fishery)	H			X					
(1) CEMP	H			X					Sec
(2) Fishery via SISO	M	X		X	X	X			Sec
(3) Research surveys	L	X			X	X			
(ii) Ecosystem modelling	L		25–	X			X		
(iii) Invasive species	L			X		X			Sec

(continued)

Table 2 (continued)

	Urgency	ASAM	SAM	EMM	IMAF	FSA	Workshop	e-group	Facilitator
(iv) Marine debris monitoring	L			X					Sec
(b) Spatial management				X			X	X	
(i) Science advice on proposals for a Representative System of MPAs	H			X				X	
(1) Current proposals	H			X			X	X	
(2) Future proposals	L			X			X	X	
(ii) Research and monitoring plans	H			X					Sec
(c) By-catch risk assessment for krill and finfish fisheries									
(i) Monitoring status and trends	H			X	X	X			Sec
(1) Implement whale sighting protocols	H				X				
(ii) By-catch species catch limits	H			X		X			
(iii) By-catch mitigation methods	L				X	X			
(iv) Incidental mortality	L				X				Sec
(d) Habitat protection from fishing impacts									
(i) Habitat classification, bioregionalisation and monitoring	L			X		X			
(ii) VME identification and management	L			X		X			
(iii) Protection of biodiversity and ecosystems (Second Performance Review, Recommendation 7)	H			X					
(1) Ecosystem impacts from krill and finfish fishing, including analyses whether research and sampling design is able to detect such impacts	H			X		X			
(2) Physical disturbance of longline fishing on benthic ecosystems	L			X		X			
(3) Suitability of reference areas for comparison between fished and unfished areas	M			X		X			
(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)	M	X	26–	X	X	X			

(continued)

Table 2 (continued)

	Urgency	ASAM	SAM	EMM	IMAF	FSA	Workshop	e-group	Facilitator
Administrative topics									
(a) Advise on database facilities required through DSAG	H	X	X	X	X	X		X	Sec
(b) Advise on quality control and assurance processes for data provided to and supplied by the Secretariat	H	X	X	X	X	X		X	Sec
(c) Refine the scheme of international scientific observation (SISO) across all fisheries	M	X	X	X	X	X		X	Sec
(d) Further develop data management systems	M	X	X	X	X	X		X	
(1) Quality assurance	H	X	X	X	X	X		X	Sec
(2) DOI	M	X	X	X	X	X		X	Sec
(3) Data access	L	X	X	X	X	X		X	Sec
(e) Communication of progress, internal and external	M	X	X	X	X	X			Sec
(f) Working group terms of reference	L	X	X	X	X	X			
(g) Scientific Committee Symposium in 2027	H	27	27	27	27	27	27	27	

Appendix A

Additional comments from working group review

Comments on Table 1 and Table 2 were incorporated directly into the tables.

WG-EMM-2022 noted that it would be beneficial to cycle through the topics listed in its terms of reference to ensure that discussion time was balanced between the management of krill resources and the status of ecosystems (WG-EMM-2022, paragraph 2.18)

WG-EMMM-2022 also noted that WG-EMM would benefit from developing integrated ecosystem reporting to ensure a more comprehensive view of monitored ecosystems (WG-EMM-2022, paragraph 2.18).

WG-EMM-2022 recommended that the Scientific Committee allocate topics to specific working groups to aid Members in scheduling work and making sure scientists with appropriate expertise are available at the appropriate working groups.

The Working Groups WG-ASAM, WG-SAM and WG-EMM reviewed and commented on their Terms of Reference. WG-FSA and WG-IMAF had not met when this paper was drafted and so are not included. Current versions of the Terms of Reference, including recommended updates in track changes are provided below:

WG-ASAM Terms of Reference were set in 2019 (SC-CAMLR-38 Annex 8) and so were not reviewed.

The Working Group on Acoustics, Survey and Analysis Methods (WG-ASAM) was established by the Scientific Committee as an expert group to examine issues related to the research on Antarctic Marine living Resources using hydro-acoustic technologies. The general terms of reference of the working group includes, but not limited to:

(i) identify new and develop standard acoustic methodology and protocols for the research and monitoring of Antarctic marine living resources, including survey design

(ii) conduct regular assessment and provide advice on area-scale or subarea-scale or division-scale acoustic survey estimates of Antarctic krill to the Scientific Committee and its relevant subsidiary bodies where appropriate

(iii) provide technical advice to scientific observers and the fishing industry for acoustic data collection on board fishing vessels

(iv) conduct annual analysis of the acoustic data collected from CCAMLR-nominated transects and submitted to the Secretariat.

WG-SAM suggested minor changes to its Terms of Reference:

To provide advice to the Scientific Committee and its working groups on:

(i) quantitative assessment methods (including stock assessment methods and management strategy methods), statistical procedures, and modelling approaches for the conservation of Antarctic marine living resources,

(ii) the implementation of and data requirements for such methods, procedures and approaches;

(iii) review of research plans and proposals;

(iv) research fishing and survey design standards.

WG-EMM, originating in 1994 (SC-CAMLR-XIII, paragraph 7.41) suggested:

Recalling that Article II of the Convention requires the conservation of harvested populations, the maintenance of ecological relationships between harvested, dependent and related populations, the restoration of depleted populations and the minimisation of the risk of irreversible changes in the Antarctic marine ecosystem, the Scientific Committee agreed that the terms of reference for WG-EMM are to:

(i) undertake assessments of the status of krill;

(ii) undertake assessments of the status and trends of dependent and related populations including the identification of information required to evaluate predator/prey/fisheries interactions and their relationships to environmental features and including the role of fish in the ecosystem;

(iii) undertake assessments of environmental features and trends which may influence the abundance and distribution of harvested, dependent, related and/or depleted populations;

(iv) identify, recommend and coordinate research necessary to obtain information on predator/prey/fisheries interactions, particularly those involving harvested, dependent, related and/or depleted populations;

(v) liaise with other working groups on matters where their expertise is related to ecosystem monitoring and management;

(vi) develop further, coordinate the implementation of, and ensure continuity in the CCAMLR Ecosystem Monitoring Program (CEMP);

(vii) Incorporate spatial ecology into the management of Antarctic marine living resources;

(viii) taking into account the assessments and research carried out under the terms of reference (i) to (v) above, to develop management advice on the status of the Antarctic marine ecosystem and for the management of krill fisheries in full accordance with Convention Article II.

Report of the Working Group
on Acoustic Survey and Analysis Methods
(Virtual meeting, 30 May to 3 June 2022)

Content

Report of the Working Group on Acoustic Survey and Analysis Methods
(Virtual meeting, 30 May to 3 June 2022)

Opening of the meeting

1.1 The 2022 meeting of the Working Group on Acoustic Survey and Analysis Methods (WG-ASAM) was held online from 30 May to 3 June, starting at 0800 UTC. The Co-conveners, Dr S. Fielding (UK) and Dr X. Wang (China) welcomed the participants (Appendix A).

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

1.3 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.

1.4 This report was prepared by the Secretariat and the Co-conveners. Sections of the report detailing advice to the Scientific Committee and other working groups are highlighted in Agenda Item 3.

Standardised procedures for survey design, data analysis and quality control of acoustically derived areal krill biomass estimates to CCAMLR

2.1 WG-ASAM-2022/02 presented R code to aid in the creation of CCAMLR management strata and the computation of their areas, aiming at establishing an agreed approach to ensure consistency and transparency in the future.

2.2 The Working Group welcomed the proposed methodology which was clear, simple and transparent. It noted that the strata boundaries shown in the paper were solely used as an example to demonstrate the method's application and discussed the importance of using version control for projections and geographical boundaries as data layers may evolve with time. The Secretariat indicated that version control of geo-referenced data, including coastlines, will be part of the future redevelopment of the online CCAMLR geographic information system.

2.3 WG-ASAM-2022/07 presented proposals towards the standardisation of methods for processing and reporting future acoustic survey results, with a particular focus on data processing (i.e. dB difference vs swarms-based krill identification methods) and survey design (time of measurements, direction of transects, frequency of synoptic and regional surveys). The authors noted the need for clear and standardised guidelines for all aspects of krill acoustic surveys in the Convention Area.

2.4 The Working Group noted that this study highlighted the importance of documenting and comparing the different methods and steps taken to estimate biomass in all surveys. Recalling that such comparisons had been undertaken in the past (e.g. SG-ASAM-18/04 Rev. 1, SG-ASAM-2019/10), the Working Group noted that both the dB difference and swarms-based krill identification methods had been agreed for estimating biomass. Given that the true biomass is unknown, it is important to continue using different target identification methods, to recognise their strengths and weaknesses (see Table 1) and to compare their results. Regarding the term ‘synoptic’ highlighted in the study, the Working Group recalled that the International 2019 Area 48 Survey had encountered issues of timing that should be an area to focus on in the future.

2.5 WG-ASAM-2022/08 presented an analysis comparing krill length composition between research and commercial samples in Subarea 48.2 to investigate variability in length compositions among vessels. Noting the difference in fishing tactics, local areas and gears between research and commercial vessels, the authors highlighted the lower relative occurrence of both the smallest and largest individuals in fishery samples compared to research trawl samples from the RV *Atlantida*. They advocated for the standardisation of trawl sampling protocols and the use of research trawls during acoustic surveys, as well as improvements in observer length distribution sampling requirements in the krill fishery.

2.6 The Working Group recalled SG-ASAM-2019/10, which investigated the potential effects of selectivity in trawl nets used for the 2019 Area 48 Survey, and noted the findings from this study and WG-ASAM-2022/08 that both scientific trawl and commercial trawl nets were able to catch all size classes of krill. However, a significant difference in the krill size composition of catches was revealed both between the scientific and commercial trawls, and between commercial trawls with different designs. The most sensitive krill length classes to the gear design and fishing method are recruits and large krill.

2.7 The Working Group further noted that the design of krill sampling requirements may differ depending on the intended use of the data as well as season and location. For example, length sampling requirements (sample size) should be targeted at providing appropriate estimates of size at recruitment accounting for gear selectivity, or appropriate estimates of biomass for acoustic surveys. The Working Group also noted that because fishing vessels use trawls with different characteristics, using the length distribution data needs to take gear selectivity into account.

2.8 WG-ASAM-2022/10 presented an analysis of the effect of the krill length-to-weight relationship on the conversion factor, C, that scales nautical area scattering coefficient (NASC) values of krill echoes to krill areal biomass density. Using example data from the East Antarctic, the authors used a linear mixed effects model to estimate weight at length along with its uncertainty, and used the resulting predictions to estimate C and its uncertainty.

2.9 The Working Group welcomed this analysis and discussed the possibility of accounting for maturity stage and sex in the model as these affect length–weight relationships, recognising that this would render the model more difficult to scale up to the population. Given the range of predicted C, the Working Group expressed interest in comparing this range to values of C reported in other studies.

2.10 The Working Group noted an ongoing experiment to measure the weight at length of krill on board a Chinese krill fishing vessel by grouping krill specimens in specific length classes and weighing them together to reduce the impact of vessel movement.

2.11 Noting the difficulty of weighing krill on board vessels, the Working Group discussed the possibility of freezing specimens to subsequently weigh them on land. The Working Group also discussed the methodology used by the authors, which involved calibration weights used in conjunction with an accelerometer to correct for effects of ship motion.

2.12 WG-ASAM-2022/13 presented a proposal for standardised metadata and maps and diagnostic plots to be included with acoustic krill biomass survey results presented to CCAMLR and proposed a verification report that could be used to validate the processing method that had been used to obtain the biomass results.

2.13 The Working Group welcomed this paper and agreed that results of acoustic krill biomass surveys presented to CCAMLR should be accompanied with standardised metadata describing the data collection and data processing methods and that the computer programs used to derive the biomass estimates should be validated against a reference dataset. The reference dataset should be available in open access and should consist of raw acoustic data files, krill length-frequency data, conductivity temperature depth probe data, and the output from the processing methods that have been endorsed by CCAMLR. The Working Group noted with appreciation the offers by Australia and the UK to contribute such datasets.

2.14 The Working Group welcomed the suggestion to use the Secretariat as a central repository for metadata from acoustic surveys for which the estimates were presented to CCAMLR and reflected on the need to expand the metadata reporting requirements when CCAMLR starts adopting the use of novel technologies such as echosounders deployed on gliders, moorings, penguins and seals.

2.15 Tables 2 to 8 document the metadata and illustrations that are to accompany the results of acoustic krill biomass surveys presented to CCAMLR. If parameters are not available for particular datasets, then the relevant field(s) can be given as N/A. For example, 'Krill identification method' and 'Krill biomass per survey' may not be relevant to data from a moored echosounder.

Biomass estimates

Area 48

3.1 WG-ASAM-2022/05 presented a proposal to conduct a local acoustic trawl survey of mackerel icefish (*Champsocephalus gunnari*) in Subarea 48.2 in the shelf and slope regions of the South Orkney Islands. Objectives of the research include estimating the pelagic biomass in the survey area, improving information on biological parameters, and further understanding of the spatial and bathymetric distribution of by-catch species.

3.2 The Working Group recalled discussions and the request of WG-SAM for WG-ASAM to review this proposal (WG-SAM-2021, paragraphs 8.6 to 8.7), including the choice of appropriate acoustic frequencies and the methodology to identify icefish from krill in acoustic data.

3.3 The Working Group noted that the acoustic equipment proposed for the survey design used two high frequencies (120 and 200 kHz) and considered whether they would be appropriate for identifying icefish targets. The Working Group noted that a previous study had identified icefish using 120 kHz backscatter data and a random forests classification analysis (Fallon et al., 2016), and SG-ASAM-09/06 introduced the target strength of *C. gunnari* from a scattering model. The Working Group welcomed any potential improvements to methods to discriminate pelagic icefish and krill in acoustic data from this survey.

3.4 Dr K. Demianenko (Ukraine) expressed his gratitude at the offer from Dr M. Cox (Australia) for the loan of a 38 kHz split-beam transceiver.

3.5 The Working Group noted the experimental nature of an acoustic survey for icefish in terms of obtaining target identification and subsequently converting target strength to a biomass estimate.

3.6 The Working Group further noted that clarity was required regarding the survey design to understand if a trawl would be conducted only for acoustic target identification, or if trawls were to be conducted at every survey station regardless of the acoustic findings at an individual station.

3.7 The Working Group noted that a 30-minute trawl duration may be excessive to simply sample acoustic marks for target identification, if the focus of the survey is for acoustic biomass estimation, not to catch large quantities of icefish.

3.8 Dr Demianenko clarified that the experimental design involved targeted trawl transects of marks on the echosounder for identification purposes. Dr Demianenko also suggested the potential of combining acoustic collection of data to aid scientific evaluation and remains open to dialogue on other aspects of the proposed research.

Local-scale biomass estimates within subareas relevant to the area of operation of the krill fishery

3.9 WG-ASAM-2022/09 presented preliminary results from Antarctic krill (*Euphausia superba*) surveys around the South Shetland Islands, conducted by Chinese fishing vessels during May and June 2021 and in April 2022. For the 2021 survey, krill swarms were found in the west of Bransfield Strait and in waters close to the Antarctic Peninsula, while few krill swarms were encountered in waters to the northwest of the South Shetland Islands. During the 2022 survey, krill swarms were more frequently observed than during the 2021 survey and were found in waters close to Joinville Island, the west of Bransfield Strait and King George Island.

3.10 The Working Group welcomed the use of the 'RapidKrill' software, noting the utility of the software for producing effective and near real-time results from surveys, and its ability to operate on less powerful computers, and encouraged continuing its development.

3.11 The Working Group noted that the surveyed areas extended into the Gerlache Strait stratum (paragraph 3.18) and encouraged the continuation of these surveys as the Gerlache Strait stratum has far fewer acoustic surveys than the strata around the northern Antarctic Peninsula.

3.12 WG-ASAM-2022/14 presented results from the annual Norwegian Institute of Marine Research survey covering five north/south transects off the South Orkney Islands. The average krill NASC in the study area was 293 m^2 n $mile^{-2}$ at 120 kHz (25.6% coefficient of variation (CV)) and the corresponding average krill density was 97.1 g m^{-2}.

3.13 The Working Group welcomed the preliminary results of the surveys and noted that consideration on inclusion of preliminary survey data would be required if the results were to be integrated as part of any assessment framework.

3.14 The Working Group noted that net-sampled krill length-frequency data were not available due to technical issues with operating the krill sampling gear. It noted that identifying suitable alternatives to net-sampled krill length-frequency distributions should be part of the standard protocols, as this requirement could also apply to other platforms such as moorings and gliders.

3.15 WG-ASAM-2022/04 presented preliminary findings from analyses of three mooring deployments spanning four summers, from 2018/19 to 2021/22. Results of the study show that biomass density is highly variable among years and within individual seasons. This was observed by declines in biomass through time along with some occasional increases in biomass, resulting in variable mean and median biomass densities. Biomass density variability may also relate to the success of krill-dependent predators, environmental variability and the dynamic nature of the krill fishery.

3.16 The Working Group noted the potential of conducting a periodogram analysis to quantitatively determine whether there is an effect of tidal or lunar cycles on the observed biomass density estimates. This may be especially relevant given the potential effect of environmental drivers on seasonal cycles in krill biomass.

3.17 The Working Group received with great interest the results from these novel techniques that seek to estimate krill density and flux from a series of moorings. The Working Group noted the challenge in how these data could be integrated with ship-based surveys data and looked forward to progress in this effort.

Subarea 48.1 strata and biomass estimates

3.18 The Working Group recalled the progress made last year regarding the update of Conservation Measure (CM) 51-07, through effective scientific collaboration on the three elements of the revision of the krill management strategy (acoustic biomass estimates, generalised R yield model (Grym) yield estimates, and risk assessment). The Working Group further recalled the management areas proposed by SC-CAMLR-40/11 and noted the methodology presented by WG-ASAM-2022/02 to refine these boundaries and calculate their areas. It noted that the 'outer' stratum was spatially separated by other strata, and therefore suggested to split it into a western stratum which was named 'Drake Passage' and an eastern stratum which was named 'Powell Basin'. The Working Group further suggested to rename the 'extra' stratum as 'Gerlache Strait' stratum.

3.19 The Working Group considered biomass estimates for these strata and recalled the previous discussions on this topic (WG-EMM-2021, paragraphs 2.23 to 2.29). Considering the availability of survey data in the different areas, and the high levels of interannual variability within areas, the Working Group summarised the biomass estimates relative to four time periods over which biomass estimates could be averaged (all years available, all years since the implementation of CM 51-07 in 2009, the last five years from 2015 to 2020, and the last three years from 2018 to 2020 (Table 9)).

3.20 The Working Group highlighted that that the CVs reported in Table 9 were based on the CVs from surveys (krill biomass metadata table) using the Jolly and Hampton (1990) method and as such were representative of the survey CVs only (sampling variability), not the total uncertainty in the biomass estimate. The Working Group noted previous attempts to estimate this (Demer, 2004) for the CCAMLR 2000 Krill Synoptic Survey of Area 48 and suggested future work to estimate a total reflection of uncertainty from the data.

3.21 The Working Group discussed the amount of data available associated with these averaged estimates with the aid of maps (Figure 1) and plots of biomass time series (Figure 2). It noted that while this represented the best available data at this time, it was important to recognise that these averages were obtained by combining results from surveys that used different methodologies, krill identification methods and trawl designs, among other characteristics, which warranted caution.

3.22 The Working Group agreed that the estimates provided in Table 9 represented the best available science. However, until more analysis of the impacts of differences among surveys, and more standardisation was brought to survey methodologies, an open question to be considered in the future, these estimates should be considered with caution.

3.23 The Working Group agreed that standardisation of acoustic survey methodologies in the future would be beneficial and increase confidence in estimates obtained by averaging results from different surveys. It further noted the need to examine how the methodology of acoustic surveys affects their results to clarify the degree of uncertainty of average biomass estimates combining different surveys. Such studies should facilitate informed decisions regarding the practical use of these average biomass estimates.

3.24 The Working Group recalled that CCAMLR uses the lower bound of the 95% confidence interval of the biomass estimate to provide precautionary advice in the case of icefish that is assessed using acoustic surveys. Application of this approach may provide a short-term, precautionary advice, while further work is developed to address the potential impact of the issues noted (paragraph 3.21).

Acoustic observations of krill to inform spatial and temporal dynamics of krill

Surveys on nominated transects by fishing vessels

4.1 WG-ASAM-2022/12 Rev. 1 presented acoustic data collected by four fishing vessels along CCAMLR nominated transects at South Georgia during the winter period. These surveys are the first nominated CCAMLR transects collected by fishing vessels in Subarea 48.3 and provide an important source of information especially in a year where the fishery did not take substantial catches due to a low krill abundance. The study also provides important information on the winter distribution of krill near South Georgia.

4.2 The Working Group welcomed the collaboration with fishing vessels to obtain winter survey data in Subarea 48.3 and thanked the Association of Responsible Krill harvesting companies (ARK) for coordinating the vessels involved. The Working Group noted that if any ancillary environmental data were collected by the vessels, these data may be useful in identifying potential causes for the low krill abundance observed in the Subarea 48.3 commercial fishery that year.

4.3 The Working Group noted that the fishing vessel echosounders had not been calibrated using standard techniques. They considered attempts to use a seabed calibration from previous

ASAM meetings (SG-ASAM-2014 and SG-ASAM-17/P01). The Working Group further noted that the bottom calibration method undertaken by the vessels was not yet proven and the acoustic scattering properties of seabed are more complex than the reference target used for the standard sphere calibration method.

4.4 WG-ASAM-2022/06 presented results from acoustic transects undertaken by a Chinese krill fishing vessel in Subarea 48.3 in June and August 2021. Preliminary analysis showed that only a small number of krill swarms with low density were observed. The study recommended vessels update echosounder software frequently and run internal checks. It also recommended that an update of the agreed protocols for acoustic instrument settings, to ensure consistency between Members and vessels, should be considered by WG-ASAM.

4.5 The Working Group welcomed the survey results and highlighted that coordination of fishing vessel survey effort would facilitate collecting timely information over a fishing season. The Working Group recommended that WG-ASAM discuss how to update the acoustic instrument instructions for unsupervised acoustic data collection on-board fishing vessel surveys and examine how to use the automatic data processing technique (such as RapidKrill) for on-board processing of acoustic data in the WG-ASAM e-group.

Acoustic observation from various platforms

4.6 WG-ASAM-2022/03 presented the ROSSKRILL project, a large-scale acoustic survey performed by the Italian RV *Laura Bassi* in January 2022 in the western Ross Sea. The project also installed an autonomous echosounder on top of the Ross Sea marine observatory 'Mooring B' that will operate throughout the year, gathering useful information of the ecosystem under the winter sea-ice. The results of the ROSSKRILL project aim to allow a comparison of the abundance and spatial distribution of krill throughout the year in relation to environmental parameters.

4.7 The Working Group noted that this study contributed to the monitoring requirement of the Ross Sea region marine protected area and that the results would provide acoustic information from Area 88, which, when combined with the acoustic surveys undertaken in Areas 48 and 58, represents the first circumpolar snapshot of krill density. The Working Group encouraged the collection of ancillary environmental data for further comparison with other *E. superba* habitats.

4.8 WG-ASAM-2022/P01 presented observations of krill biomass and flux in Subarea 48.1 (paragraphs 3.15 to 3.17), collected in summer using arrays of six submerged moorings equipped with echosounders and acoustic Doppler current profilers (WG-ASAM-2022/04).

4.9 The Working Group noted the utility of the mooring system for localised krill monitoring and the potential for large-scale ecosystem monitoring if several moorings were deployed with a wide geographic spread.

4.10 The Working Group further noted that novel acoustic devices and technologies would potentially require the development of acoustic data collection protocols and definition of common terminologies by WG-ASAM, to ensure integration with vessel-based acoustic surveys for fishery and ecosystem management purposes.

Other business

Chair's report of the Scientific Committee Symposium

5.1 On behalf of the Chair of the Scientific Committee, Dr S. Parker (Secretariat) presented the report of the CCAMLR Scientific Committee Symposium that met virtually on 8 and 10 February 2022 (WG-ASAM-2022/01). The informal Scientific Committee meeting discussed the progress and outcomes from the first CCAMLR Scientific Committee's workplan (SC-CAMLR-XXXVI/BG/40) and provided an opportunity for participants to propose long-term priorities and strategies to inform the development of the next five-year strategic plan (2023–2027). Recommendations and plans will be refined during the intersessional period by all working groups and agreed at SC-CAMLR-41 according to the Scientific Committee's Rules of Procedure.

5.2 The Working Group welcomed and endorsed such an approach that will enable the working groups and the Scientific Committee to identify and focus their efforts on the priorities. The Working Group undertook to review the priority research topics presented in Table 2 of the document and preliminary discussions and recommendations for work sequencing took place, however, due to the time constraints of the meeting, the review was only partially completed. The Working Group undertook to continue progressing the review through the WG-ASAM e-group, with results to be presented at SC-CAMLR-41 by the WG-ASAM Co-conveners.

Development of an acoustic data repository

5.3 The Secretariat presented WG-ASAM-2022/11, an overview of the raw acoustic data collected by fishing vessels along CCAMLR nominated transects currently held at the Secretariat. The authors recommended that WG-ASAM consider the collection and reporting of additional metadata attributes along CCAMLR nominated transects and the development of a data exploration tool.

5.4 The Working Group welcomed this contribution and thanked the Secretariat for developing the database. The Working Group recommended that interested participants work together with the Secretariat in the WG-ASAM e-group to review the metadata collection and reporting requirements for fishing vessels, taking into account the metadata table developed at this meeting (see Table 2) for data collection in acoustic surveys, and provide an updated 'Instruction manual for the collection of fishing-vessel-based acoustic data' for consideration at the next WG-ASAM meeting.

5.5 The Working Group welcomed the suggestion to develop a data exploration tool using the R package Shiny and recommended that the Secretariat include detailed position data which it can extract from the raw data files using open-source software such as the python library Echopy. The Working Group requested the Secretariat consider interoperability with acoustic databases of other organisations, including the US National Oceanic and Atmospheric Administration.

Data access rules (Data Services Advisory Group)

5.6 The Working Group noted WG-ASAM-2022/15 which describes the implementation of the Rules for Access and Use of CCAMLR Data into the CCAMLR data request procedure, and the procedure for publication of derived materials in the public domain. However, due to the time constraints, the Working Group was unable to consider the paper. The Working Group undertook to discuss it in the WG-ASAM e-group, with comments to be presented to SC-CAMLR-41.

Adoption of the report and close of the meeting

6.1 The report of the meeting was adopted.

6.2 At the close of the meeting, Dr Fielding and Dr Wang thanked all participants for their hard work and collaboration that had contributed greatly to the successful outcomes from WG-ASAM this year, and the Secretariat and the Interprefy team for their support.

6.3 On behalf of the Working Group, Dr X. Zhao (China) thanked the Co-conveners and the Secretariat for successfully guiding the WG-ASAM discussions and the report adoption process.

References

Demer, D.A. 2004. An estimate of error for CCAMLR 2000 survey estimate of krill biomass. *Deep-Sea Res. II*, 51: 1237–1251.

Fallon, N.G., S. Fielding and P.G. Fernandes. 2016. Classification of Southern Ocean krill and icefish echoes using random forests. *ICES J. Mar. Sci.*, 73 (8): 1998–2008.

ICES. 2016. A metadata convention for processed acoustic data from active acoustic systems. *Series of ICES Survey Protocols SISP 4-TG-AcMeta*, doi: https://doi.org/10.17895/ices.pub.7434.

Jolly, G.M. and I. Hampton. 1990. A stratified random transect design for acoustic surveys of fish stocks. *Can. J. Fish Aquat. Sci.*, 47 (7): 1282–1291.

Table 1: Pros and cons of two methods used to identify krill during acoustic biomass estimation. The reliance on target strength model parameters to scale krill echoes to krill biomass impacts both methods.

Method	Pros	Cons
dB-difference (2 or 3 frequencies)	• Based on a validated acoustic scattering model implemented at different frequencies. • Has been tested, validated and applied in CCAMLR working group and primary literature papers. • Has a standardised acoustic data processing procedure (workflow) endorsed by WG-ASAM.	• Rely on many target strength model parameters to identify krill echoes (e.g. acoustic material properties, orientation, size composition) which may be difficult to estimate accurately. • If 3 frequencies, i.e. 200 kHz is also used, the effective working depth for surface-based platforms may be limited by this frequency to 150 to 200 m depth, although it is well known that krill may be found deeper than 300 m.
Swarms-based	• Can be undertaken on single frequency 120 kHz datasets, thus more echosounder platforms can be used and estimates of krill density or biomass can be attained with lower cost or shorter time, spanning even the entire fishing season. • Allows an automated and unsupervised standardised processing. • Has been tested, validated and applied in CCAMLR working group and primary literature papers. • Has a standardised acoustic data processing procedure (workflow) endorsed by WG-ASAM.	• Other organisms in schooling form can be mistaken as krill, whereas dispersed krill targets will be excluded.

Table 2: Recommended echosounder metadata. Where an ICES name exists, there is greater explanation in the ICES report for what is required.

Parameter	Units	ICES (2016) name
Operating frequency	kHz	instrument_frequency
Transducer location		instrument_transducer_location
Transducer manufacturer		instrument_transducer_manufacturer
Transducer model		instrument_transducer_model
Transducer depth	m	instrument_transducer_depth
Transducer orientation		instrument_transducer_orientation
Transducer equivalent beam angle	dB	instrument_transducer_psi
Transducer beam angle major (athwartship, where applicable)	degrees	instrument_transducer_beam_angle_major
Transducer beam angle minor (alongship, where applicable)	degrees	instrument_transducer_beam_angle_minor
Transceiver manufacturer		instrument_transceiver_manfacturer
Transceiver model		instrument_transceiver_model
Transceiver serial		instrument_transceiver_serial
Transceiver firmware version		instrument_transceiver_firmware
Calibration date		calibration_date
Calibration method		calibration_acquisition_method
Calibration processing method		calibration_processing_method
Calibration accuracy estimate		calibration_accuracy_estimate
Calibration location		
Acquisition software name		data_acquisition_software_name
Acquisition software version		data_acquisition_software_version
Echosounder platform type		platform_type, restricted to values given by https://vocab.ices.dk/?ref=311
Echosounder platform name(s)		
Echosounder platform flag country		
Echosounder platform length	m	

Table 3: Recommended echo-integration metadata. Where an ICES name exists, there is greater explanation in the ICES report for what is required.

Parameter	Units	ICES (2016) name
Processing software name		data_processing_software_name
Processing software version		data_processing_software_version
Minimum echo-integration depth	m	
Maximum echo-integration depth	m	
Echo-integration cell horizontal units		data_ping_axis_interval_type
Echo-integration cell horizontal size		data_ping_axis_interval_value
Echo-integration cell vertical size	m	
Echo-integration frequency	kHz	
Krill identification method		
Krill identification parameters		

Table 4: Recommended metadata for conventional transect/strata-based surveys.

Parameter
Survey design methodology
Number of survey transects per strata
Number of strata

Table 5: Recommended krill length sampling metadata.

Parameter	Description
Method by which the krill were obtained	(e.g. trawl, predator diet sample)
Sampling gear parameters (e.g. mesh size, opening area)	Details on the sampling methodology used
Method for overall length probability density function construction	

Table 6: Recommended krill target strength stochastic distorted-wave Born approximation model metadata.

Parameter	Units
Number of cylinders	
Krill length	mm
Phase variability standard deviation	rad
Fatness coefficient	
Density contrast	
Sound speed contrast	
Sound speed in water	m s^{-1}
Orientation mean	degrees
Orientation standard deviation	degrees

Table 7: Recommended biomass result metadata.

Parameter	Units
Start date of acoustic data used to estimate biomass	ISO 8601
End date of acoustic data used to estimate biomass	ISO 8601
Time of day of acoustic data used to estimate biomass (e.g. day/night only, day and night)	
Biomass area (e.g. strata) names	
Biomass area (e.g. strata) areas	km^2
NASC to biomass conversion factor	g m^{-2} n $mile^{-2}$
Mean krill density per area (e.g. strata)	g m^{-2}
Krill biomass per area (e.g. strata)	tonnes
Mean krill density per survey*	g m^{-2}
Krill biomass per survey*	tonnes
Survey sampling coefficient of variation per survey	%

* ‘survey’ is used to mean a period of time from which data have been used to generate a biomass estimate. This can be a conventional moving platform survey with strata and transects, or, for example, a biomass generated from analysis of data from stationary platforms.

Table 8: Recommended illustrations.

Illustration	Description
Overview map	A map showing the krill nautical area scattering coefficient or area backscattering coefficient locations, any conductivity temperature depth probe stations, and any trawl locations. The map should include coastlines and a latitude/longitude grid. Locations should visually distinguish between data collected during the night and during the day.
Krill lengths	Histogram(s) of the krill length distributions used in the conversion of krill backscatter to krill biomass.
Krill areal density	Map(s) showing krill areal density (in units of g m^{-2}) in the survey area. The map(s) should include coastlines and a latitude/longitude grid.
Effect of noise removal threshold	A plot showing the effect of changing the maximum threshold value in the CCAMLR swarms Echoview template on the biomass results.

Table 9: Updated strata krill biomass estimates based on Table 2.6 in WG-EMM-2021/05 Rev. 1 and SC-CAMLR-40/11 using the strata area calculation method provided in WG-ASAM-2022/02. The revised values are shown in **bold**. Where multiple surveys, the overall coefficients of variation (CVs) were calculated as in WG-EMM-21/05 Rev. 1. Time periods: yall – all available years 1996–2020, y5107 – since implementation of Conservation Measure 51-07 (2009–2020), y5 – 5 years (2015–2020) and y3 – 3 years (2018–2020).

Strata	Density (g m^{-2})	Variance of weighted density	CV of weighted density (%)	**Revised strata area based on WG-ASAM-2022/02**	**Biomass (tonnes) based on revised strata area**	CV biomass (%)	Years included for averaging biomass	Number of years with surveys	Number of surveys
Joinville (JI)[1]	83.01	723.28	32.40	**23 001**	**1 909 313**	32.40	y3	1	1
Joinville (JI)[1]	83.01	723.28	32.40	**23 001**	**1 909 313**	32.40	y5	1	1
Joinville (JI)	51.85	750.75	47.60	**23 001**	**1 192 602**	47.60	y5107	4	4
Joinville (JI)	37.42	410.24	46.86	**23 001**	**860 697**	49.51	yall	8	11
Elephant (EI)	85.48	253.13	22.31	**51 648**	**4 414 871**	22.31	y3	2	2
Elephant (EI)	85.48	253.13	22.31	**51 648**	**4 414 871**	22.31	y5	2	2
Elephant (EI)	78.45	250.21	18.64	**51 648**	**4 051 786**	18.65	y5107	5	5
Elephant (EI)	65.49	487.64	26.69	**51 648**	**3 382 428**	26.92	yall	18	27
Bransfield (BS)	69.34	241.74	24.20	**34 732**	**2 408 317**	24.20	y3	3	4
Bransfield (BS)	54.36	204.27	30.30	**34 732**	**1 888 032**	30.30	y5	5	6
Bransfield (BS)	39.85	154.41	32.35	**34 732**	**1 384 070**	33.81	y5107	9	11
Bransfield (BS)	34.19	343.83	41.28	**34 732**	**1 187 487**	42.83	yall	21	30
South Shetland Islands West (SSIW)	59.12	219.96	21.89	**47 066**	**2 782 542**	26.75	y3	3	4
South Shetland Islands West (SSIW)	47.08	166.29	26.93	**47 066**	**2 215 867**	29.85	y5	5	6
South Shetland Islands West (SSIW)	41.05	109.99	23.68	**47 066**	**1 932 059**	25.30	y5107	9	10
South Shetland Islands West (SSIW)	53.45	326.48	32.86	**47 066**	**2 515 678**	36.27	yall	21	29
Gerlache Strait (GS)[2]	58.53	**1364.31**	63.11	**44 198**	**2 586 908**	63.11	yall	1	1
Powell Basin (PB)[1]	**32.73**	**155.74**	**38.13**	**144 680**	**4 735 100**	**38.13**	yall	1	1
Drake Passage (DP)[1]	**41.53**	**40.56**	**15.33**	**294 531**	**12 233 000**	**15.33**	yall	1	1

1 Single survey: 2019 Area 48 Survey (WG-ASAM-2019).
2 Single survey: 2020 *Atlantida* survey (WG-ASAM-2021/04 Rev. 1).

(a)

(b)

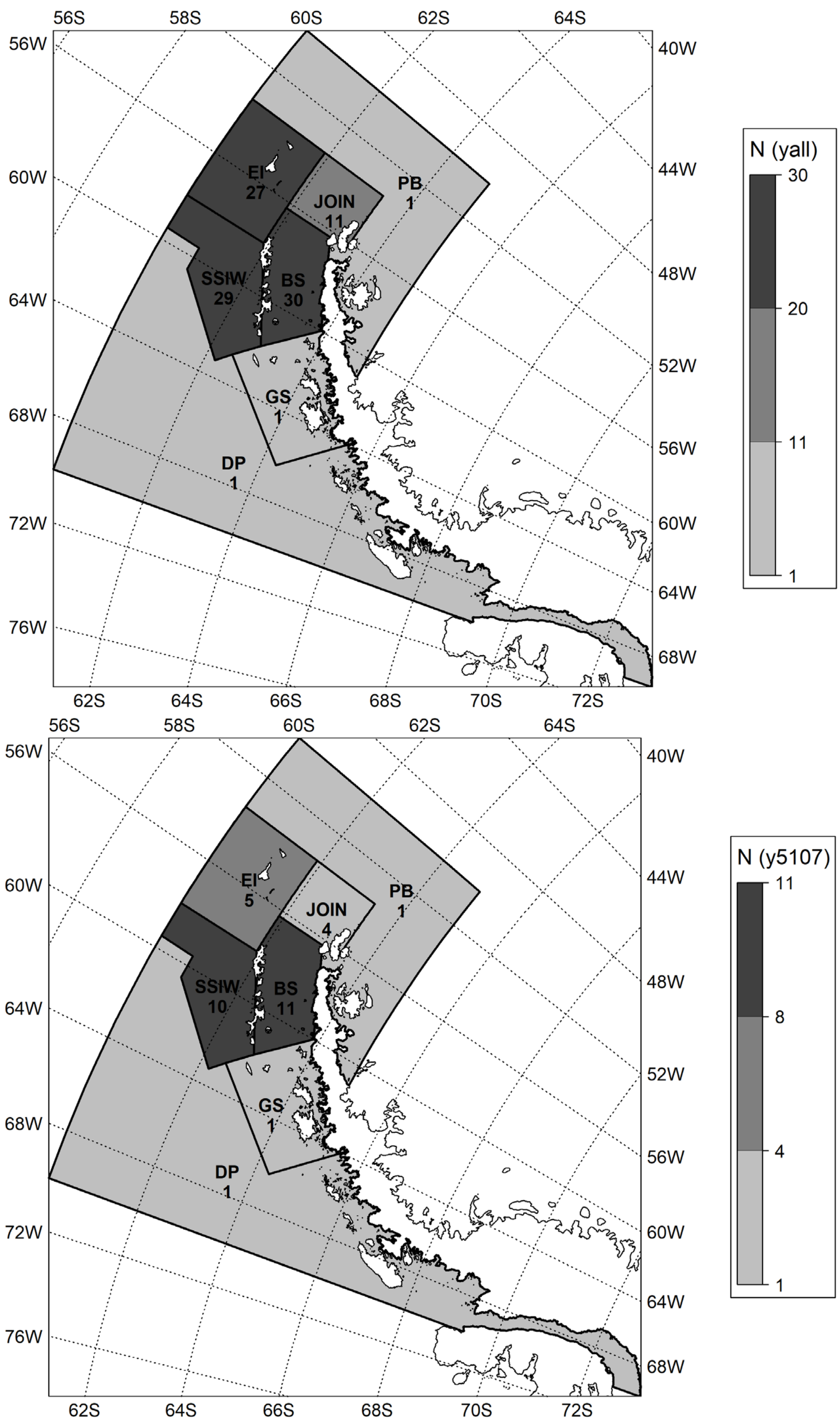
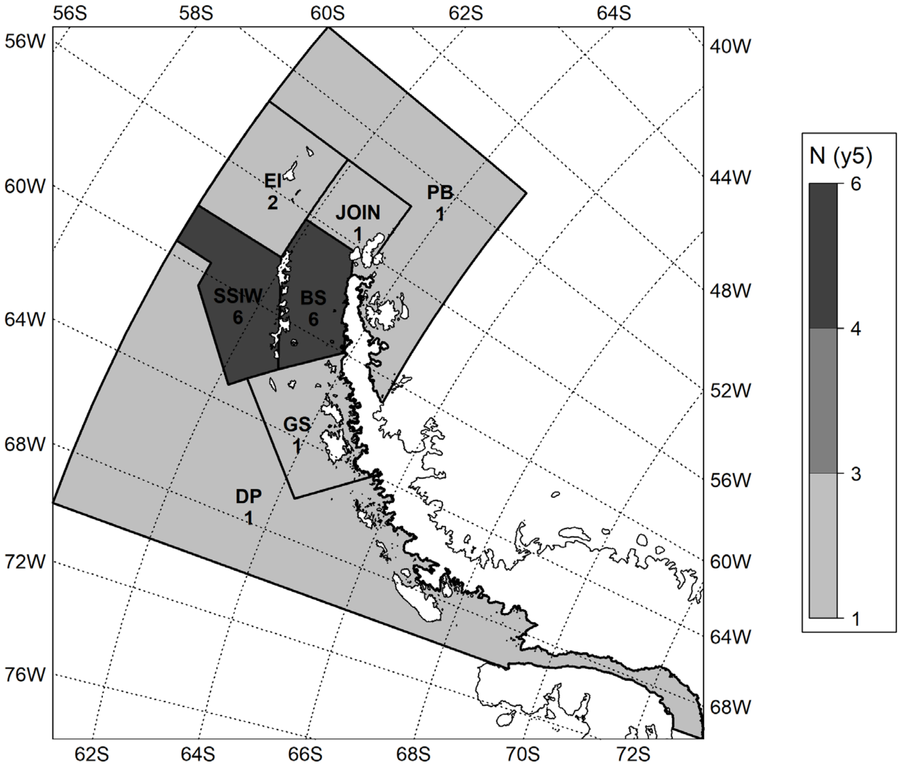


Figure 1: Strata shaded according to the number of surveys (N) conducted in each stratum (see Table 9). Survey numbers are from WG-EMM-2021/05 Rev. 1, Table 2.6, with additional data from the RV *Atlantida* survey in Gerlache Strait in 2020, and the 2019 Area 48 Survey in Drake Passage and Powell Basin, based on re-worked information provided in SC-CAMLR-40/11. EI – Elephant Island, JOIN – Joinville, BS – Bransfield Strait, SSIW – South Shetland Islands West, GS – Gerlache Strait, DP – Drake Passage, PB – Powell Basin.
Time period: (a) yall – all available years 1996–2020 and (b) y5107 – since implementation of Conservation Measure 51-07 (2009–2020).

(c)



(d)

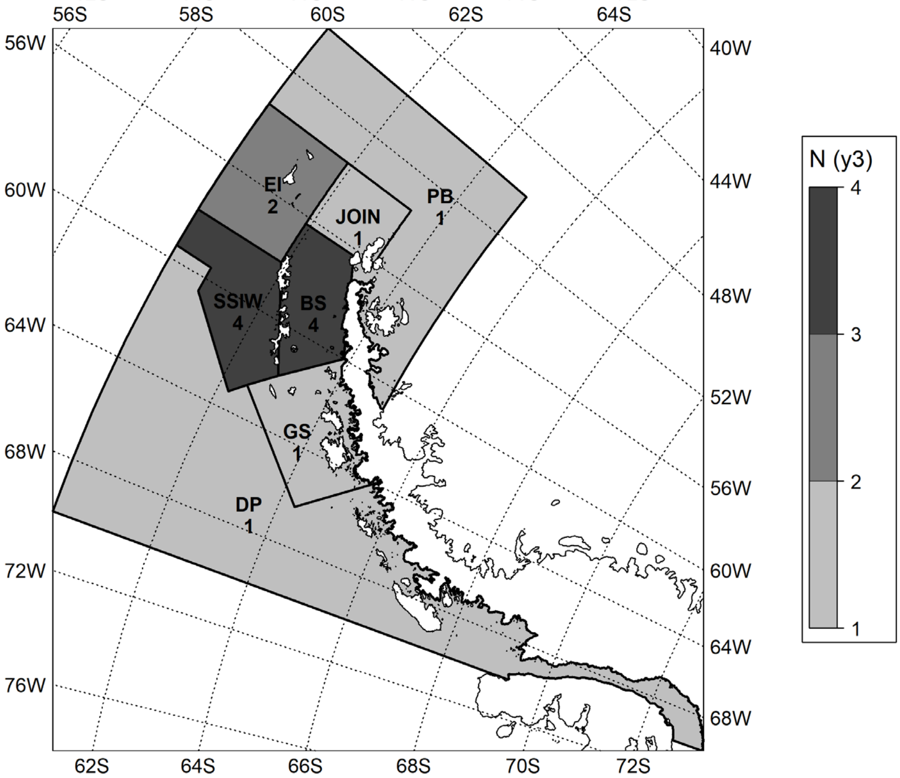


Figure 1 (continued)
Time period: (c) y5 – 5 years (2015–2020) and (d) y3 – 3 years (2018–2020).

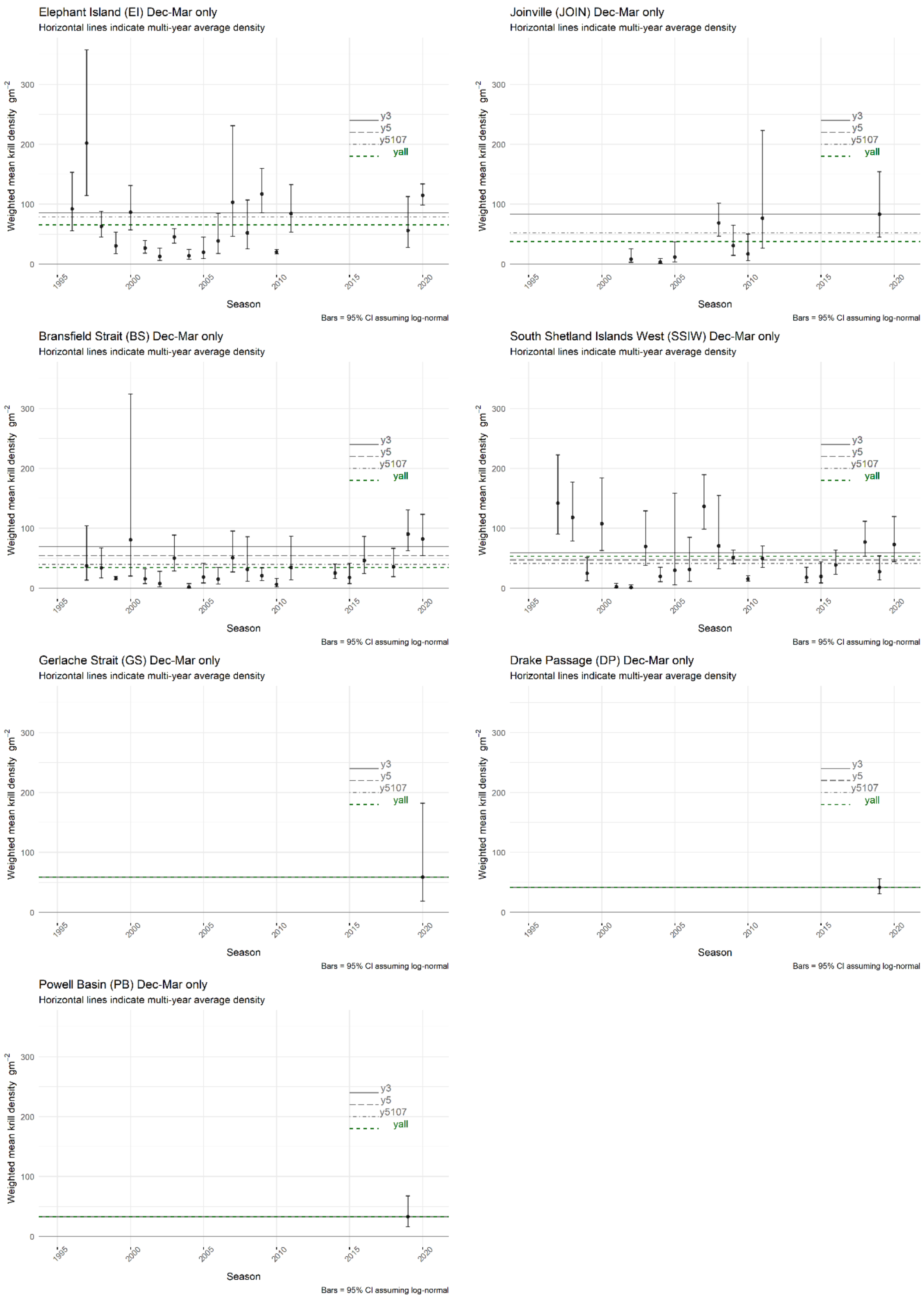


Figure 2: Timeseries of krill biomass density estimates for each stratum in Subarea 48.1 for the December to March period from 1995 to 2020. Error bars show the 95% confidence interval. Horizontal lines indicate the average density across different periods; yall – All available years 1996–2020, y5107 – since implementation of Conservation Measure 51-07 (2009–2020), y5 – 5 years (2015–2020) and y3 – 3 years (2018–2020). Stratum names correspond to the strata map in Figure 1 (see 'Krill biomass estimates from acoustic surveys' e-group).

Appendix A

List of Participants

Working Group on Acoustic Survey and Analysis Methods
(Virtual Meeting, 30 May to 3 June 2022)

Co-conveners	Dr Sophie Fielding British Antarctic Survey
	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
	Dr So Kawaguchi Australian Antarctic Division, Department of Climate Change, Energy, the Environment and Water
	Ms Abigail Smith University of Tasmania
Chile	Professor Patricio M. Arana Pontificia Universidad Catolica de Valparaíso
	Dr César Cárdenas Instituto Antártico Chileno (INACH)
	Mr Mauricio Mardones Instituto de Fomento Pesquero
	Mr Francisco Santa Cruz Instituto Antártico Chileno (INACH)
China, People's Republic of	Dr Qing Chang XU Yellow Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences
	Dr Yi-Ping Ying Yellow Sea Fisheries Research Institute
	Mr Jichang Zhang Yellow Sea Fisheries Research Institute

	Dr Yunxia Zhao Yellow Sea Fisheries Research Institute
	Dr Xianyong Zhao Yellow Sea Fisheries Research Institute, Chinese Academy of Fishery Science
	Professor Guoping Zhu Shanghai Ocean University
France	Dr Sara Labrousse Sorbonne Université
Italy	Dr Ilaria Biagiotti IRBIM - CNR
	Dr Andrea De Felice CNR-IRBIM
	Dr Marino Vacchi IAS – CNR
Japan	Dr Koki Abe Japan Fisheries Research and Education Agency
	Dr Taro Ichii Fisheries Resources Institute, 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 Hyoung Sul La Korea Ocean Polar Research Institute (KOPRI)
	Dr Haewon Lee National Institute of Fisheries Science
	Mr Sang Gyu Shin National Institute of Fisheries Science (NIFS)

Norway	Dr Gavin Macaulay Institute of Marine Research
Russian Federation	Dr Svetlana Kasatkina AtlantNIRO Mr Aleksandr Sytov FSUE VNIRO
South Africa	Mr Sobahle Somhlaba Department of Agriculture, Forestry and Fisheries
Ukraine	Dr Kostiantyn Demianenko Institute of Fisheries and Marine Ecology (IFME) of the State Agency of Melioration and Fisheries of Ukraine Dr Leonid Pshenichnov Institute of Fisheries and Marine Ecology (IFME) of the State Agency of Fisheries of Ukraine
United Kingdom	Dr Chris Darby Centre for Environment, Fisheries and Aquaculture Science (Cefas)
United States of America	Mr Anthony Cossio National Marine Fisheries Service Dr George Cutter National Marine Fisheries Service, Southwest Fisheries Science Center Dr Christian Reiss National Marine Fisheries Service, Southwest Fisheries Science Center

CCAMLR Secretariat	Belinda Blackburn Publications Officer
	Dane Cavanagh Web Project Officer
	Daphnis De Pooter Science Data Officer
	Gary Dewhurst Data and Information Systems Manager
	Doro Forck Communications Manager
	Isaac Forster Fisheries and Observer Reporting Coordinator
	Angie McMahon Human Resources Officer
	Ian Meredith Systems Analyst
	Dr Steve Parker Science Manager
	Alison Potter Data Administration Officer
	Dr Stephane Thanassekos Fisheries and Ecosystems Analyst
	Robert Weidinger IT Assistant
	Thomas Williams Database Administrator/Technical Analyst
	Claire van Werven Research, Monitoring and Compliance Analyst

Appendix B

Agenda

Working Group on Acoustic Survey and Analysis Methods
(Virtual meeting, 30 May to 3 June 2022)

1. Opening of the meeting

2. Standardised procedures for survey design, data analysis and quality control of acoustically derived areal krill biomass estimates to CCAMLR

   2.1 Dedicated surveys

3. Krill biomass estimates

   3.1 Area 48
      3.1.1 Subarea biomass estimates
      3.1.2 Local-scale biomass estimates within subareas relevant to the area of operation of the krill fishery

   3.2 Area 58

4. Acoustic observations of krill to inform spatial and temporal dynamics of krill

   4.1 Survey on nominated transects by fishing vessels
   4.2 Acoustic observation from various platforms

5. Other business

   5.1 Chair's report of the SC-Symposium
   5.2 Development of an acoustic data repository
   5.3 Data Access Rules (DSAG)

6. Adoption of the report and close of the meeting.

Appendix C

List of Documents

Working Group on Acoustic Survey and Analysis Methods
(Virtual Meeting, 30 May to 3 June 2022)

WG-ASAM-2022/01	Report of the Chair of the Scientific Committee on the CCAMLR Scientific Committee Symposium Chair of the Scientific Committee
WG-ASAM-2022/02	Strata creation and area calculation – a template Secretariat
WG-ASAM-2022/03 Rev. 1	Monitoring krill in the Ross Sea MPA A. De Felice, G. Canduci, I. Biagiotti, G. Giuliani, I. Costantini and I. Leonori
WG-ASAM-2022/04	Krill biomass and flux in Subarea 48.1 near Cape Shirreff during four austral summers G. Cutter, C. Reiss and G. Watters
WG-ASAM-2022/05	Proposal to conduct a local acoustic-trawl survey of the *Champsocephalus gunnari* in the Statistical Subarea 48.2 Delegation of Ukraine
WG-ASAM-2022/06	Acoustic transects survey undertaken by a Chinese krill fishing vessel in Subarea 48.3 in June and August 2021 X. Wang, J. Zhu, Y. Ying and X. Zhao
WG-ASAM-2022/07	Proposals to standardise the collection and processing of krill acoustic survey data S. Kasatkina and A. Abramov
WG-ASAM-2022/08	Comparison analysis of krill length compositions from catches obtained by research and commercial gears S. Kasatkina and S. Sergeev
WG-ASAM-2022/09	Preliminary results from the Antarctic krill surveys around the South Shetland Islands conducted by the Chinese fishing vessels during May to June 2021 and April 2022 X. Wang, G. Fan, B. Yuan and X. Zhao
WG-ASAM-2022/10	The effect of the krill length to wetmass relationship on the scaling of acoustic data M.J. Cox and S. Wotherspoon

WG-ASAM-2022/11 Rev. 1	Repository of acoustic data collected by fishing vessels along CCAMLR nominated transects Secretariat
WG-ASAM-2022/12 Rev. 1	CCAMLR nominated acoustic transects undertaken by fishing vessels at South Georgia in 2021 S. Fielding and J. Arata
WG-ASAM-2022/13	Proposal for standardised methods for processing and reporting krill acoustic survey results G. Macaulay
WG-ASAM-2022/14	Distribution and abundance of Antarctic krill off South Orkney Islands, February 2022 S. Menze, B. Krafft and G. Macaulay
WG-ASAM-2022/15	Review of the Rules for Access and Use of CCAMLR Data Chair of the Data Services Advisory Group (DSAG)

Other Documents

WG-ASAM-2022/P01	Antarctic krill biomass and flux measured using wideband echosounders and acoustic doppler current profilers on submerged moorings G. Cutter, C. Reiss, S. Nylund and G. Watters *Front. Mar. Sci.*, 9 (2022): 784469, doi: 10.3389/fmars.2022.784469
WG-ASAM-2022/P02	Estimating the average distribution of Antarctic krill *Euphausia superba* at the northern Antarctic Peninsula during austral summer and winter V. Warwick-Evans, S. Fielding, C.S. Reiss, G.M. Watters and P.N. Trathan *Polar Biol.*, 45 (2022): 857–871

Annex 6

Report of the Working Group
on Statistics, Assessment and Modelling
(Virtual meeting, 27 June to 1 July 2022)

Contents

Report of the Working Group on Statistics, Assessments and Modelling
(Virtual meeting, 27 June to 1 July 2022)

Introduction

1.1 The meeting of the Working Group on Statistics, Assessments and Modelling (WG-SAM) was held online from 27 June to 1 July 2022, starting at 04:00 UTC. The meeting was convened by Dr T. Okuda (Japan). Dr Okuda welcomed the participants (Appendix A), noting that the Co-Convener of WG-SAM, Dr C. Péron (France), was unable to attend due to extraordinary circumstances, but will remain closely engaged with future work of WG-SAM and the reporting of the meeting to the Scientific Committee.

Opening of the meeting

Adoption of the agenda and organisation of the meeting

2.1 The meeting's provisional agenda was discussed, and the Working Group adopted the proposed agenda (Appendix B). Documents submitted to the meeting are listed in Appendix C.

2.2 The Working Group noted that its agenda followed topics assigned through the 2016 Scientific Committee workplan. Review of the current terms of reference for WG-SAM was included as a discussion topic under future work.

2.3 The Working Group report was prepared by the Secretariat and the Convener. Sections of the report dealing with advice to the Scientific Committee and other working groups are highlighted in grey and collated in 'Advice to the Scientific Committee'.

Development and progress of stock assessments

Stock assessments for krill

3.1 Dr C. Darby (UK) reported on the progress of the 'CM 51-07 revision' e-group. He noted the process that was undertaken by the working groups in 2021 to review the three elements of the revised krill management approach (acoustic biomass estimates, krill stock assessment yield estimates and risk assessment) and thanked all those involved. Although the Scientific Committee did not recommend any changes to the krill management framework in 2021, resulting in a rollover of Conservation Measure (CM) 51-07 for another 12 months, Dr Darby considered that the process was now well understood by Member scientists and Commissioners. The role of WG-SAM in reviewing the application of the krill stock assessment model and discussing input parameters was reiterated, and the outcomes of WG-ASAM-2022 in providing biomass estimates for management areas in Subarea 48.1 were highlighted (WG-ASAM-2022, Table 9).

3.2 The Working Group thanked Dr Darby for the update and his coordination of the process, noting the extensive efforts by many scientists to further develop the krill management approach, as well as the time constraints imposed by online meetings.

3.3 WG-SAM-2022/29 presented a report from a training workshop on fitting krill assessments with the generalised R yield model (Grym) held online on 13 and 14 January 2022. The paper highlighted the usefulness of such workshops as they allow potential users an opportunity to gain an understanding of the structure of assessments and the functioning of the underlying code.

3.4 The Working Group thanked Mr D. Maschette (Australia) for leading the workshop and noted the availability of the workshop code on the GitHub (github.com/Maschette/Krill_Grym_Workshop) repository for scientists to continue to develop the model, as well as recordings of the workshop for training purposes on the CCAMLR YouTube channel. The current version of the Grym model for krill assessment is available at (https://github.com/ccamlr/Grym_Base_Case /tree/Simulations).

3.5 WG-SAM-2022/10 and WG-EMM-2022/32 presented the results of an experiment conducted to estimate the length-weight relationship of krill on board a krill fishing vessel by grouping krill specimens into length classes and weighing them together, to reduce the impact of vessel movement on weight measurements.

3.6 The Working Group welcomed the study, and endorsed its future work plan by noting that determining the minimum number of individuals to be weighed in each length bin relative to the desired precision would be valuable. It, however, noted that weighing individual krill is a time-consuming task that would best be undertaken by having an additional observer or designing a specific research task, rather than tasking CCAMLR Scheme of International Scientific Observation observers with this work.

3.7 WG-SAM-2022/26 presented a summary of the status of the krill assessment fitted using the Grym following work undertaken during 2021. While recalling that the Grym model for krill stock assessment is ready for use, the paper noted that agreement on some parameter values has not yet been reached, in particular for the proportional recruitment parameters, the weight-at-length relationship and the maturity-at-length relationship. Regarding proportional recruitment, the authors identified two sets of parameter values that they deemed appropriate (recruitment scenarios (1) and (4) in Table 4 of WG-FSA-2021/39). The authors noted that scenario (1) showed the most overlap with the expected natural mortality range, used a clear and biological well defined age class (R2) as the recruitment, and estimated the recruitment with data collected by the recommended sampling net (RMT8), which can reduce net avoidance. The scenario (4) results overlapped with the expected natural mortality in acceptable level, and used data collected based on a sampling net with a similar mouth opening (6 m^2) with RMT8.

3.8 The Working Group noted that several options for the parametrisation of the stock assessment using the Grym, other than those presented in WG-SAM-2022/26, were discussed in 2021. It further noted that recruitment and mortality were linked in the model, and recalled the important improvement brought by WG-SAM-2021/09 in allowing higher variability to be modelled by the proportional recruitment model used for krill.

3.9 The Working Group discussed the relationship in the proportional recruitment model (WG-SAM-2021/09) between recruitment variability and natural mortality and noted that in the model high recruitment variability was associated with highly variable natural mortality estimates. The Working Group suggested this relationship in the model requires further investigation.

3.10 WG-EMM-2022/01 presented a review of recruitment studies collected by CCAMLR Members over the last 30 years and previously discussed at WG-Krill, WG-ASAM and WG-EMM. The authors considered that the proportional recruitment parameter values should be derived using data from long-term monitoring programs in the area in which the fishery occurs, using standard techniques, and including recently collected data if possible. The authors demonstrated that three long-term studies (the US AMLR Program, Palmer LTER and German surveys), all show that much of the recruitment variability is a result of multiple years of low recruitment, including years with no recruitment, and that recruitment is correlated with various environmental parameters. They further highlighted issues with other data sources that are currently considered potentially useful to estimate recruitment parameters for the krill stock assessment. Specifically, the authors concluded that the recruitment parameters from recruitment scenarios (1) and (4) in Table 4 of WG-FSA-2021/39 (see also paragraph 3.7) were not representative of recruitment in Subarea 48.1, and also noted the recruitment parameters for these two scenarios excluded surveys with observation of zero or low recruitment.

3.11 The Working Group agreed that the periodic nature of krill recruitment was an important characteristic that should not be ignored and would, ideally, be mechanistically incorporated in future stock assessment methodology. It noted that krill size distributions are highly variable in space and time and ensuring that a population is sampled representative is of vital importance but resource intensive. The Working Group further noted that addressing the data needs of the krill management framework would benefit from an evaluation of existing survey data (e.g. by comparing variability in survey haul data to model-based estimates of biomass from acoustic data) to ensure data used for parameter estimation was fit for purpose. This would assist in evaluating different parameter estimates proposed, as well as future survey designs to estimate recruitment and contemporary population demographics.

3.12 Dr S. Kasatkina (Russia) noted that the significant spatial and temporal variability in krill length distributions indicated that estimates of recruitment indices should be based on current krill demographics and, to a lesser extent, on data from historical long-term programs or on the reanalysis of data from existing surveys, taking into account differences in their methodology for collecting and processing data. Instead, Dr Kasatkina noted that it would be advisable to conduct additional surveys to assess the current recruitment parameters.

3.13 The Working Group noted that the estimation of krill recruitment in Subarea 48.1 would benefit from a better understanding of the different contributions of adjacent areas (e.g. Weddell Sea and Bellingshausen Sea contributions to the Antarctic Peninsula) which would be addressed through the establishment of a stock hypothesis. Such a hypothesis would provide a framework for interpreting patterns observed in survey and fishery data, and provide a crucial tool to evaluate the appropriateness of time series used to estimate proportional recruitment. The Working Group encouraged Members to communicate in the ‘CM 51-07 revision’ e-group and submit research to WG-FSA-2022 towards this end.

3.14 The Working Group recalled the request from the Scientific Committee to develop a database for biological and survey data from the krill fishery (SC-CAMLR-40, paragraph 8.4(ii)(c)) and encouraged Members to submit data to facilitate any survey evaluation process.

3.15 WG-EMM-2022/02 presented an analysis of krill proportional recruitment indices in Subarea 48.1 based on seven different data sources and using different size thresholds below which individuals are considered as recruits. The choice of size threshold was found to have a larger effect on proportional recruitment parameters than differences among datasets, and, given the importance of gear selectivity, the authors argued that length-frequency distributions should be adjusted prior to the computation of proportional recruitment parameters.

3.16 The Working Group noted that traditionally, proportional recruitment is fitted to cohorts (age classes) due to interannual variation in growth. Therefore, the choice of the size threshold used to consider krill as recruits was an important component in the estimation of proportional recruitment and a long-standing issue that needed to be considered alongside selectivity and availability.

3.17 WG-SAM-2022/27 presented an analysis of the methodological aspects of measuring the selectivity of gears in the krill fishery, focusing on the study by Krag et al. (2014) which was used to estimate the selectivity parameter values for the krill stock assessment model. Noting some methodological issues with the data collection protocols described in Krag et al. (2014), the authors highlighted that these protocols did not meet the International Council for the Exploration of the Sea (ICES) recommendations in a number of significant aspects (Wileman et al., 1996). In the authors' opinion, the published selectivity functions for gears in the krill fishery (Krag et al., 2014) should be treated with some caution. The authors highlighted the need for the development of a unified approach to estimating gear selectivity in the krill fishery, taking into account ICES recommendations on that subject, and noting the usefulness of vessels towing two gears simultaneously.

3.18 The Working Group noted that the points raised by the authors constituted useful suggestions for future work and that the selectivity function described by Krag et al. (2014) was currently the best available information.

3.19 WG-SAM-2022/28 Rev. 2 presented an alternative method of computing precautionary yield in the krill stock assessment projections. Instead of using the current implementation of the decision rules which compare the spawning stock biomass (SSB) under different fishing mortalities to pre-exploitation SSB (SSB_0), SSB in each year of fishing is compared to the same projections without fishing. As a result, non-zero yield is possible under simulations of high recruitment variability, which may not be the case when using the current decision rules.

3.20 The Working Group noted that such an implementation had similarities with that of the icefish assessment (which relies on frequent surveys) and that considering the lifespan of krill, the frequency of assessment update was also worth considering when calculating a precautionary harvest rate. It noted that progress towards a revision of the krill management approach needed to balance the short-term need for the provision of advice and the long-term testing of different management approaches though formal management strategy evaluations.

3.21 The Working Group recommended comprehensive management strategy evaluation be undertaken to assess the impacts of any changes to the decision rules as future priorities.

3.22 The Working Group agreed that the Grym and krill assessment model implementations are fit for purpose as a numerical projection tool. It noted no new parameter estimates had been provided for testing since WG-FSA-2021. It further noted that a range of opinions regarding parameter values and the implementation of the decision rules as applied to krill persisted, and that WG-EMM could help constrain the range of potential scenarios by providing expected bounds to output values from the models. An evaluation of a smaller set of parameter values could then be provided by Members to WG-FSA-2022.

Stock assessment for established toothfish fisheries

3.23 WG-SAM-2022/11 presented a laboratory-based experiment investigating the dynamics of odour release by two different types of bait (squid, fish) using a spectrophotometer. The authors noted that the two different samples of bait release odour at different rates, and recommended that bait type, size and thawing prior to use should all be standardised and integrated into the design of CCAMLR toothfish research proposals.

3.24 The Working Group thanked the authors for the study and encouraged further research on bait preference and detectability by toothfish, including an increase in sample size of the initial experiment and consideration of different bait sizes, as the experimental design had only been completed once. The Working Group noted that when data are collected for the purpose of catch-per-unit-effort (CPUE) analyses, not all operational factors can be standardised when setting longlines, and there will be a need for a post-hoc standardisation of variables. It also noted that standardisation of variables in a CPUE analysis is a different issue to standardisation of survey design.

3.25 The Working Group noted that fish are often attracted to combinations of amino acids and these attractants would diffuse below detection thresholds quickly due to currents, thereby constraining the area where bait is likely to be effective. The Working Group also noted that the type of bait deployed and soak time of longlines are recorded in the C2 data and that this information is currently used in CPUE standardisation analyses.

3.26 WG-SAM-2022/14 presented a comparison of CASAL and Casal2 model implementations using the 2021 CASAL assessments of Antarctic toothfish (*Dissostichus mawsoni*) in Subarea 88.1 and small-scale research units 882A–B (Ross Sea region) and Patagonian toothfish (*Dissostichus eleginoides*) in Subarea 48.3 (South Georgia). The comparisons show that the two software packages provided equivalent estimates of key parameters for the two case studies. Diagnostics derived from the CASAL and Casal2 models provided identical conclusions on model fits and Markov chain Monte Carlo (MCMC) outcomes, including stock status and catch limit projections. In addition, optimised performance compared to CASAL allows a faster estimation process in Casal2.

3.27 The Working Group noted that Casal2 models for other integrated toothfish assessments were in development, and further noted WG-SAM-2022/P01 which presented the Casal2 user manual for age-based models.

3.28 The Working Group noted that a length-based version of the Casal2 model is also being developed which may allow it to be used to conduct krill stock assessments. Planned developments for Casal2 include adding the ability to estimate parameters such as growth curves using age-length paired data.

3.29 The Working Group recommended that the Secretariat conduct a similar validation procedure of the Casal2 stock assessment results as has previously been agreed for CASAL models (e.g. WG-FSA-2021, paragraph 3.13).

3.30 The Working Group further noted that while Casal2 requires specifying more data and model characteristics than CASAL, it also has more advanced unit testing procedures and error messages. The Working Group also noted the complementary R package r4Casal2 (https://github.com/NIWAFisheriesModelling/r4Casal2) which can be used for visualisation, interpretation and diagnostics of Casal2 outputs.

3.31 The Working Group recommended that:

(i) Casal2 be accepted as being validated for use by CCAMLR for integrated statistical catch-at-age toothfish stock assessments

(ii) CASAL models for each area be presented alongside the equivalent Casal2 models for the next toothfish stock assessments presented to working groups to further demonstrate the equivalence of the CASAL and Casal2 software packages

(iii) the guidelines given in Appendix B of WG-SAM-2022/14 for validating Casal2 files be used for any Casal2 models presented to CCAMLR (Appendix D)

(iv) the version of Casal2 used is described in assessment reports, and models are validated using 'asserts' with backwards compatibility checks for each model implemented using Casal2

(v) Casal2 compatibility switches used for equivalence with CASAL be set to the 'casal' option for comparing between CASAL and Casal2, and to the default 'casal2' option for new models using Casal2

(vi) further research be encouraged to consider the use of parameter transformations (log, average-difference and simplex) to improve stability and MCMC performance in Casal2 models.

3.32 The Working Group noted the UK's intention to present a stock assessment for Subarea 48.3 using both CASAL and Casal2 to WG-FSA-2022, and welcomed the proposal by New Zealand to facilitate a future workshop to introduce Members to using Casal2 to conduct stock assessments.

3.33 WG-SAM-2022/15 presented a methodology to predict spatio–temporal changes in macrourid by-catch in the Antarctic toothfish fishery in the Ross Sea region using a spatio–temporal delta-generalised linear mixed models implemented in the R package vector autoregressive spatio–temporal (VAST) models. Preliminary results suggest that the methodology is useful to examine spatial patterns in key by-catch species, to monitor trends in species' catch rates when there is strong spatio–temporal variability in fishing effort, and to identify by-catch hotspots.

3.34 The Working Group welcomed this contribution, noting that this analysis was based on a subset of the available data, because by-catch hotspots were likely to be better identified by vessels that have operated over a longer period of time and in a consistent manner in the Ross Sea region. The Working Group suggested that future analyses could include data collected using other gear types, also noting that this would need to account for differences in by-catch reporting by vessels with different gear types. The Working Group noted that a 10 km × 10 km spatial prediction grid was used, but that the results would be qualitatively unchanged if a finer prediction grid was used.

3.35 The Working Group discussed the need to establish by-catch limits and management options for the two main macrourid species in the Ross Sea region. The Working Group noted that the VAST model provides spatial density estimates of by-catch species but is not designed to disentangle direct and indirect impacts of the fishery through by-catch mortality and predation release. The Working Group noted that such an approach requires the development of a multi-species model accounting for trophic interactions.

3.36 The Working Group recommended that the authors continue their efforts to understand the impacts of the Ross Sea toothfish fishery on by-catch species, and present this information for discussion at WG-FSA-2022.

3.37 WG-SAM-2022/17 presented estimates of tag loss rates for *D. eleginoides* in Subarea 48.3 tagged between 2004 and 2020. Initial single tag loss was estimated as 2.8% (95% confidence interval (CI) 2.0%–3.6%), as well as the ongoing single tag loss rate, estimated as 0.037 y^{-1} (95% CI 0.035–0.041 y^{-1}) in the best-fitting model. The estimates also showed no trend in initial tag loss or ongoing tag loss by season, suggesting that initial tag retention has remained consistent for different annual cohorts of releases. The results demonstrated a minor change between the updated tag loss parameters and those parameters currently used in the stock assessment.

3.38 The Working Group noted that the updated tag loss parameters will be used in future Subarea 48.3 stock assessment model updates.

3.39 WG-SAM-2022/21 and 2022/19 presented alternative CASAL stock assessment models of *D. eleginoides* in Subarea 48.4 and their diagnostics. Alternative models were presented for discussion (where L_∞ and k were either estimated, or fixed while otolith data was excluded), which aimed to address a lack of convergence in model fit owing to memory allocation issues caused by the increasing quantity of data.

3.40 The Working Group welcomed the update to the CASAL stock assessment for Subarea 48.4. Mr A. Dunn (New Zealand) offered to assist with further investigations into model inputs or parameter switches that may result in better estimation of parameters in the MCMC analysis.

3.41 WG-SAM-2022/24 presented a statistical comparison of age at maturity and length at age for *D. eleginoides* in Subarea 48.3 between 2011 and 2020 under alternative approaches for selecting otoliths from observer-collected samples. For the period considered, revising the otolith selection regime from random to stratified random to provide coverage on the full length-class distribution of the catch had no influence on the estimation of maturity. However, the revised otolith sampling procedure led to substantial changes in the estimated growth parameters for the time period 2011–2015.

3.42 The Working Group noted that the study presented age and length data for separate sexes and welcomed the future addition of separate sex modelling as well as updated biological parameters into the Subarea 48.3 stock assessment. The Working Group recommended investigating the effects of fishing selectivity and stratified length sampling on the estimation of growth parameters (see e.g. 2018 Summary Report of the CCAMLR Independent Stock Assessment Review for Toothfish – SC-CAMLR-XXXVII/02 Rev. 1).

3.43 The Working Group noted that the time of year during which sampling occurred may affect the macroscopic staging used to estimate maturity. The Working Group further noted that the revised maturity-at-age function predicted that some young fish in the age range of 1–7 are mature. This appears to be inconsistent with the expectation of the life-history characteristics of a long-lived deep-water species. The Working Group recommended that an adjusted function, assuming that all fish up to the age of 5 years are immature (similar to that presented in WG-FSA-2021/21) may be more appropriate for the assessment.

3.44 The Working Group encouraged the presentation of further work at WG-FSA-2022, on resampling and reading of historic otolith samples for length and age classes that are currently under-represented to allow the comparison of parameter estimates across a longer time series. The Working Group further noted that the availability of an extensive database of age readings would allow determining minimum sample size requirements by comparing biological parameter estimates between the entire database and sub-samples of the database.

3.45 WG-SAM-2022/20 and 2022/22 presented stepwise updates to a CASAL stock assessment of *D. eleginoides* in Subarea 48.3 and the diagnostics for its fully updated version (step 5). Updates were applied to recruitment assumptions, growth parameters, age compositions, weightings and survey uncertainty estimation.

3.46 The Working Group welcomed the large amount of work that had been devoted to the additional analysis in the Subarea 48.3 stock assessment model and noted the utility of regularly reviewing underlying assumptions and parameters. The Working Group further noted that the updates that had been applied were requested by WG-FSA-2019 (WG-FSA-2019, paragraph 3.61) and WG-FSA-2021 (WG-FSA-2021, paragraph 3.27). The Working Group noted that additional recommendations from the CCAMLR Independent Stock Assessment Review for Toothfish (SC-CAMLR-XXXVII/02 Rev. 1) were also addressed through the analyses developed to support the Subarea 48.3 stock assessment model.

3.47 The Working Group noted that the stock assessment process undertaken was the best available approach for the Subarea 48.3 toothfish stock assessment.

3.48 The Working Group noted that the graphical summaries of stock performance presented in WG-SAM-2022/18 demonstrated that the current fishing selection pattern and harvest rate in Subarea 48.3 is precautionary in achieving the CCAMLR objective of a long-term average of 50% of B_0. In addition, in relation to the Scientific Committee's objective to examine the utility of target and limit exploitation rate objectives within the CCAMLR decision rules, the Working Group noted that the graphical analysis showed that the Subarea 48.3 toothfish stock is exploited at a fishing mortality that is currently at around half of F_{MSY}. It is therefore well below the thresholds that regional fishery management organisations would consider appropriate limits or targets.

Stock assessment for data-limited toothfish fisheries

3.49 WG-SAM-2022/08 presented a provisional trend analysis for research blocks in data-limited toothfish fisheries and requested feedback from WG-SAM.

3.50 The Working Group thanked the Secretariat for the analysis, considered the requested feedback, and recommended that:

(i) time-at-liberty constraints remain unchanged

(ii) fishable area calculations be made within the 600–1 800 m depth range and that a comparison of estimates be provided to WG-FSA-2022 with fishable areas computed using other depth ranges if the proponents provide a scientific basis for an alternative range

(iii) the decision tree diagram include a new step for those research blocks where fishing restarted after a five year period without fishing. In such cases, after one year of effort-limited fishing, the next catch limit would be computed as 4% of the latest CPUE-by-seabed area biomass estimate. Once two years of data would be available, the trend analysis would be applied in subsequent years

(iv) all papers cited in the report be included in the reference list at the end of the document

(v) the trend analysis code be made available on the CCAMLR GitHub page

(vi) while retaining the map of all research blocks, investigate different display options to distinguish those research blocks that do not require catch advice in a given year from those that do.

3.51 The Working Group recalled that the trend analysis was intended to be a stepping stone towards the development of both a stock hypothesis and a stock assessment in data-limited areas. It is intended to provide precautionary catch advice in the absence of a stock assessment. The Working Group noted that customisation of the presentation and summary of trend analyses within individual research blocks was possible but needed to be driven and justified by proponents, with support from the Secretariat. It further noted that assessing the trend analysis (as well as other data-limited statistical approaches) within a management strategy evaluation using simulation models would be beneficial, and that a draft plan built in collaboration between Members and with the support of the Secretariat, should be submitted to WG-FSA-2022.

3.52 WG-SAM-2022/16 presented a survey design tool (R Shiny interface) to create simulated survey outputs by resampling historic catch, effort and observer data, and test survey designs in areas where longline fishing has previously occurred.

3.53 The Working Group welcomed this initiative and noted its usefulness as a testing tool to assess models and in developing statistically robust methods. It noted that additional visualisations of summary statistics and graphics would be helpful in such assessments. The Working Group also noted the value of such a tool to analyse the impact of CPUE gear standardisation approaches on abundance estimates. It recommended the development of a power analysis functionality within the tool to assist users in their survey designs.

3.54 WG-SAM-2022/23 presented an analysis comparing estimates of *D. eleginoides* fishing mortality in Subarea 48.3 between three approaches to estimating fishing mortality in recent years: the integrated CASAL assessment, the percentage tag return rate, and a simple per-cohort catch-curve analysis of tagging data. The similarity of exploitation rate estimates (4%) across the three methods provides support from independent methods that the current assessment and management of the Subarea 48.3 toothfish stock is consistent with the CCAMLR management objectives.

3.55 The Working Group noted the value in using different numerical approaches to corroborate stock assessment outputs. It further supported the idea of using simple methods and graphical approaches to communicate fishery performance to Commissioners and encouraged all Members to consider such an approach in parallel to the communication of stock assessment outputs.

Management strategy evaluations: consideration of alternative toothfish harvest control rules, including F based rules for stocks with integrated assessments

4.1 WG-SAM-2022/18 presented an assessment of the utility of surface plots in the evaluation of the CCAMLR decision rules and their future development, and to aid in interpretation and discussion of modelling outcomes. Graphical approaches showing various alternative management and fisheries metrics (e.g. the use of exploitation rates as well as historic biomass) were illustrated using the Subarea 48.3 toothfish fishery as an example. The approaches offer simple and effective reporting tools to communicate a range of fisheries management strategies and performance metric summaries to managers.

4.2 The Working Group welcomed this contribution and agreed that the inclusion of graphics describing fisheries performance relative to specified targets would be a useful addition to stock assessment documents. The Working Group noted that some additional intersessional work will be needed to adapt some of the graphical summaries such as yield per recruit plots or Kobe plots to incorporate exploitation rates in decision rules, as the current approach simulates constant catch rather than a constant fishing mortality.

Review of new research proposals

Ross Sea region under CM 24-01

5.1 WG-SAM-2022/13 presented a review of the Ross Sea shelf surveys, which were first undertaken in 2012 for monitoring the recruitment of juvenile *D. mawsoni*. The surveys were expanded in 2016 to monitor trends and biological characteristics in Terra Nova Bay and McMurdo Sound and to collect data that would contribute to the research and monitoring plan (RMP) for the Ross Sea region marine protected area (RSRMPA).

5.2 The Working Group congratulated New Zealand and collaborating Members on the successful outcomes of the research, noting the extensive list of publications, breadth of scientific information, and data generated which is used for stock assessment and fisheries management in the region.

5.3 WG-SAM-2022/01 Rev. 1 presented a proposal to continue the Ross Sea shelf survey for an additional three years from 2022/23 to 2024/25 under CM 24-01. The main objectives of the plan are the continuation of the existing annual time series of research surveys, to monitor trends in abundance and biological characteristics of the larger (sub-adult and adult) toothfish in McMurdo Sound and Terra Nova Bay, and to collect and analyse a wide range of data and samples to contribute to the RMP for the RSRMPA.

5.4 The Working Group noted that the proposal was using the same methods and design as in previous surveys, had used standardised gear and methods in the design, was an important time series for informing the Ross Sea region stock assessment by delivering a long-term time series of recruitment, and provided the ability to track cohorts as they move from the shelf to the slope and then to the seamounts.

5.5 The Working Group noted that while the acoustic component was valuable to the RMP of the RSRMPA, it would benefit from further documentation on the acoustic instruments used and the aim of the acoustic component of the survey and suggested presenting the acoustic monitoring plan at WG-ASAM-2023.

5.6 The Working Group supported the proposed method to determine the catch limit using catches of previous surveys, with the 95th percentile used for the core strata and the 90th percentile for McMurdo Sound and Terra Nova Bay. The Working Group recommended that additional power analyses in the Terra Nova Bay and McMurdo Sound strata would be beneficial to assess the appropriate frequency for sampling these strata to achieve the survey objectives and requested the proponents to submit such analyses to WG-FSA-2022. The Working Group further noted that this survey constituted a notable example of fishing vessels being successfully used as scientific research platforms.

5.7 The Working Group evaluated the proposal and the self-assessment provided in Appendix 1 of WG-SAM-2022/01 Rev. 1 and recommended that the Ross Sea shelf survey continue for another three years.

Divisions 58.4.1 and 58.4.2 under CM 21-02

5.8 WG-SAM-2022/07 presented a multi-Member report on the exploratory fishing activities for *D. mawsoni* undertaken in Divisions 58.4.1 and 58.4.2 between fishing seasons 2011/12 and 2021/22.

5.9 WG-SAM-2022/09 presented a review of the *D. mawsoni* stock hypothesis in East Antarctica and the spatial design of research in Divisions 58.4.1 and 58.4.2. Based on habitat modelling, genetics, fish movement, and egg and larvae transport modelling, the paper concluded that *D. mawsoni* in Divisions 58.4.1 and 58.4.2 should be considered as a single stock. The paper also provided a qualitative assessment of research blocks in these two divisions and concluded that the spatial design of the proposed research plan in WG-SAM-2022/04 was likely to: (i) achieve the stated research objectives, (ii) support a viable fishery, and (iii) provide data to further support the development of the stock hypothesis. The assessment found that many of the research blocks in both divisions scored consistently well in suitability against the factors examined. However, most research blocks in Division 58.4.1 scored overall lower on criteria which depended on fishery data compared to the previous analysis in WG-SAM-18/17 since there has not been any fishing allowed in this division since the 2018 season.

5.10 The Working Group noted that despite directed fishing having not been allowed in Division 58.4.1 since the 2018 season, considerable desktop research has been undertaken by all Members involved, and has provided valuable information on the stock structure and life history of *D. mawsoni* in this region.

5.11 The Working Group supported the proposal to consider *D. mawsoni* in Divisions 58.4.1 and 58.4.2 as a single stock, based on data available, and considered the spatial design of the research to be appropriate.

5.12 WG-SAM-2022/04 presented a multi-Member proposal for exploratory fishing under a new research plan for 2022/23 to 2025/26 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 in accordance with CM 21-02, paragraph 6(iii). The four-year plan was based on the low-risk profile of this fishery and to allow more time for the review of stock assessments by working groups in 'non-assessment' years.

5.13 The Working Group noted that many previous recommendations regarding the design of this research plan had been incorporated. Most participants agreed that the proposed research plan presented was of high quality, and that research in this area greatly contributed to the objectives of the Commission.

5.14 Dr Kasatkina considered that the multi-Member research plan in the exploratory fishery for *D. mawsoni* in Divisions 58.4.1 and 58.4.2 required standardised sampling gear types to meet its objectives and did not support the proposal.

5.15 Most participants noted that gear standardisation was not required in the research proposal for this exploratory fishery for which one of the main objectives is to develop a tag-based stock assessment. Such an assessment relies mainly on data of tag-releases and the ratio of tagged to untagged fish in the catch which are independent of the gear types used. Several participants further noted that gear standardisation was not required in any other CCAMLR fishery or multi-vessel research activities that collect data for assessment purposes.

5.16 The Working Group noted that CPUE by seabed area calculations are not an objective of this proposal. Most participants therefore considered that standardisation of gear types is not needed for the success of this proposal in meeting its objectives.

5.17 The Working Group noted that different longline gear configurations and bait may influence some aspects of the catch and recalled extensive discussions on this subjects in previous meetings, including WG-SAM-2019, paragraphs 6.1 to 6.7 and 6.54 to 6.72, WG-FSA-2019, paragraphs 4.89 to 4.114, SC-CAMLR-38, paragraphs 3.102 to 3.123, SC-CAMLR-39, paragraphs 4.10 to 4.13, WG-SAM-2021, paragraphs 8.8 to 8.14, WG-FSA-2021, paragraphs 4.17 to 4.28 and SC-CAMLR-40, paragraphs 3.100 to 3.104.

5.18 Dr Kasatkina considered that the fishery in Division 58.4.1 should be classified as a 'new' fishery rather than an exploratory fishery operating under CM 21-02.

5.19 The Working Group noted that CM 41-11 identifies the toothfish fishery in Division 58.4.1 as an exploratory fishery, this topic has previously been discussed (SC-CAMLR-40, paragraph 3.103 and CCAMLR-40, paragraph 6.44) and that this was a matter for the Commission.

5.20 The Working Group was unable to provide consensus advice on the design of the WG-SAM-2022/04 research plan.

Review of ongoing research plan results and proposals

Research results and proposals from Area 48

6.1 WG-SAM-2022/02 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 second year of an ongoing three-year plan, with no significant changes proposed. An overview of the key objectives and methods involved were provided, with preliminary results reported.

6.2 WG-SAM-2022/02 was not discussed as it was in year two of a three-year plan and was therefore not required to be reviewed by WG-SAM (CCAMLR-38, paragraph 5.64).

6.3 WG-SAM-2022/03 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. Further, warmer southward winds in early 2022 may have contributed to fast ice melting, influencing offshore oceanographic conditions, followed by weaker winds in June stimulating less spatial mixing. These results suggest an increased temperature of surface water near the continent.

6.4 The Working Group thanked the authors for this paper, and suggested conducting further analysis, potentially through the integration of a statistical model used to predict SICs as described within a paper to be presented at WG-EMM (WG-EMM-2022/P13).

6.5 WG-SAM-2022/06 presented a proposal to conduct a local acoustic trawl survey of mackerel icefish (*Champsocephalus gunnari*) in Subarea 48.2 within the shelf and slope regions of the South Orkney Islands. Objectives of the research include estimating the pelagic biomass in the survey area, improving information on biological parameters, and furthering understanding of the spatial and bathymetric distribution of by-catch species.

6.6 The Working Group recommended the proponents address the following for submission to WG-FSA-2022:

(i) incorporate biomass and biological results as well as acoustic data from the 2018 Chilean trawl survey (WG-SAM-18/25, WG-FSA-18/05) to estimate and evaluate the expected coefficient of variation (sampling variability) of survey estimates to improve survey design given the proposed transects

(ii) clarify how many years of fishing is planned, noting three years of research milestones scheduled in the proposal

(iii) rotate acoustic transects connecting the gridded trawl stations to progress the survey in an on–off shelf pattern (perpendicular to bathymetry contours)

(iv) include maps of planned transects

(v) add a strata boundary around the survey transects (typically half a transect spacing) to indicate coverage

(vi) consider if there may be benefits to using a smaller trawl net, and describe how the trawls will be conducted (i.e. targeting acoustic aggregations or using oblique tows)

(vii) clarify number of trawls, noting that target trawls will be required for acoustic marks and random/gridded trawls for random length-density distribution

(viii) clarify trawl implementation for gridded trawls, oblique tows or set depths, and provide justification for the 30-minute time duration

(ix) consider impacts of time of day of trawling on survey design

(x) describe how video observations could be used to estimate catchability, with the methodology further reviewed by WG-FSA

(xi) clarify ways to distinguish acoustic signals from krill and icefish (see paragraph 6.8)

(xii) remove icefish ageing milestones from the table within the paper

(xiii) evaluate the appropriate working group that milestones might be delivered to, noting for example, that acoustic biomass estimates are best suited to WG-ASAM.

6.7 WG-SAM-2022/12 presented a potential survey design to estimate the biomass of *C. gunnari* in Subarea 48.3 through combined midwater acoustic surveys and bottom trawl surveys. The suggested methods would be intended to provide further information on the ecology and population dynamics of *C. gunnari* in Subarea 48.3.

6.8 The Working Group thanked the authors for their work and noted that conducting acoustic surveys for icefish still had many challenges, including difficulty in distinguishing icefish and krill using solely the dB difference technique (Fallon et al., 2016), and the lack of a validated target strength model to convert acoustic data to biomass (see also WG-ASAM-2022, paragraph 3.3). The Working Group also noted the merit of such surveys regarding the pelagic component of the icefish, including its ecological interaction with krill. The Working Group suggested that this should be further considered by WG-ASAM.

6.9 The Working Group further considered that the survey design, as suggested, would provide information on the pelagic component of the stock (mostly the first two age groups of fish) but would not provide information on natural mortality of icefish in the pelagic population. Additional research such as the survey methods outlined in WG-SAM-2022/12, especially icefish diet analysis, would enhance understanding of the ecology of the pelagic component of the population.

6.10 Dr Darby noted that during the current UK survey series acoustic information data have been collected during several surveys, as analysed by Fallon et al., 2016, analysis of which could be made available at WG-ASAM. The current survey could potentially be adapted to collect acoustic information on a regular basis. Ecological sampling has been reported in all survey reports submitted to WG-FSA.

6.11 The Working Group noted that the current survey methodology for icefish was appropriate for the provision of highly precautionary catch limit management advice. Should acoustic methods prove successful in the future, inclusion of the pelagic component would increase catch limits.

Research results and proposals from Area 88

Subarea 88.3

6.12 WG-SAM-2022/25 presented a progress report on research conducted in 2022 under CM 24-01 on *D. mawsoni* in Subarea 88.3 by the Republic of Korea and Ukraine. The report indicated that CPUE was higher in research blocks 883_3 and 883_4 than in research blocks 883_6 and 883_7. A vessel calibration study in research block 883_4 indicated differences in CPUE between the two survey vessels. Large *D. mawsoni* individuals were found in research blocks 883_3 and 883_4, while juveniles were observed in research blocks 883_6 and 883_7. Otoliths, stomach contents, gonad, fin and muscle samples were collected. The main by-catch species and main prey of toothfish were macrourids, 95.5% of which were identified as *Macrourus caml*.

6.13 The Working Group noted WG-SAM-2022/05, presenting a proposal by Korea and Ukraine for the continuation of a research plan from 2021/22 to 2023/24, for *Dissostichus* spp. under CM 24-01, paragraph 3, in Subarea 88.3. This is the second year of an ongoing three-year plan, with no significant changes proposed. Following the research proposal review process (CCAMLR-38, paragraph 5.64), the Working Group did not review this paper. This research proposal will be reviewed at WG-FSA-2022.

6.14 The Working Group welcomed this research plan and congratulated the authors on successfully addressing a number of the recommendations from WG-FSA-2021.

6.15 The Working Group encouraged the proponents to:

(i) conduct work towards addressing the by-catch analysis milestones of the research proposal (as requested by WG-FSA-2021, paragraph 4.44)

(ii) include latitudes and longitudes in maps in the proposal

(iii) evaluate the purpose and value of research blocks 883_9 and 883_10.

Future work and comments on draft strategic plan (2023–2027)

7.1 On behalf of the Chair of the Scientific Committee, Dr S. Parker (Secretariat) presented the report of the CCAMLR Scientific Committee Symposium that met virtually on 8 and 10 February 2022 (WG-ASAM-2022/01). The informal Scientific Committee meeting discussed the progress and outcomes from the first CCAMLR Scientific Committee's workplan (SC-CAMLR-XXXVI/BG/40) and provided an opportunity for participants to propose long-term priorities and strategies to inform the development of the next five-year strategic plan

(2023–2027). Recommendations and plans will be reviewed and refined during the intersessional period by all working groups and agreed at SC-CAMLR-41 according to the Scientific Committee's Rules of Procedure.

7.2 The Working Group welcomed and endorsed such an approach that will enable the working groups and the Scientific Committee to identify and focus their efforts on the priorities. The Working Group undertook to review the priority research topics presented in Table 2 of the document and preliminary discussions and recommendations for work sequencing took place, however, due to the time constraints of the meeting, a comprehensive review was not possible.

7.3 The WG-SAM Convener provided a template to organise the WG-SAM topic areas according to the year in which the topic would be progressed. The Working Group thanked Dr Okuda for preparing this tool and endeavoured to review and update the work program by correspondence in the 'Scientific Committee Symposium 2022' e-group.

7.4 The Working Group noted that whilst some tasks in the Scientific Committee's workplan had multiple working groups assigned, some of these (for example acoustic biomass estimates) fell outside the terms of reference and expertise of WG-SAM and could be removed to allow more focus on pressing tasks of the Working Group.

7.5 Due to the recurrence of discussions regarding gear standardisation in research fishing and fishing operations, the Working Group noted that formal analyses regarding the effect of bait and fishing gear on catchability could be included in the work plan.

7.6 The Working Group discussed its terms of reference and initiated some editorial changes but could not complete this task due to time constraints. The Working Group undertook to continue progressing these tasks through the 'Scientific Committee Symposium 2022' e-group, with results to be presented at SC-CAMLR-41 by the WG-SAM Co-conveners.

Other business

Data access rules (Data Services Advisory Group)

8.1 WG-ASAM-2022/15 presented the implementation of the Rules for Access and Use of CCAMLR Data (hereafter referred to as "the Rules") in the CCAMLR data request procedure, and the procedure for publication of derived materials in the public domain.

8.2 The Working Group reflected on the procedure to request permission to publish the data from the data owners and noted that the Rules could be interpreted to require that data requesters consult directly with data owners during their analyses of the data and prior to deciding to create a paper to be published in the public domain.

8.3 The Working Group recommended that:

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

(ii) The Secretariat reduces the length of the data request procedure to two weeks after the abovementioned alternate representatives have been identified.

(iii) The Secretariat investigates assigning digital object identifiers (DOIs) to its data holdings and to data extracts to facilitate data citation in papers submitted to peer-reviewed journals.

(iv) The Data Services Advisory Group (DSAG) considers whether the Rules can discriminate between different categories of data such as fishery data and research data. Additional specifications could apply to research data for which the originator indicates that they are still being analysed with the intent to publish.

(v) The Rules be modified to specify that the following statement needs to be included in the acknowledgement section of papers using CCAMLR data published in the public domain:

> 'This work makes use of data under the competence of the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR). The authors acknowledge that they received permission to publish this work from the CCAMLR data owners.'

(vi) Paragraph 7 of the Rules be modified to allow the Secretariats of other organisations such as the Southern Indian Ocean Fisheries Agreement (SIOFA), the South Pacific Regional Fisheries Management Organisation (SPRFMO) and the South East Atlantic Fisheries Organisation (SEAFO) to initiate requests for CCAMLR data on behalf of their members.

(vii) A footnote be added to the Rules in order rectify the contradiction between the Rules and CM 10-04, paragraphs 17 and 23.

Advice to the Scientific Committee

9.1 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) toothfish stock assessments using Casal2 (paragraph 3.31)
(ii) characteristics of the Ross Sea shelf survey (paragraphs 5.6 and 5.7)
(iii) data access requests and rules (paragraph 8.3).

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 Okuda thanked all participants for their hard work and collaboration that had contributed greatly to the successful outcomes of WG-SAM this year, also acknowledging the work of Dr Péron. Dr Okuda also thanked the Secretariat, Interprefy staff and the stenographers for their support, noting the length of the meeting had been shorter than an in-person event, a large body of work had been accomplished and a considerable future workplan developed for WG-SAM.

10.3 On behalf of the Working Group, Dr Darby and Dr X. Wang (China) thanked Dr Okuda for his guidance during the meeting, with additional mention to Dr Péron for her support outside of the meeting. Dr Wang made special mention to the success of the meeting, noting in particular the value of acoustic advice discussed. The Working Group thanked the Secretariat for its work compiling the report, the technical support provided by the Interprefy team, and the provision of official advice to the Scientific Committee.

References

Fallon, N.G., S. Fielding and P.G. Fernandes. 2016. Classification of Southern Ocean krill and icefish echoes using random forests. *ICES J. Mar. Sci.*, 73 (8): 1998–2008.

Krag, L.A., B. Herrmann, S.A. Iversen, A. Engås, S. Nordrum and B.A. Krafft. 2014. Size selection of Antarctic krill (*Euphausia superba*) in Trawls. *PLoS One*, 9, e102168, doi: https://doi.org/10.1371/journal.pone.0102168

Wileman, D.A., R.S.T. Ferro, R. Fonteyne and R.B. Millar (Eds). 1996. Manual of methods of measuring the selectivity of towed fishing gears. *ICES Cooperative Research Report*, N215.

Appendix A

List of Registered Participants

Working Group on Statistics, Assessments and Modelling
(Virtual Meeting, 27 June to 1 July 2022)

Co-conveners	Dr Clara Péron (did not attend the meeting) Muséum national d'Histoire naturelle
	Dr Takehiro Okuda National Research Institute of Far Seas Fisheries
Australia	Dr Jaimie Cleeland Institute for Marine and Antarctic Studies (IMAS), University of Tasmania
	Dr So Kawaguchi Australian Antarctic Division, Department of Agriculture, Water and the Environment
	Mr Dale Maschette Institute for Marine and Antarctic Studies (IMAS), University of Tasmania
	Dr Cara Miller Australian Antarctic Division, Department of Agriculture, Water and the Environment
	Dr Philippe Ziegler Australian Antarctic Division, Department of Agriculture, Water and the Environment
Chile	Dr Lucas Krüger Instituto Antártico Chileno (INACH)
	Mr Mauricio Mardones Instituto de Fomento Pesquero
	Dr Lorena Rebolledo Instituto Antártico Chileno (INACH)
	Mr Francisco Santa Cruz Instituto Antartico Chileno (INACH)
China, People's Republic of	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 Qing Chang XU Yellow Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences
	Dr Yi-Ping Ying Yellow Sea Fisheries Research Institute
	Mr Jichang Zhang Yellow Sea Fisheries Research Institute
	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	Dr Marc Eléaume Muséum national d'Histoire naturelle
	Dr Félix Massiot-Granier Muséum national d'Histoire naturelle
Germany	Professor Thomas Brey Alfred Wegener Institute for Polar and Marine Research
	Dr Jilda Caccavo Institute Pierre-Simon Laplace
	Dr Ryan Driscoll Alfred Wegener Innstitute
Japan	Dr Taro Ichii Fisheries Resources Institute, Japan Fisheries Research and Education Agency
Korea, Republic of	Mr Gap-Joo Bae Hong Jin Corporation

Mr Hyun Joong Choi
TNS Industries Inc.

Mr Sang-jin Choi
Korea Overseas Fisheries Association

Dr Sangdeok Chung
National Institute of Fisheries Science (NIFS)

Mr Kunwoong Ji
Jeong Il Corporation

Mr Yoonhyung Kim
Dongwon Industries

Dr Haewon Lee
National Institute of Fisheries Science

Mr Sang Gyu Shin
National Institute of Fisheries Science (NIFS)

New Zealand	Mr Adam Berry Ministry for Primary Industries
	Dr Jennifer Devine National Institute of Water and Atmospheric Research Ltd. (NIWA)
	Mr Alistair Dunn Ocean Environmental
	Mr Jack Fenaughty Silvifish Resources Ltd
	Dr Arnaud Grüss National Institute of Water and Atmospheric Research Limited
	Dr Bradley Moore National Institute of Water and Atmospheric Research Limited
	Mr Nathan Walker Ministry for Primary Industries
Norway	Mr Elling Deehr Johannessen Norwegian Polar Institute

	Dr Rodrigo Wiff Pontifical Catholic University of Chile
Russian Federation	Dr Svetlana Kasatkina AtlantNIRO
	Mr Oleg Krasnoborodko FGUE AtlantNIRO
	Mr Aleksandr Sytov FSUE VNIRO
South Africa	Mr Sobahle Somhlaba Department of Agriculture, Forestry and Fisheries
Spain	Dr Takaya Namba Pesquerias Georgia, S.L
	Mr Roberto Sarralde Vizuete Instituto Español de Oceanografía
Ukraine	Dr Kostiantyn Demianenko Institute of Fisheries and Marine Ecology (IFME) of the State Agency of Melioration and Fisheries of Ukraine
	Dr Leonid Pshenichnov Institute of Fisheries and Marine Ecology (IFME) of the State Agency of Fisheries of Ukraine
	Mr Illia Slypko Institute of Fisheries and Marine Ecology (IFME) of the State Agency of Fisheries of Ukraine
	Mr Pavlo Zabroda Institute of Fisheries and Marine Ecology (IFME) of the State Agency of Fisheries of Ukraine
United Kingdom	Dr Martin Collins British Antarctic Survey
	Dr Chris Darby Centre for Environment, Fisheries and Aquaculture Science (Cefas)
	Dr Timothy Earl Centre for Environment, Fisheries and Aquaculture Science (Cefas)

	Dr Sophie Fielding British Antarctic Survey
	Dr Phil Hollyman British Antarctic Survey
	Dr Matthew Kerr Centre for Environment, Fisheries and Aquaculture Science (CEFAS)
	Dr Jessica Marsh Centre for Environment, Fisheries and Aquaculture Science (Cefas)
	Ms Lisa Readdy Centre for Environment, Fisheries and Aquaculture Sciences (Cefas)
United States of America	Dr Christopher Jones National Oceanographic and Atmospheric Administration (NOAA)
	Dr Doug Kinzey National Oceanographic and Atmospheric Administration (NOAA)
	Dr Christian Reiss National Marine Fisheries Service, Southwest Fisheries Science Center
	Dr George Watters National Marine Fisheries Service, Southwest Fisheries Science Center
Uruguay	Dr Yamandú Marín DINARA
	Professor Oscar Pin Direccion Nacional de Recursos Acuaticos (DINARA)

CCAMLR Secretariat	Belinda Blackburn Publications Officer Daphnis De Pooter Science Data Officer Gary Dewhurst Data and Information Systems Manager Doro Forck Communications Manager Isaac Forster Fisheries and Observer Reporting Coordinator Mitchell John Technical Business Analyst Angie McMahon Human Resources Officer Ian Meredith Systems Analyst Dr Steve Parker Science Manager Alison Potter Data Administration Officer Dr Stephane Thanassekos Fisheries and Ecosystems Analyst Thomas Williams Database Administrator/Technical Analyst Claire van Werven Research, Monitoring and Compliance Analyst

Appendix B

Agenda

Working Group on Statistics, Assessments and Modelling
(Virtual meeting, 27 June to 1 July 2022)

1. Introduction

2. Opening of the meeting

   2.1 Adoption of the agenda and organisation of the meeting

3. Development and progress of stock assessments

   3.1 Stock assessments for krill
   3.2 Stock assessment for established toothfish fisheries
   3.3 Stock assessment for data-limited toothfish fisheries

4. Management strategy evaluations: consideration of alternative toothfish harvest control rules, including F-based rules for stocks with integrated assessments

5. Review of new research proposals

6. Review of ongoing research plan results and proposals

   6.1 Research results and proposals from Area 48
   6.2 Research results and proposals from Subarea 58.4
   6.3 Research results and proposals from Area 88

7. Future work and comments on draft strategic plan (2023–2027)

8. Other business

9. Advice to the Scientific Committee

10. Adoption of report and close of meeting.

Appendix C

List of Documents

Working Group on Statistics, Assessments and Modelling
(Virtual Meeting, 27 June to 1 July 2022)

WG-SAM-2022/01	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 21-02, paragraph 6(iii) Delegation of New Zealand
WG-SAM-2022/02	Continuation of the research proposal on Antarctic toothfish (*Dissostichus mawsoni*) in Statistical Subarea 48.6 in 2022/23 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-2022/03	2022 updated analysis of the sea ice concentration in research blocks 4 and 5 of Subarea 48.6 with sea surface temperature and winds T. Namba, R. Sarralde, T. Ichii, T. Okuda, S. Somhlaba and J. Pompert
WG-SAM-2022/04	New research plan for 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 CM 21-02, paragraph 6(iii) Delegations of Australia, France, Japan, Republic of Korea and Spain
WG-SAM-2022/05	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 Korea and Ukraine
WG-SAM-2022/06 Rev. 1	Proposal to conduct a local acoustic-trawl survey of *Champsocephalus gunnari* in Statistical Subarea 48.2 Delegation of Ukraine
WG-SAM-2022/07	Report on exploratory fishing in Divisions 58.4.1 and 58.4.2 between fishing seasons 2011/12 and 2021/22 G. Phillips and P. Ziegler
WG-SAM-2022/08	2022 provisional trend analysis – preliminary estimates of toothfish biomass in research blocks Secretariat

WG-SAM-2022/09	Review of the Antarctic toothfish stock hypothesis in East Antarctica and the spatial design of research in Divisions 58.4.1 and 58.4.2 J. Cleeland, P. Ziegler, C. Miller, G. Phillips, P. Yates, T. Okuda, C. Péron, S. Chung and R. Sarralde
WG-SAM-2022/10	A pilot study on the length-weight relationship of fresh Antarctic krill with weight-at-length based on multiple individuals G. Fan, Y. Ying, J. Zhu and X. Zhao
WG-SAM-2022/11	A study of odour parameters for different bait types used in the toothfish fishing in CCAMLR area O.Y. Krasnoborodko
WG-SAM-2022/12	Proposal for complex acoustic and trawl surveys for the mackerel icefish (*Champsocephalus gunnari*) estimates in the CCAMLR Statistical Subarea 48.3 S. Kasatkina
WG-SAM-2022/13	A review of the Ross Sea shelf survey J. Devine
WG-SAM-2022/14	Integrated toothfish stock assessments using Casal2 A. Dunn, A. Grüss, J.A. Devine; C. Miller, P. Ziegler, D. Maschette, T. Earl, C. Darby and F. Massiot-Granier
WG-SAM-2022/15	Using VAST (vector autoregressive spatio–temporal) models to predict spatio–temporal changes in macrourid by-catch in the Ross Sea region Antarctic toothfish (*Dissostichus mawsoni*) fishery: Methods and preliminary results A. Grüss, B.R. Moore, M.H. Pinkerton and J.A. Devine
WG-SAM-2022/16	A tool for creating simulated survey outputs from longline data M. Kerr and T. Earl
WG-SAM-2022/17	Estimates of tag loss rates for Patagonian toothfish (*Dissostichus eleginoides*) in Subarea 48.3 tagged between 2004 to 2020 J. Marsh, T. Earl and C. Darby
WG-SAM-2022/18	The utility of surface plots in the development of the CCAMLR Decision Rule, its interpretation, and the rationalisation of current management and fishery metrics C. Darby and T. Earl

WG-SAM-2022/19	Stock assessment of Patagonian toothfish (*Dissostichus eleginoides*) in Subarea 48.4: assessment diagnostics L. Readdy, T. Earl and C. Darby
WG-SAM-2022/20	Stock assessment of Patagonian toothfish (*Dissostichus eleginoides*) in Subarea 48.3 – proposed model updates L. Readdy and T. Earl
WG-SAM-2022/21	Stock assessment of Patagonian toothfish (*Dissostichus eleginoides*) in Subarea 48.4 – addressing the convergence issues encountered in the 2021 assessment L. Readdy, T. Earl and C. Darby
WG-SAM-2022/22	Stock assessment of Patagonian toothfish (*Dissostichus eleginoides*) in Subarea 48.3: assessment diagnostics L. Readdy and T. Earl
WG-SAM-2022/23	A comparison of fishing mortality estimates derived using data-rich and data-limited approaches C. Darby and T. Earl
WG-SAM-2022/24	A comparison of estimates of Patagonian toothfish (*Dissostichus eleginoides*) maturity and growth in Subarea 48.3 using different otolith selection procedures J. Marsh, T. Earl, P. Hollyman and C. Darby
WG-SAM-2022/25	Progress report on the joint research for *Dissostichus* spp. in Subarea 88.3 by the Republic of Korea and Ukraine in 2022 Delegations of the Republic of Korea and Ukraine
WG-SAM-2022/26	The status of Grym simulations developed in 2021 Y. Ying, X. Wang, X. Zhao and Q. Xu
WG-SAM-2022/27	Methodical aspects of measuring the selectivity of gears in krill fishery S. Sergeev and S. Kasatkina
WG-SAM-2022/28 Rev. 2	An alternative method of calculating precautionary yield D. Kinzey and G.M. Watters
WG-SAM-2022/29	Report from a training workshop on Grym krill assessments D. Maschette and S. Wotherspoon

Other documents

WG-SAM-2022/P01	Casal2 User Manual for Age-Based Models Casal2 Development Team *NIWA Technical Report*, 139 (2022): ISSN 1174-2631. User manual for age-based models with Casal2 v22.06 (2022-06-07)
WG-ASAM-2022/01	Report of the Chair of the Scientific Committee on the CCAMLR Scientific Committee Symposium Chair of the Scientific Committee
WG-ASAM-2022/15	Review of the Rules for Access and Use of CCAMLR Data Chair of the Data Services Advisory Group (DSAG)
WG-EMM-2022/01	Recruitment variability along the Antarctic Peninsula: What's the best way forward C.S. Reiss and G.M. Watters
WG-EMM-2022/02	Recruitment variability in Antarctic krill in Subarea 48.1 expressed as 'proportional recruitment' D. Kinzey, J.T. Hinke, C.S. Reiss and G.M. Watters
WG-EMM-2022/32	Preliminary results on the length-weight relationship of fresh Antarctic krill with weight-at-length based on multiple individuals Y. Ying, G. Fan, J. Zhu and X. Zhao

Appendix D

Validation of Casal2 Parameter Files

1. The process of validation requires that WG-FSA are satisfied that Casal2 model parameter files contain the parameter values and model assumptions described in accompanying assessment papers, and that the parameter files can be used to reproduce the key results reported by those papers.

2. Such validation comprises a number of discrete steps, and the guidelines to assist WG-FSA and the Secretariat in carrying out validation are described below.

Part A: Secretariate validation of the supplied input configuration files and the reproducibility of outputs

3. Part A of the process of validation 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) the MCMC data, when projected using the CCAMLR decision rules, produce the yields reported in the assessment papers

(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.

Part B: Working Group validation of the contents and model structure defined in the supplied input configuration files and outputs

4. Part B of the process of validation requires that WG-FSA verify that the Casal2 parameter files contain the parameter values and structure as outlined in accompanying assessment papers, and further, that the structure and assumptions in the paper have been reviewed by the Working Group. The Working Group should then confirm that:

(i) the version of Casal2 that was used was clearly specified, a recent and appropriate version of the Casal2 software has been used to run the assessment, and that there are no inappropriate warnings, information message, or errors resulting from running the model

(ii) the biological parameters, catches and other parameters used in the input configuration files are the same as described in the accompanying assessment paper

(iii) the reported output quantities (B_0, current status and precautionary yields) are the same as described in the accompanying assessment paper

(iv) the key model population structure, observation, estimation and other assumptions are those described in the accompanying assessment paper.

Additional notes on the validation process

5. The Casal2 input configuration files (commonly referenced by the config.csl2 file and including population.csl2, observation.csl2 estimation.csl2, and report.csl2 – but specific names depend on the user choices) contain all the information required by the stock assessment program Casal2 to run an assessment model.

6. Output from Casal2 is directed to the std::err, or std::out stream, and can be redirected by the user to appropriate files. These files contain all requested reports from Casal2 but may differ in their appearance and content depending on the run mode being undertaken and the user options chosen to run the model.

7. The Casal2 output can sometimes depend on the computer central processing unit (CPU) model and make, and/or the operating system being used. Hence, the results may not be identical to those produced here as the operating system, CPU and other local aspects of implementation may be different than those used to produce the runs reported in accompanying assessment papers. However, the results would always be the same to at least 3–6 significant digits, and, in most circumstances, more than 6 significant digits. Any conclusions drawn from model output should be robust to minor differences in accuracy of output.

8. Rounding of key output parameters may have been used in reporting the results in the accompanying assessment paper. Where appropriate rounding has been used, this should not be flagged as an error.

Report of the Working Group on Ecosystem Monitoring and Management
(Virtual meeting, 4 to 11 July 2022)

Content

Report of the Working Group on
Ecosystem Monitoring and Management
(Virtual meeting, 4 to 11 July 2022)

Opening of the meeting

1.1 The meeting of the Working Group on Ecosystem Monitoring and Management (WG-EMM) was held online from 4 to 11 July 2022 starting at 21:00 UTC. The meeting was convened by Dr C. Cárdenas (Chile), who welcomed the participants (Appendix A).

Adoption of the agenda and organisation of the meeting

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

1.3 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.

1.4 This report was prepared by the Secretariat and the Convener. Sections of the report dealing with advice to the Scientific Committee and other working groups are highlighted and collated in 'Advice to the Scientific Committee'.

1.5 The Working Group noted that due to the short duration of the meeting and the extensive discussions required to progress the krill management approach, there was not enough time to consider and comment on all papers. The Working Group agreed to consider all published papers ('P-papers') as read and only consider recommendations arising from those papers. The Working Group recognised that while many agenda items would have benefitted from longer discussions, progress has been made in good spirit and in good cooperation.

Krill management

2.1 WG-EMM-2022/07 presented the report of the 2022 Scientific Committee on Antarctic Research (SCAR) Krill Action Group (SKAG) meeting, held online from 7 to 11 March 2022. The discussions focused on recruitment estimation and modelling, with an emphasis on gear selectivity, standardisation of data collection, computation of proportional recruitment and opportunities for collaboration between researchers and the fishing industry.

2.2 The Working Group thanked all those involved in the SKAG meeting and noted the valuable role that SKAG plays in allowing for further consideration and more detailed discussion of krill biology, sampling methodology and krill research projects than is possible by CCAMLR working groups due to the time constraints of these meetings.

2.3 WG-EMM-2022/11 presented results of scientific research on krill conducted on board the *Antarctic Endurance*, a commercial fishing vessel. The study demonstrated the potential for using commercial krill trawlers to address questions identified by CCAMLR to support krill fisheries management (e.g. seasonal size and sex composition, vertical movements, identification of spawning hotspots and the role of the northwestern Weddell Sea as a source of recruits to the area of the South Orkney Islands (SOI)).

2.4 The Working Group welcomed the successful at-sea collaboration between the fishing industry and scientists, noting that the increase in fishing depth during autumn and early winter in comparison to summer, and the variation in maturity and sex of krill caught throughout the study period are important aspects to the interpretation of catch data.

2.5 WG-EMM-2022/41 presented a comparison of data collection protocols and outputs between CCAMLR Scheme of International Scientific Observation (SISO) observers and scientists taking part in an Alfred Wegener Institute (AWI) research project on a trawl vessel using a continuous fishing system. The study focused on the effects of methodological differences in data collection by comparing concurrently collected length-frequency distributions from SISO observers with dedicated researchers. Results indicated that length frequencies collected by SISO observers tended to underestimate small individuals when compared to those collected by AWI researchers in some cases.

2.6 The Working Group noted that this study represented an effective collaboration between scientists, observers and the fishing industry and that reasons for the observed differences in length frequencies, in addition to methodological aspects, may include individual observer effects as length measurements were taken by multiple SISO observers. It also noted that SISO data were collected far less frequently and usually whilst vessels were actively fishing krill swarms. The Working Group further noted that the tendency of SISO observers to sample whilst vessels were fishing krill swarms may affect the composition of by-catch records and potentially results in by-catch underestimates.

2.7 Noting that the aim of the SISO krill length data collection is documenting the size composition of the catch, and that the workload of observers is already substantial, the Working Group discussed the possibility of involving dedicated scientists on board fishing vessels to augment data collection capabilities in the future. It also recalled WG-SAM-16/39 which discussed changes to SISO length sampling requirements and sampling instructions to allow better estimates of catch at length. The Working Group suggested that more robust statistical tests were required to determine if the length distributions were significantly different, and that in the study area, samples may have come from different swarms with different geographic origins. The Working Group further noted that many of the issues discussed could potentially be addressed at the future krill observer workshop (paragraph 5.18).

2.8 The Working Group noted that the vessel had also collected acoustic data and that once analytical issues associated with processing data that were not collected during transects and calibration issues are addressed with the help of WG-ASAM, the data may potentially provide biomass estimates.

2.9 WG-EMM-2022/39 presented a proposed workplan for developing and implementing data collection needs for CCAMLR krill fisheries, and re-scoping of the krill observer workshop that has been delayed by COVID-19 to align it with the timeline of the proposed workplan. The document outlines several pressing issues that have been identified for consideration by the Scientific Committee and its working groups, processes to address these, a timeline for changes to data entry forms and instructions, and implementation of these outcomes through appropriate liaison with industry and training (see WG-EMM-2022/39, Table 1).

2.10 The Working Group supported the proposed changes to the terms of reference for the krill observer workshop planned to be hosted by China (Appendix D).

2.11 The Working Group noted that issues such as sampling protocols, by-catch in krill fisheries and incidental mortality may result in changes to SISO observer sampling requirements and encouraged Members to submit papers addressing these issues to WG-IMAF and WG-FSA (paragraph 5.18). It further noted the importance of training observers in new or revised sampling protocols and with respect to the potential future increases in krill catch limits and highlighted the possible future use of electronic monitoring on board krill fishing vessels to assist in data collection.

2.12 WG-EMM-2022/06 presented the report of an online workshop held in August and November 2021 to investigate a potential krill ageing method for their absolute age based on the count of growth bands in eyestalks. Given its low accuracy and the low level of agreement among age readers, the workshop concluded that this method requires further development before it can be applied.

2.13 The Working Group thanked Members who participated in the online workshop and encouraged further work to develop a method to determine the absolute age of krill.

2.14 WG-EMM-2022/P08 presented findings from a genetics study examining the spatial structuring of krill bacterial epibiont communities in the East Antarctic. Distance, rather than environmental factors, was found to be the leading driver, and bacterial communities associated with Antarctic krill (*Euphausia superba*) were found to be geographically segregated, in contrast with the current assumption of a panmictic krill population.

2.15 The Working Grouped noted that this study raised questions regarding the relationship between oceanographic processes and population dynamics and encouraged further research on this topic, including on possible seasonal variations of bacterial epibionts. It further noted that the hypothesised panmixia of krill could be a result of the very large and diverse genome of Antarctic krill, which may render the detection of sub-populations difficult, particularly in combination with the enormous population size of Antarctic krill. The Working Group noted the great potential of this method to help develop krill stock structure hypotheses, given the more rapidly changing microbiome compositions.

2.16 WG-EMM-2022/18 presented an overview of CCAMLR-related ecosystem monitoring and scientific activities undertaken by the British Antarctic Survey during the period April 2021 to March 2022, including sea-ice extent and sea-surface temperature observations, results from acoustic mooring and plankton research trawls, and data collected from several higher predator CCAMLR Ecosystem Monitoring Program (CEMP) sites. Observations of low krill abundance in the 2021 winter in Subarea 48.3, followed by an influx of small krill in October 2021, with impacts on seals and penguin colonies, were reported.

2.17 The Working Group noted the observations of low krill abundance in the winter of 2021 in Subarea 48.3, recalled that a similar anomaly was reported in 2009 (WG-EMM-09/23) and encouraged the authors to investigate possible causes of these events, as understanding such events is crucial to the management of the krill fishery. The Working Group noted that observed natural events of low krill abundance may be important for understanding the existence of food chains in which krill is not the dominant species. The Working Group further noted that this study exemplified how CEMP monitoring could contribute to management, and that some of the observed patterns were also seen in CEMP sites in the western region of the Antarctic

Peninsula. The Working Group encouraged the authors to consider the use of automated camera systems to ensure the continuity of data collection during years of reduced accessibility to certain CEMP sites.

2.18 While noting that investigating these anomalies represented a significant body of work, the Working Group recommended that it would be beneficial to consider cycling through topics (e.g. every three years) in its terms of reference, as the krill fishery management topic had taken a lot of resources in recent years and more discussion on ecosystem status was needed. It also noted, based on many regional and potentially conflicting CEMP indices, that WG-EMM would benefit from developing integrated ecosystem reporting to ensure a more comprehensive view of the monitored ecosystems (see also paragraph 5.5).

Krill fishery status

2.19 WG-EMM-2022/P09 presented an analysis of the implications of the spatial and temporal concentration of Antarctic krill fishing effort. Analysis of 38 years of data revealed the highest spatial and temporal fishing concentration across the west Antarctic Peninsula and South Orkney Islands, a general declining trend in catch-per-unit-effort (CPUE), and the need to expand the coverage of krill surveys to new, highly fished, and non-monitored areas such as the Gerlache Strait.

2.20 The Working Group noted that this analysis represented an effective use of krill fishery data, confirming the concentration of fishing operations in recent years (see also WG-FSA-2021/56). It discussed concerns regarding the interpretation of CPUE trend declines, which could be indicative of localised depletion, but noted that CPUE data needed careful consideration since it could be affected by krill demographics, flux, fishing tactics (skippers may leave a given fishing spot to search for higher-quality krill rather than high-density krill aggregations) and changes in fishing technology. The Working Group noted that this study reported important trends in the fishery, highlighting the need for regular acoustic surveys to enhance the responsiveness of the management of the krill fishery.

2.21 WG-EMM-2022/29 presented a review of trawl gear information provided by vessels operating in the krill fishery during the notification process. The paper proposed a framework to standardise trawl gear reporting requirements based on SC-CAMLR-XXVIII, Annex 9 and in accordance with Conservation Measure (CM) 21-03.

2.22 The Working Group welcomed this paper and noted that CM 21-03 requires that Members, during the fishery notification process, submit net configuration measurements and refer to a relevant net diagram in the CCAMLR gear library or, if no relevant diagram is available, submit a detailed diagram and description to the forthcoming meeting of WG-EMM. The Working Group further noted that there are no krill trawl diagrams available from the CCAMLR gear library and that information is currently only available in the fishery notifications.

2.23 The Working Group recommended that the Secretariat be tasked with collating the available net diagrams and net configuration measurements submitted during the fishery notification process in the CCAMLR gear library and Members be requested to submit papers with additional net diagrams, configurations and descriptions of operations to subsequent meetings of WG-EMM for inclusion in the gear library.

2.24 The Working Group noted WG-EMM-2022/09, which presented a summary description and analysis of the activities the fishing vessel *Antarctic Endeavour* carried out in the Antarctic krill fishery between December 2020 and November 2021, but did not discuss this paper due to time constraints.

WG-ASAM advice and considerations on the krill management strategy

2.25 The Co-convener of WG-ASAM, Dr S. Fielding (UK) presented an overview of relevant advice pertaining to the management of the krill fishery (WG-ASAM-2022). She noted that WG-ASAM discussed standardised procedures for survey design, data analysis and quality control of acoustically derived estimates of krill biomass. Dr Fielding also noted the new R code available to aid in the creation of CCAMLR strata and the computation of their areas (WG-ASAM-2022/02 and updated output posted on the 'Krill biomass estimates from acoustic surveys' e-group), indicating the potential utility of this method for WG-EMM. She further reported that WG-ASAM considered biomass estimates for Subarea 48.1 at scales relevant to the area of operation of the fishery, noting discussions to calculate such estimates over different time periods. Lastly, Dr Fielding reported on discussions about fishing vessels conducting surveys on the CCAMLR-nominated transects and welcomed papers describing methods for acoustic surveys targeting icefish, to be submitted for discussions at WG-ASAM-2023.

2.26 The Working Group recognised the success of the WG-ASAM meeting and the relevance to WG-EMM discussions on krill assessments, and reinforced the need for standardisation of data collection and processing methodologies when combining survey results.

2.27 WG-EMM-2022/25 Rev. 1 presented krill biomass estimates for the combined Subarea 48.1 strata defined by WG-ASAM-2022. A range of options were presented based on the duration of biomass time series used and different approaches to pooling strata. Based on a preliminary wavelet analysis indicating that similar periods with high power seemed to occur within five years, the authors considered the 'y5' scenario to be appropriate for computing subarea-level mean biomass and its coefficient of variation (CV).

2.28 The Working Group noted the utility of the wavelet analysis to document the periodicity observed in the data and the consistency of this periodicity with that observed in proportional recruitment time series. It discussed the impact of the choice of time period over which to average acoustic estimates on the estimation of the variability in biomass estimates (see also WG-EMM-2021, paragraph 2.27). Given the observed period, the Working Group agreed that the 'y3' option could be excluded from the table of biomass estimates provided by WG-ASAM-2022 (Table 1).

2.29 The Working Group recommended that future analyses would benefit from including data from the long time series of surveys conducted by Peru in the Antarctic Peninsula area.

2.30 The Working Group noted that the biomass estimate for the Gerlache Strait stratum was based on the result of a single acoustic survey, which would not account for interannual variability and the episodic recruitment that is evident in other areas within Subarea 48.1. It also noted reports of juvenile aggregations in the area, which warranted caution if it were a potential source region, and indicated the need for development of a juvenile krill distribution layer in this area within the risk assessment. The Working Group further noted that the transect coverage of the single survey was mainly offshore, and thus had limited spatial overlap with fishery operations in this area. Some participants indicated that this issue would result in an underestimate of biomass since high abundances targeted by the fishery were mainly closer to the shore. The Working Group also noted that the large biomass estimates in the outer strata were driving up the resulting subarea-scale biomass estimate.

2.31 The Working Group considered the time series of acoustic biomass estimates provided by WG-ASAM-2022. The Working Group noted that when only a single survey was available for a given stratum, using the lower bound of the one-sided 95% confidence interval (assuming a lognormal distribution) of estimates would provide a precautionary estimate of biomass. It discussed whether consistency across strata could be increased by using the same approach for all estimates, in line with current management strategies applied to mackerel icefish (*Champsocephalus gunnari*) fisheries. The Working Group agreed that this approach could be applied to the Gerlache Strait, Drake Passage and Powell Basin strata.

2.32 The Working Group discussed the time period over which to average acoustic biomass estimates. Some participants noted that using all the available data would ensure representativeness and that the best contemporary estimate, when surveys are not conducted in every stratum and every year, would be obtained by computing the long-term average. Other participants noted that contemporary estimates would be better depicted using recent data that covered a single cycle of a periodic signal to reflect the latest trend of the stock.

2.33 The Working Group noted that the wavelet analysis presented in WG-EMM-2022/25 Rev. 1 was undertaken on data spanning 1997–2011, where there was at least one survey every year. They noted that the ‘y5’ time period could be appropriate if surveys had occurred in every year. The Working Group recognised that data collection gaps in recent years and areas meant there was insufficient data to use the ‘y5’ time period at present.

2.34 The Working Group identified that the best contemporary estimate would, for the purpose of an initial revision to catch limits in Subarea 48.1, be obtained by computing the long-term average, and therefore recommended using the ‘yall’ time period for those areas. It further recommended to use the lower bound of the one-sided 95% confidence interval (assuming a lognormal distribution) for strata with a single survey. Should strata surveys occur annually, the Working Group considered that a five-year window to average acoustic biomass estimates may become appropriate.

2.35 The Working Group recommended that given the periodic and dynamic nature of krill population dynamics, future catch limits should be revised frequently to ensure a precautionary management of the krill fishery.

2.36 The Working Group noted that enabling responsive management would require regular acoustic surveys and discussed the possibility of making such surveys mandatory for krill fishing vessels, in line with the tagging requirements for participation in toothfish longline fisheries. In such context, the participants favouring the use of all acoustic data at hand indicated that if surveys were to be conducted frequently, the time period over which biomass estimates were averaged could be shortened.

2.37 The Working Group noted that the overarching management strategy of different fisheries needed to account for the specific dynamics and ecosystems in the areas where those fisheries operate.

WG-SAM advice and considerations on the krill management strategy

2.38 Dr S. Parker (Secretariat), on behalf of the WG-SAM Co-conveners, summarised the discussions regarding the krill stock assessment using the generalised R yield model (Grym) provided by WG-SAM-2022. WG-SAM noted that a range of opinions regarding parameter values and the implementation of the decision rules as applied to krill persisted and made a request to WG-EMM to help constrain the range of potential scenarios by providing expected bounds to output values from the models (WG-SAM-2022, paragraph 3.22). Dr Parker noted that WG-SAM recommended Members develop stock hypotheses to guide the interpretation and use of data for parameter estimates (WG-SAM-2022, paragraph 3.13). The Working Group noted that WG-SAM-2022 agreed that the Grym and krill assessment model implementations are fit for purpose as a numerical projection tool.

2.39 WG-EMM-2022/05 presented a proposed practical revision to CM 51-07 that would distribute catch and increase catch limits in Subarea 48.1. Using selected Grym parameter values, an alternative decision rule, selected biomass estimates and a risk-assessment scenario that specifies management units consistent with the likely conduct of future surveys, the analysis proposed summer and winter catch limits for each management stratum. The authors further indicated that if consensus could not be reached on the revision of the krill management approach, a subdivision of the current trigger level in Subarea 48.1 would be possible.

2.40 The Working Group thanked the authors for providing a proposed revision to CM 51-07, noting the utility of seeing the three components of the krill management strategy integrated into the proposal. It suggested that accounting for the redefinition of strata boundaries by WG-ASAM (paragraph 2.25) would be welcome, and that catch limits could be presented in tonnes, rather than percentages, to simplify the revised conservation measure. The Working Group noted that the proposed revision to CM 51-07 involved a change to the CCAMLR decision rules and recalled that WG-SAM-2022 recommended that comprehensive management strategy evaluations be undertaken to assess the impacts of any changes to the decision rules (WG-SAM-2022, paragraph 3.21; paragraph 2.54).

2.41 The Working Group noted that using this reformulated decision rule resulted in a gamma value of 0.03 rather than 0.0018, and that for a short-lived species this value was notably lower than for other fisheries in the Convention Area (e.g. 0.04 for data-limited toothfish fisheries). The Working Group noted, however, that low gamma values for krill could also be explained by the high variability in krill recruitment.

2.42 Many participants recalled studies that hypothesised ecosystem effects from fishing under the current management regime (Watters et al., 2020; Krüger et al., 2021) and noted that whilst the proposal represented an overall increase in the catch limit, the distribution of catch limits both in time and space reduced the risk of localised depletion from fishing. Some participants stated that there was not currently enough information to quantify fishery impacts and that future surveys and studies were needed to provide such assessments as well as to better understand the effects of climate change.

2.43 The Working Group supported the recommendation from WG-SAM-2022 that establishing a krill stock hypothesis would provide a framework for interpreting patterns observed in survey and fishery data, and provide a crucial tool to direct surveys and analytical efforts (e.g. surveys designed to investigate recruitment in hypothesised source areas).

2.44 The Working Group agreed on the use of the weight-at-length and maturity-at-length relationships presented in 'Scenario 18' of Table 5 in WG-FSA-2021/39 and used in WG-EMM-2022/05, for the purpose of the krill stock assessment using the Grym, until further data could be collected to update these parameter values.

2.45 WG-EMM-2022/01 presented a review of recruitment studies conducted over the last 30 years and previously discussed at WG-Krill and WG-EMM. The authors considered that the proportional recruitment parameter values should be derived using data from long-term monitoring programs in the areas in which the fishery occurs, using standard techniques, and including recently collected data where available. The authors demonstrated that three long-term studies (the US AMLR Program, Palmer LTER and German surveys) all show consistent periodicity and that much of the estimated recruitment variability is a result of this periodicity. They further highlighted issues with other data sources currently considered potentially useful to estimate recruitment parameters, in particular those excluding surveys with observations of zero or low recruitment. While presenting a draft stock hypothesis, the authors indicated that the Antarctic Peninsula was a well understood and well documented system.

2.46 The Working Group noted that the periodic recruitment patterns were consistent across long-term time series, from different areas along the Antarctic Peninsula and reflected a key characteristic of the krill population in the area. It noted that while the periodicity was evident, the magnitude of peaks might be affected by selectivity, availability and net avoidance. Further noting the correspondence between time series generated by these historical surveys, sometimes using different survey nets and recruitment indices, the Working Group considered that these issues have likely had a minimal impact on describing the dynamics of recruitment. However, for estimation of proportional recruitment values further investigation in the future may be useful.

2.47 The Working Group discussed the importance of spatial coverage for future surveys as some participants noted that juveniles were often found aggregated in coastal areas, which may present accessibility issues. It also noted that periods of low proportional recruitment were not followed by subsequent low fishery yield, and that studies quantifying the relative contribution of krill production from different areas to the harvested stock in Subarea 48.1 may be necessary.

2.48 The Working Group recalled that krill length-frequency, abundance and acoustic survey data have been collected by Peruvian scientists for more than 25 years in Bransfield Strait and noted that it would be valuable to account for these data in this context (paragraph 2.29). The Working Group recalled a previous request from the Scientific Committee to develop a database for biological data from the surveys as well as from the krill fishery (WG-FSA-2021, paragraph 5.12), which could include those data as well as the data presented by WG-EMM-2022/01.

2.49 WG-EMM-2022/02 presented an analysis of krill proportional recruitment indices in Subarea 48.1 based on seven different data sources and using different size thresholds below which individuals are considered as recruits. The choice of size threshold had a larger effect on proportional recruitment parameters than differences among datasets, and, given the importance of gear selectivity, in particular for fishery data, the authors argued that length-frequency distributions should be adjusted prior to the computation of proportional recruitment parameters.

2.50 The Working Group welcomed the paper and noted that the periodicity in recruitment indices (paragraph 2.46) was supported by predator diet data. It noted that the selectivity of the commercial gear was potentially reducing the capture of small individuals. Some participants noted that the location of fishing operations, away from coastal areas (where juveniles may aggregate) was a factor to consider as well. The Working Group noted that differences in magnitudes between time series from very different data sources were possibly due to a combination of differences in selectivity and availability (paragraph 2.46).

2.51 The Working Group noted that prior to the calculation of recruitment indices, the krill length-frequency data from the US-AMLR surveys and the LTER surveys were standardised by swept volume and the fishery data were standardised by catch (WG-SAM-2021/07). The Working Group noted that while the krill length-frequency data obtained from penguin diets showed periodicity, it could not be used at present for proportional recruitment indices in a stock assessment as it could not be standardised.

2.52 WG-SAM-2022/28 Rev. 2 presented an alternative method of computing precautionary yield in the krill stock assessment projections. Instead of using the current implementation of the decision rules which compares the spawning stock biomass (SSB) under different fishing mortalities to pre-exploitation SSB, SSB in each year of fishing is compared to the same projections without fishing. As a result, non-zero yield is possible under simulations of high recruitment variability, which may not be the case when using the current decision rules.

2.53 The Working Group noted the usefulness of studies focusing on decision rules but voiced concern that this approach was less precautionary than intended. The Working Group recognised that the relationship between proportional recruitment and the resulting mortality estimates was an area of potential future improvements, and that the current implementation (WG-SAM-2021/09) was already an improvement over the original proportional recruitment model (de la Mare, 1994).

2.54 The Working Group agreed that further work on this subject required a management strategy evaluation which could test different decision rules as well as different proportional recruitment models.

2.55 The Working Group noted that in other areas with long time series of data, methods such as time series weighting are used to enable recent data, which is likely more relevant, to have a greater weight than historic data whilst still allowing for the variability in the time series to be present. This method may be useful for exploring future proportional recruitment values which may have changed through time due to regime shifts.

2.56 WG-SAM-2022/26 presented a summary of the status of the krill assessment fitted using the Grym following work undertaken during 2021. While recalling that the Grym model for krill stock assessment is ready for use, the paper noted that agreement on some parameter values has not yet been reached. Regarding proportional recruitment, the authors identified two sets of parameter values that they deemed appropriate (recruitment scenarios (1) and (4) in Table 4 of WG-FSA-2021/39). The authors noted that the results of scenario (1) showed the most overlap with the expected natural mortality range, used a clear and biologically well-defined age class

(R2) as the recruitment, and estimated the recruitment with data collected by the recommended sampling net (RMT8), which can reduce net avoidance by krill. The results of scenario (4) overlapped the expected natural mortality range to an acceptable level, and used data collected based on a sampling net with a mouth opening (6 m^2), similar to an RMT8.

2.57 The Working Group noted the usefulness of the pros/cons table generated by the authors in their presentation. The Working Group noted that such a table may be useful to assist in the selection of scenarios and could help guide future analysis of the existing long-term data to provide recruitment series for the Grym model for stock assessment. Some participants also noted that using an R2 recruitment index alleviates concerns over the under-representation of small individuals in samples due to gear selectivity and krill availability.

2.58 WG-EMM-2022/32 presented the results of an experiment which estimated the length-weight relationship of krill on board a krill fishing vessel by grouping krill specimens by length classes and weighing them together to reduce the impact of vessel movement. Results indicated that an adequate krill length-weight relationship could be obtained using this method. The Working Group did not have time to discuss this paper, which had been considered by WG-SAM (WG-SAM-2022, paragraph 3.6).

2.59 WG-EMM-2022/28 presented an analysis comparing krill length composition between research and commercial samples in a local area in Subarea 48.2. Noting the difference in fishing tactics and gears between research and commercial vessels, the authors highlighted the significant differences of both the recruits and largest individuals in fishery catches of 12 fishing vessels in the Bransfield Strait compared to research trawl samples from the *Atlantida*. The authors expressed concern that typical sample size of length measurements per observed haul and sampling interval (200 individuals of krill should be sampled once every 3 or 5 days) would not be effective for accurate data to assess krill length compositions from fishery catches. They advocated for the standardisation of trawl sampling protocols for acoustic surveys (including gear construction and fishing tactics) and for the use of research trawls during acoustic surveys on board commercial vessels as well as increase in observer sampling frequency in the krill fishery, taking into account the number of hauls per day and the amount of catch per haul. They noted that the requirements for krill sampling during an acoustic survey on board fishing vessels should be determined by the objectives of the survey, going beyond the requirements of SISO.

2.60 The Working Group noted that due to the dynamic nature of krill populations, the possibility that different swarms had been sampled by the compared vessels could not be excluded. It noted that the difference in trawling methods between vessels was also to be considered. The Working Group noted that the study raised an important point about the representativeness of observer data, which warranted the need for an assessment of SISO sampling methodologies, while recognising that the aim of observer data collection was to document the harvested stock (see also paragraphs 2.18 and 5.8). It supported the suggestion of deploying research nets from fishing vessels during acoustic surveys, while enabling some flexibility on gear design to avoid the exclusion of data due to small differences between the survey nets used and the recommended RMT-8. The Working Group encouraged the authors to augment their analysis by including statistical tests to quantify the differences between size distributions as well as using their data to attempt and estimate gear selectivity (WG-SAM-2022/27).

2.61 Dr G. Watters (USA), reflecting on the discussion regarding the comparison between the gamma for krill fisheries and that for data-limited toothfish fisheries (paragraph 2.41), presented a proposal, developed ad-hoc, in an attempt to facilitate the provision of advice on the revision of the krill management strategy. Noting that while agreement had been reached on several points during discussions, Dr Watters indicated that several issues precluded agreement on a gamma for the krill fishery in Subarea 48.1. He noted that a range of options, with a range of desirability were at hand, including a rollover of CM 51-07 and a spatial subdivision of the trigger level. Aiming towards agreement, he argued that the suggested proportionality between gammas in different fisheries could prove useful and presented a relationship in which harvest rate (i.e. gamma) divided by the inverse of recruitment variability was hypothesised to be equal across fisheries. Solving the equation resulted in a gamma of 0.03, hence providing support for the estimate provided in WG-EMM-2022/05. After swapping the proposed catch limits between the Bransfield Strait and the Gerlache Strait to alleviate concerns over the catch limit for the latter stratum (paragraph 2.30), noting that a few issues could soon be resolved regarding the risk assessment, Dr Watters indicated that agreeable interim advice was now at hand for this year, and that further collaborative refinements of the krill fishery management approach could be developed in the future.

2.62 Dr C. Darby (UK) thanked Dr Watters and noted that agreement over acoustic biomass estimates and the risk assessment was close, but that agreement over the appropriate krill stock exploitation rate, derived using the Grym, remained more distant due to the uncertainty around recruitment. Given that the role of the Grym was to estimate a single number, gamma, he suggested that a possible approach would be to agree on a range of values to be applied to acoustic biomass estimates, while using the survey time series of biomass estimates to provide a retrospective analysis. The resulting range of proposed catch limits and the consequences of applying them could then be discussed via an e-group in preparation for WG-FSA-2022.

2.63 Dr X. Zhao (China) thanked both speakers and indicated that he was in general agreement with them. He noted that having a backup approach was very useful and agreed that agreement over the revision of the krill fishery management approach was very close. He shared their optimism and indicated that collaborative refinements were possible to reach interim advice, including concessions regarding elements for which complete agreement has not yet been reached (e.g. using all years of available acoustic data). He thanked Dr Watters and Dr Darby for their valuable contributions and indicated that e-groups were available to progress discussions prior to WG-FSA-2022.

2.64 Dr S. Kasatkina (Russia) thanked all speakers for their very interesting discussion and noted that a direct comparison of harvest rates between toothfish and krill fisheries was not appropriate. She argued that krill fluxes needed to be taken into account as oceanic transport had a larger impact on krill than on toothfish, and that fish stocks were comparatively more affected by harvesting. She noted that the revision of the krill fishery management approach will require regular standardised acoustic surveys.

2.65 The Working Group recalled that the use of a data-limited approach to the revision of the krill fishery management strategy (SC-CAMLR-40/BG/28) was a recognition of the difficulty of accounting for all ecological, biological, oceanographic and fishery elements underpinning the dynamics involved. Without ignoring these important elements, the Working Group agreed that sufficient information was available to provide interim advice, which will be regularly improved over years, through international collaboration and intensive scientific efforts.

Advice from the meeting on the details of the risk analysis
for Subarea 48.1, data layers, catch scenarios

2.66 WG-EMM-2022/17 presented the implementation of the krill risk assessment in Subarea 48.1, at a scale more closely aligned with the scale at which the krill fishery would potentially operate under different management scenarios. The lowest relative risk scenarios were those whereby management of the fishery was based on the US AMLR survey strata, but split further into additional management units. The next joint lowest relative risk scenarios were also based on the US AMLR survey strata, but with extra management units added. In many cases there was very little difference in relative risk or in the proportion of catch assigned to each management unit, whether the fishery desirability was scaled or unscaled.

2.67 The Working Group noted that both the baseline and the fishery desirability scenarios where management of the fishery were split into US AMLR survey strata with additional management units, resulted in lower overall relative risk than the current fishery management scenario.

2.68 The Working Group acknowledged that whilst in some cases there was very little difference in risk between including and omitting the fishery desirability layer, agreement could not be reached on using a single approach. Some participants considered that using the baseline scenario was more appropriate as the inclusion of the fishery desirability layer may introduce spatial concentration of catches in particular management areas, counter to the purpose of the risk assessment. Other participants considered that the inclusion of the fishery desirability layer was appropriate as it represented a proxy for the current krill distribution (paragraph 2.30; WG-FSA-2021/56).

2.69 Noting the lack of winter distribution data, some participants indicated that the risk assessment would benefit from accounting for fishery desirability as it may help reflect the recent krill distribution (WG-FSA-2021/56).

2.70 The Working Group noted that CEMP was designed to monitor impacts from the fishery on dependent predators. If spatial management of the fishery is modified as part of a revision of CM 51-07, this may result in catches being taken in areas where less information from CEMP is currently available. Under such a scenario, more survey information would be required to ensure adequate understanding of any impacts from the fishery in these new management areas. The Working Group further noted that data gaps during the winter period exist for both krill and predator distributions which may be biasing estimates of relative risk. The Working Group noted that increased monitoring of both krill and krill-dependent predators is required in each management unit to fill in current data gaps, in addition to monitoring potential impacts from the fishery (paragraphs 2.95 and 2.96).

2.71 The Working Group noted that the desirability layer used in the krill risk assessment was based on the current location of the fishery and overlapped with higher predator distributions. Thus, the Working Group considered the approach to be a data-limited spatial overlap analysis. The Working Group further noted that the current approach calculates 'relative risk', however, previous work (Plaganyi and Butterworth, 2012; Watters et al., 2013) has demonstrated that 'absolute risk' to the ecosystem is reduced when catch is spread in space and time.

2.72 The Working Group considered that the term krill risk assessment was potentially misleading to managers and Commissioners as it implied an unspecified level of threat, whereas the values produced from the analysis produce relative risk levels. The Working Group recommended renaming the process as the 'spatial overlap analysis' to more accurately reflect the procedures undertaken.

2.73 WG-EMM-2022/27 presented comments and proposals on the use of the risk assessment framework to allocate catch in Subarea 48.1 based on the results of two acoustic surveys, carried out in the Bransfield Strait with one month time shift (February–March 2020), and accompanied by regular observations of marine mammals and seabirds. The authors proposed that the presence of krill transport casts doubt on the impact of the krill fishery on krill stocks and populations of dependent predators, and that krill transport processes affecting krill biomass and distribution variability should be considered in the risk analysis for Subarea 48.1. Proposals in the paper include: (i) the development of scientifically based indicators accompanied by criteria and diagnostics to assess the potential ecosystem impact of the fishery, taking into account the mixed effects of fishing, environmental variability (or climatic changes), and the competitive relationship between predator species; (ii) a set of indicators for the risk assessment framework, accompanied by transparent descriptions, criteria and diagnostics that should be approved by the Scientific Committee; and (iii) investigating the possibility of using CEMP data to provide information on the effects of fishing on dependent species.

2.74 The Working Group noted that while the *Atlantida* survey conducted in the Bransfield Strait during March 2020 showed a lower krill density and a higher predator density than the survey conducted in the same area during February 2020, the spatial distribution of areas with high krill density in 2020 did not overlap with areas of high predator density in 2020. The Working Group noted that the krill spatial overlap analysis was not designed to be used to evaluate impacts from the fishery, rather it is a mechanism by which to split the krill catch limit between management units, to reduce any potential impact based on spatial overlap of krill and predators.

2.75 The Working Group considered that the establishment of marine protected areas (MPAs) contributes to holistic conservation objectives, builds ecosystem resilience and protects against uncertainties, and would be an important contribution of the future krill management approach. The Working Group recalled that the Domain 1 MPA proposal (D1MPA) to establish an MPA includes Subarea 48.1, and that it was developed using Marxan, an already agreed methodology. It also noted that a combination of different measures is needed to comply with Article II of the Convention.

2.76 WG-EMM-2022/31 presented a comparison of distribution and biological data between the CCAMLR 2000 Krill Synoptic Survey of Area 48 and the Russian *Atlantida* 2020 survey. Results indicate significant seasonal variability, and clearer links between size classes and water masses in 2020 than in 2000. In particular, larger krill were observed in the warmer waters of the Antarctic Circumpolar Current (ACC) compared to the colder waters of the Weddell Sea.

2.77 WG-EMM-2022/42 Rev. 1 highlighted recent changes to the conservation status of Antarctic fur seals (*Arctocephalus gazella*) summarised in WG-EMM-2022/P15 and presented an update on the population status and a metric of foraging habitat quality for South Shetland Islands (SSI) Antarctic fur seals, based on data from the 2021/22 field season at Cape Shirreff. The post-weaning dispersal and habitat use of SSI Antarctic fur seal pups over four austral winters between 2005 and 2019 were also summarised. Analysis of post-weaning distribution highlighted that Antarctic fur seal pups were dependent on continental slope areas around the Antarctic Peninsula during the austral autumn and winter, with the shelf and slope north of Livingston Island showing the highest concentration of animals in April and May.

2.78 The Working Group welcomed the paper and noted that the decrease in Antarctic fur seal pups in the Cape Shirreff area was dramatic (86% reduction in pup production between 2007 and 2020) and coincided with increasing foraging trip duration by adult females and an increase in leopard seal (*Hydrurga leptonyx*) predation during the breeding season.

2.79 The Working Group further noted that despite low breeding success, adult females forage during winter north of the Antarctic Convergence and were returning to breeding colonies exhibiting high rates of survival and good body condition. Collectively, these results indicate that the environmental stressors forcing the population decline are likely spatially restricted to the northern and western Antarctic Peninsula.

2.80 The Working Group recommended that data on the overwinter distribution of SSI fur seal juveniles be integrated into the data layers of the spatial overlap analysis and the D1MPA proposal. The Working Group also noted that this previously depleted population has fallen below a level which ensures greatest net annual increment. As such, it should be of concern to the Commission.

2.81 The Working Group noted that while myctophid fish represent a small portion of overall fur seal diet, in years before 2010 where foraging trips by breeding females were abnormally long, myctophids tended to increase in their diet. The Working Group considered that myctophid fish could be a candidate for incorporating in CEMP parameters and noted that this could be considered during the CEMP workshop (paragraph 2.96) to support further evaluation of the role of krill in fur seal diets. The Working Group also noted that fur seals continue to eat krill during the winter even as they move north of the Antarctic Convergence but that the proportion of myctophids, other pelagic fish and squid in their diet increases.

2.82 WG-EMM-2022/P10 presented a study on adaptability of the spiny icefish (*Chaenodraco wilsoni*) that is dependent on Antarctic krill to potential changes in food availability. Muscle samples were collected and analysed for fatty acid composition from three areas in the Bransfield Strait and the northern Antarctic Peninsula during February–April 2016 to evaluate their feeding variability. The results showed the diet of *C. wilsoni* varied in different marine environments. This flexibility in prey may assist their adaptation response if available prey species vary due to the effects of climate change.

2.83 The Working Group welcomed this paper and noted that New Zealand and Chinese scientists have applied for joint funding to use fatty acids to investigate trophic linkages in the Ross Sea region.

2.84 WG-EMM-2022/P11 presented a simulation on the influence of the tide on residual water mass transport in the Bransfield Strait. The model indicated that the residual current produced by the diurnal tide is dominant and primarily distributed along the shelf break and near the coast, and water stratification amplifies this residual current system. The model suggests that tidal dynamics in this region should be included when studying cross-shelf water transport.

2.85 WG-EMM-2022/P12 presented a study on the concentrations of four trace elements present in Antarctic krill in the northern Antarctic Peninsula, to explore the suitability of Antarctic krill as a bioindicator of trace elements to reflect the heterogeneity of marine environments in this area. The results suggested some trace elements found in Antarctic krill are suitable and effective bioindicators for reflecting regional heterogeneity in marine environments in the northern Antarctic Peninsula (paragraph 2.89).

2.86 The Working Group noted that regional and large-scale demographic and ecological studies need to consider the localised areas and hydrographic interactions between them, particularly in the northern Antarctic Peninsula region (paragraph 2.89). These studies can be useful to better understand krill stock structure in this region and are especially important for krill ecology and management.

2.87 The Working Group noted, but did not consider, WG-EMM-2022/16 which presented a dynamic krill distribution model for the waters surrounding the SOI Archipelago and the wider Subarea 48.2, using data from a spatially and temporally consistent krill-targeted acoustic survey (2011–2020) and year-specific environmental predictors within a two-part 'hurdle' model. Predictors found to be important in both hurdle components were distance from shelf break, distance from summer sea-ice extent, and salinity. Year-specific projections of krill distribution revealed that the shelf break surrounding the SOI, particularly the northern shelf break, was a consistently important area for krill. Model projections for 2021 also revealed low probability of krill presence and the combined hurdle model estimated krill densities to be an order of magnitude lower than previous years, aligning with reports of poor breeding success in krill predators at SOI.

Advice to the Scientific Committee on the review of CM 51-07
and implementation of the krill management for other subareas

2.88 WG-EMM-2022/21 presented options for the interim revision of CM 51-01 and CM 51-07 to progress the new krill management approach in 2022. Two options were proposed, one requiring revisions to CM 51-01 and CM 51-07, the other to revise CM 51-07 only, but with an interim exemption of the relevant provisions stipulated in CM 51-01. The authors argued that given the state of scientific knowledge, Subarea 48.1 should be separated from the other subareas (catch limits in these other subareas would be updated at a later stage), and that the advice initially given for Subarea 48.1 should be reviewed in two years. The review periodicity of krill catch limits in all subareas was highlighted as a subject to be discussed by the Working Group.

2.89 The Working Group welcomed the paper and noted that, as krill stocks have a known transport pathway from Subarea 48.1 to Subareas 48.2 and 48.3, a holistic approach to all subarea catch limits is required when considering any revision to CM 51-07. The Working Group recommended the need for a krill stock hypothesis workshop.

2.90 The Working Group recommended that if CM 51-07 is revised, data reporting and collection, including from the fishery, need to be reviewed and increased as necessary to assess the possible effects of the revised measure consistent with CM 23-06, paragraph 4.

2.91 The Working Group encouraged Members to continue ongoing data collection designed to elucidate the potential effects of fishing and climate change on Antarctic Marine Living Resources.

2.92 The Working Group noted that proposed text for a revision to CM 51-07 was also included in WG-EMM-2022/05 and invited Members to participate in further discussions on both papers in the 'CM 51-07 revision' e-group.

2.93 The Working Group noted but did not discuss WG-EMM-2022/P02, which presented a summary of the current krill management strategy, the evolution of the fishery's dynamics and a proposed way forward for the revision of the management of that fishery in Subarea 48.1. The authors suggested that CM 51-01 alone is not sufficient to limit concentrated fishing, and that a continuation of CM 51-07 remains an imperfect, but acceptable, fallback if agreement on a revision to CM 51-07 cannot be reached.

CEMP

2.94 WG-EMM-2022/38 Rev. 2 presented an updated summary of the CEMP data holdings. The CEMP database contains time series for 479 unique site–species–sex–colony parameter indices, with many spanning more than 10 years. The paper provided suggestions to assist in the improvement of annual monitoring reporting, in addition to recalling the recommendation from WG-EMM to enhance CEMP to better inform the krill management approach.

2.95 The Working Group welcomed the paper and recommended a workshop on CEMP be convened, noting the last workshop occurred in 2003 when the program had no direct links to fishery management. The Working Group noted that updating CEMP to support both fishery management and MPA objectives is an important consideration, as the krill fishery in Area 48 continues to evolve.

2.96 The Working Group recalled that the terms of reference for such a workshop have already been drafted (SC-CAMLR-XXXVII, Appendix 8, paragraph 4.36), however, may need to be revised given the recent developments in the krill management approach. It further noted that such revisions should include consideration that an expanded CEMP provides data required to inform spatial distribution layers for higher trophic level predators in key areas, and for winter periods where data gaps are largest.

2.97 The Working Group agreed that the terms of reference should be further developed in the 'CCAMLR Ecosystem Monitoring Program (CEMP)' e-group and refined during WG-IMAF and WG-FSA, as many CEMP participants will be attending these meetings. Following these discussions, it is intended a complete workshop proposal be developed, inclusive of conveners, timing and location, to be considered by the Scientific Committee.

2.98 The Working Group discussed a number of CCAMLR activities requiring ecosystem monitoring in addition to management of the krill fishery through CEMP, including MPAs (paragraphs 3.8 to 3.15), vulnerable marine ecosystems (VMEs) (paragraphs 3.61 to 3.66) and climate change (paragraphs 4.1 to 4.9). Noting the breadth of these monitoring needs and the large amount of work required, the terms of reference for the CEMP enhancement workshop will need to define the scope of the workshop in relation to which of these monitoring needs will be addressed.

2.99 The Working Group also recognised the need to develop sustainable funding mechanisms for the CEMP work required to deliver and maintain the krill fishery management approach. This could be developed using contributions to the CEMP Special Fund and the CCAMLR General Capacity Building Fund.

2.100 WG-EMM-2022/22 presented a preliminary review of data obtained from the Ukrainian monitoring program across three CEMP sites (Peterman Island, Galindez Island and Yalour Island). Results indicated a small number of nestlings were observed, possibly the result of an unusually large amount of snow and unfavourable ice conditions. Updated CEMP data for the 2021/22 breeding season will be submitted to the Secretariat when completed.

2.101 The Working Group welcomed the preliminary contributions and synthesis of the observations, and invited interested Members to contact the authors directly as there was not sufficient time to discuss the paper in plenary.

2.102 WG-EMM-2022/P01 described results from the long-term monitoring of the diets of breeding macaroni penguin (*Eudyptes chrysolophus*) and eastern rockhopper penguin (*E. filholi*) between 1994 and 2018. The study found substantial overlap in diets with annual variations in relative prey contribution, however, no significant long-term changes were detected when compared with previous literature. Changes in the relative proportions of prey were considered unlikely to account for the recent declines in these populations.

2.103 The Working Group thanked the authors for the analysis of this long-term dataset and acknowledged its value in contributing towards the krill management approach. Due to the time constraints imposed by the virtual meeting, there was not sufficient time to discuss further questions pertaining to this paper.

Spatial management

3.1 WG-EMM-2022/45 requested CCAMLR to review the management plan for the Antarctic Specially Protected Area (ASPA) that would result from the proposed merger of ASPA No. 152 (Western Bransfield Strait) and ASPA No. 153 (Eastern Dallmann Bay) for consideration by the Committee for Environmental Protection (CEP) following Antarctic Treaty Consultative Meeting (ATCM) Decision 9 (2005).

3.2 The Working Group recalled the significant amount of research already undertaken in this area and noted that this proposal provided an opportunity to communicate results with relevant CCAMLR stakeholders. The Working Group noted that the proposals sought to allow unimpeded transit of vessels and benthic protection of waters deeper than 20 m. The proposal included a minor increase in the size of the protected areas to simplify boundaries and better align them with relevant depth contours. The Working Group requested a justification for these changes and requested regular reporting of scientific studies conducted in ASPAs.

3.3 The Working Group supported the revised management plan for ASPA No. 152 and No. 153 and referred it for consideration to the Scientific Committee.

3.4 WG-EMM-2022/08 presented a management plan for ASPA No. 145 Port Foster, Deception Island and SSI. The revised management plan incorporates a new sub-site, considered to be a biodiversity hotspot for benthic fauna. This new sub-site of Deception Island is between 0 and 50 m depth and has been named sub-site C.

3.5 The Working Group considered this proposal, highlighting the importance of continuing scientific research of this nature which increases understanding of unique biological hotspots of ecological significance.

3.6 The Working Group supported the revised management plan proposal for ASPA No. 145 and referred it for consideration to the Scientific Committee.

3.7 The Working Group requested the Scientific Committee and Commission give further consideration to the process for engagement with the ATCM on the development of new or revised ASPAs with only a marine area.

3.8 WG-EMM-2022/44 presented a study which tracked Adélie penguins (*Pygoscelis adeliae*) from the Ardley Island CEMP site in the SSI. Preliminary results showed that habitat use during the breeding stage was concentrated in Subarea 48.1, while during the post-breeding and moulting stage, habitat use was in Subareas 48.1, 48.2 and 48.5 during winter. Results highlighted the importance of this data for protection and conservation proposals such as the D1MPA and the Weddell Sea MPA.

3.9 The Working Group welcomed the preliminary results from this paper, acknowledging the difficulties in linking local area management with large-scale processes. Further, the Working Group recognised the value of information concerning the movement of juvenile and non-breeding predators and welcomed further studies targeting the tracking of multiple colonies. The Working Group noted the importance of continuing this study to assist in filling gaps in winter distributions, in addition to revealing ecosystem interactions during other life stages of Adélie penguins.

3.10 WG-EMM-2022/33 presented a report from recent scientific expeditions from a small research vessel (i.e. 23 m) in the Western Antarctic Peninsula, Gerlache Strait and surroundings. The value of this research was emphasised through the provision of biodiversity data from places that large research vessels cannot easily reach, and obtained using a range of methods.

3.11 The Working Group welcomed the results of this study and acknowledged its importance in contributing to the development of new ways to observe ecosystems. The Working Group noted progress with similar efforts to develop autonomous vehicles and using ships of opportunity to help long-term monitoring of the CAMLR Convention Area.

3.12 WG-EMM-2022/03 presented a methodology employing baited remote underwater video systems to survey fish and identify benthic organisms at depths that are not well-studied due to technology restrictions. The survey was conducted in Silverfish Bay, which is located near the Italian and Korean research stations in the Ross Sea region MPA (RSRMPA) general protection zone (i). The surveys were analysed using video data collected during 2017 and 2018 and found 26 taxa belonging to four phyla identified from the video data and associated with habitat morphology.

3.13 The Working Group welcomed the preliminary results from this paper, noting the area is of high ecological value and the technique represents an efficient way to bring new information on the characterisation and locations of diverse benthic communities to the discussion on VME management in other areas as well. The Working Group noted that the local area of the research was near several notified VMEs in Silverfish Bay, some of which are in ASPA No. 161 and knowledge of the benthos described by the survey may better inform the distribution of fragile habitats in the area.

3.14 WG-EMM-2022/40 presented a multi-year NASA-funded project designed to produce data layers of polynyas at a circum-Antarctic scale. The project is developing novel methods to aid in the classification and quantification of polynyas as they can be important drivers of ecosystem processes.

3.15 The Working Group thanked the author for providing valuable inputs to discussions concerning the ecological value of polynyas in the broader Southern Ocean ecosystem and looked forward to the results, especially regarding how polynyas develop and may move along the coast seasonally. The Working Group noted the authors' intention to develop a data portal to make the data layers available to the CCAMLR community once completed.

3.16 The Working Group noted that both WG-EMM-2022/03 (Dr E. Carlig, Itlay) and WG-EMM-2022/40 (Ms Z. Sylvester, Belgium) were led by current CCAMLR scholarship recipients. The Working Group noted that despite challenges due to COVID restrictions, the projects have been successful and the CCAMLR scholarship scheme was an essential part of the Scientific Committee's capacity building strategy and drew attention to the continued success of this program to the Scientific Committee.

3.17 WG-EMM-2022/10 presented the report of a workshop on pelagic regionalisation held virtually in June 2022, which focused on determining pelagic ecoregions by combining abiotic and biotic variables to classify the ecological areas of the Indian Ocean sector between 20°W to 160°E and 30°S (includes waters between subtropical and sub-Antarctic areas).

3.18 The Working Group welcomed the paper and considered the results important to evaluate various assemblages across many regions, especially in relation to climate change and the linkages made by species that migrate long distances between the subtropical and the northern part of the Southern Ocean. The Working Group suggested that it would be important for future work to expand the analyses to a larger scale to include more southern areas.

3.19 The Working Group noted that multi-Member collaborations, which can be leveraged by CCAMLR, and funding sources from non-governmental organisations have been a productive model for progressing important topics that are too complex to progress at CCAMLR meetings. The Working Group encouraged more use of this model in progressing issues and encouraged collaboration among Members.

Data analysis supporting spatial management approaches in CCAMLR

3.20 WG-EMM-2022/26 Rev. 1 reported findings from a recent multi-vessel sightings survey carried out as part of the International 2019 Area 48 Survey for Krill. Results demonstrated that the fin whale (*Balaenoptera physalus*) abundance in the area is increasing since the CCAMLR-2000 Survey period, an important consideration for the development of the krill management approach.

3.21 The Working Group welcomed this paper and noted that the assumed fin whale foraging time in the area (120 days) is based on data from the early 1980s and may be an underestimate as fin whales are known to forage around South Georgia through winter. The Working Group considered that whale tagging data could be used to update the estimated seasonal foraging duration of baleen whales in Area 48 for use in estimating krill consumption.

3.22 The Working Group noted that humpback whale (*Megaptera novaeangliae*) and blue whale (*B. musculus*) populations in Area 48 have also been reported to be recovering. The Working Group further noted that the distribution of the fin whales overlaps with the krill fishery around Subarea 48.2 and that fin whales likely account for a substantial amount of krill removal, which should be considered in the krill management approach and during the proposed CEMP workshop (paragraph 2.95).

3.23 The Working Group noted that the International Whaling Commission (IWC) is developing a Southern Hemisphere fin whale assessment and looked forward to having that information submitted to future working group meetings.

3.24 WG-EMM-2022/35 presented the first biological description of Welchness Cape, Dundee Island. Preliminary results from seabird and marine mammal surveys were reported with the aim to generate baseline data at this site to support decision-making regarding conservation and environmental management, and future research and monitoring initiatives such as those planned for the currently proposed D1MPA.

3.25 The Working Group welcomed the paper and noted the large number of observations of Antarctic fur seals relative to those reported at Cape Shirreff in WG-EMM-2022/42 Rev. 1. The Working Group noted the report that mainly skinny juveniles were observed and that the number represents the number of observations and not necessarily the presence of 3 000 individuals.

3.26 WG-EMM-2022/P14 and 2022/15 presented detailed information regarding the discovery of a breeding colony of notothenioid icefish (*Neopagetopsis ionah*, Nybelin 1947) of globally unprecedented extent observed in the southern Weddell Sea during the Continental Shelf Multidisciplinary Flux Study expedition from February to March 2021 on board the *Polarstern*. The colony was estimated to cover at least 240 km^2 of the eastern flank of the Filchner Trough, and comprised fish nests at a density of 0.26 nests m^{-2}, representing an estimated total of ~60 million active nests and associated fish biomass of over 60 000 tonnes. This discovery provides support for the establishment of a regional MPA.

3.27 The Working Group congratulated the authors for the discovery of this significant ecological feature which attracted interest from the general marine biology community and the public at large. The Working Group noted that despite extensive work in the Weddell Sea, discovery of the icefish spawning site was accidental and it is likely that other spawning sites with similar significance are still to be discovered. The Working Group noted that small numbers of nests for *N. ionah* have been observed in very different habitats in other areas and that nesting areas for other icefish species are also likely to be discovered in the future. The Working Group further noted the importance of protecting clearly defined spawning areas in terms of conservation and stock management and encouraged that further research be conducted.

3.28 The Working Group recommended that the recently discovered icefish spawning area should be protected in a timely manner, and that a suitable mechanism is needed to enable this.

3.29 The Working Group noted that protecting the icefish spawning area in the more immediate term could potentially be provided, for example by expanding CM 22-06 on VMEs to include fish nesting areas, or through the creation of a conservation measure dedicated to the protection of essential fish habitats. The Working Group invited interested participants to continue discussion of protection for important areas such as this spawning site in the 'Vulnerable Marine Ecosystems Review' e-group.

3.30 WG-EMM-2022/43 presented the Eastern Weddell Sea Observation System (EWOS), a new multinational initiative to provide coordinated and systematic observations in the Eastern Weddell Sea. An EWOS pilot study was carried out on board the *Polarstern* in March–April of 2022 which will provide unique quantitative information for integrated ecosystem functions such as carbon export and secondary production.

3.31 The Working Group congratulated the authors of the paper on the success of the pilot study and noted that the project represented an excellent example of scientific collaboration between Members. The Working Group strongly supported the continuation of the project as it contained many novel scientific approaches such as vertically integrated sampling within a well-defined and diverse region in the Weddell Sea. Ecosystem components sampled included characterising flying seabirds, air breathing predators, fish and invertebrates within and under sea ice, under ice shelves, in the water column, on the seafloor and under the seafloor. These approaches had the potential to greatly increase the scientific knowledge of the Weddell Sea region and contribute to environmental monitoring and management by CCAMLR.

3.32 The Working Group noted that while using a larger rectangular midwater net might allow for better sampling of pelagic fish, the M-RMT net which was used, allows for comparison of the krill data with previous surveys. The Working Group noted that the highest krill density was encountered in the deepest sampling layer (200–500 m), which is deeper than most maximum sampling depths of krill surveys.

3.33 The Working Group noted that this multidisciplinary international research made use of innovative technology such as under-ice sampling techniques. The Working Group noted that this approach to research could be used as a model that could be aspired to in other areas.

3.34 The Working Group noted, but did not discuss, WG-EMM-2022/P03, which presented the latest krill biomass estimate for Area 48 from the international large-scale 2019 Area 48 Survey. Following the acoustic transects of the CCAMLR-2000 Survey, survey vessels were provided by Norway, the Association of Responsible Krill harvesting companies and Aker BioMarine AS, the UK, Ukraine, Republic of Korea and China. Biomass was estimated to be 62.6 million tonnes (mean density of 30 g m^{-2} over 2 million km^2) with a sampling CV of 13%. The highest mean krill densities were found in the SOI stratum (93.2 g m^{-2}) and the lowest in the South Georgia Island stratum (6.4 g m^{-2}).

Research and monitoring plans

3.35 WG-EMM-2022/36 presented the initial steps undertaken by Argentina and Chile to map the extensive research developed and underway by CCAMLR Members in the West Antarctic Peninsula and South Scotia Arc, which can contribute to the development of a research and monitoring plan (RMP) for the proposed D1MPA. The paper provided a preliminary survey that responds to the need of developing a comprehensive, multinational and open RMP while contributing to other initiatives such as the krill management strategy and the CCAMLR MPA Information Repository (CMIR). The survey will be shared through the

D1MPA Expert Group for general suggestions and subsequently distributed more widely. The proponents encourage broad participation by other Members and stakeholders to this initiative.

3.36 The Working Group thanked Argentina and Chile for undertaking a survey to catalogue the research that has the potential to contribute towards an RMP for the D1MPA proposal and encouraged participation by interested parties.

3.37 WG-EMM-2022/30 presented data on the spatial distribution, density and size composition of two species of salps (family Salpidae) in Subarea 48.1, from a Russian survey conducted in January–March 2020 by the vessel *Atlantida*.

3.38 The Working Group noted that some studies in the scientific literature have suggested that salps may replace krill as the dominant species in the Antarctic due to the effects of climate change. The results from this study suggested that salps were constrained to coastal areas, with very little presence of salps in research hauls conducted offshore. The Working Group encouraged further analysis to explore spatial relationship with environment conditions and studies on *Ihlea racovitzai* as little is known about the life history of this species.

3.39 WG-EMM-2022/04 presented a summary of research on euphausiid larvae and salps conducted by Argentina during the summer seasons of 2019 and 2020 in waters off the West Antarctic Peninsula (Mar de la Flota/Bransfield Strait) and Elephant Island surroundings. During 2019, *E. superba* and bigeye krill (*Thysanoessa macrura*) abundances were very high, while during 2020 all euphausiid larvae had very low densities. Salp densities showed an opposite pattern. The paper correlated the changes in abundance with environmental conditions (satellite chlorophyll-*a* and water masses properties).

3.40 The Working Group welcomed the study and noted that investigating the correlations between different species as well as links to environmental variables in the data could provide valuable ecosystem information.

3.41 WG-EMM-2022/37 provided the first summary of projects within the CMIR and offered potential revisions to the structure of the repository to better align it with its intended use. It noted the highly collaborative nature of the CMIR with 20 Members, two States and seven Cooperating Parties partnering with submitted projects and suggested that revisions to the CMIR structure could assist in communicating progress in MPA-related research and in developing routine reporting.

3.42 The Working Group welcomed this paper, recognising the usefulness of the summary to map research activities supporting the RSRMPA, while also noting that this project list may not be representative of all Member research effort occurring in the area as it was driven by reports of activities from four Members and other research effort may not have been reported.

3.43 The Working Group noted that WG-EMM-2022/37 included a compilation of Member-submitted activities, as well as the current CMIR database as supplemental files and that the activity reports would be made available on the CMIR website.

3.44 The Working Group considered recommendations to improve the CMIR design, suggesting the development of categorical variables to be included in project reporting to improve accessibility for key metrics such as collaboration, geographic areas and key species investigated, in addition to providing the CMIR as an open-access resource for the wider scientific community. The Working Group suggested continuing discussion on aligning CMIR structure and function via the ‘RSRMPA Member activities 2022’ e-group.

3.45 WG-EMM-2022/47 presented the research and monitoring contributions by the Republic of Korea in the Ross Sea region in support of CM 91-05. The paper reported progress by the 'Korea Ecosystem Structure and Function of Marine Protected Area in Antarctica' program, by presenting a list of 15 datasets submitted to the CMIR, reporting on CEMP data collected at Cape Hallett, and providing summaries of 17 peer-reviewed scientific papers.

3.46 The Working Group welcomed this paper, acknowledging the value of the research in contributing information to the limited genetic database available for zooplankton species in the Southern Ocean. The data are freely available with access provided through the Korean Polar Data Centre, for which the Working Group expressed its appreciation for such transparency.

3.47 Many participants also noted their willingness to collaborate with Korea to continue progressing this work, in particular to contribute to the development of methods to monitor zooplankton.

3.48 The Working Group recalled the RMP for the Ross Sea region, noting the importance of undertaking research on all five designated geographic areas to address key indicators established within the plan.

3.49 WG-EMM-2022/14 presented an overview of the research activities conducted in the RSRMPA since its establishment, which were supported by the Italian National Antarctic Research Programme. A significant amount of work focused on environmental pollution, which is not a current focus of the management framework for MPAs.

3.50 The Working Group welcomed this paper, noting the significant contributions to the development of best practices and standardised procedures for research in the RSRMPA, in addition to the significant opportunity for collaboration among Members.

3.51 The Working Group further noted that this research enables the generation of various research opportunities for Members to develop future research plans based on agreed objectives, in addition to addressing emerging stressors to MPAs and the broader marine ecosystem, such as marine pollution and climate change.

3.52 WG-EMM-2022/P04 presented a study which investigated spatio–temporal distributions of the epipelagic meso-zooplankton community in the western RSRMPA based on three surveys conducted in the late summers of 2018, 2019 and 2020. The study also documented the drivers of the succession in zooplankton community structure within the area.

3.53 The Working Group welcomed the paper, noting the importance of increasing the understanding of the ecological role of meso-zooplankton for management of both MPAs and fisheries in the RSRMPA.

3.54 The Working Group recalled the opportunity for collaboration as requested within the presentation, with many participants noting their support of the coordination of this research in the RSRMPA as well as in other areas such as the East Antarctic ecosystem.

3.55 WG-EMM-2022/P13 presented a statistical model that evaluates the sea-ice cover with two measures: accessibility (i.e. the probability that a given area is navigable by vessels at a given time) and repeated accessibility (i.e. the probability that a given area is navigable by vessels at a given time and again at least once within a defined timespan). Such a tool may facilitate the planning of research and monitoring activities in the Southern Ocean, as well as in Arctic seas.

3.56 The Working Group welcomed the technique and considered it a useful tool to provide an overview of sea-ice and invited interested Members planning research to contact the authors directly as there was not sufficient time to discuss the paper in full.

3.57 WG-EMM-2022/P05 presented a study of metabarcoding methods to analyse plankton samples obtained during February 2018 and January 2019 from the Ross Sea region. The results indicated that zooplankton assemblages were highly diverse within sample sites and the authors concluded that as metabarcoding data accumulate, better insights will be gained into zooplankton communities and their ecological implications in the Ross Sea region.

3.58 WG-EMM-2022/P06 and 2022/P07 presented a study which reconstructed chlorophyll-*a* concentration data using machine learning-based models. Based on comparison with in-situ observations, the results of the chlorophyll-*a* reconstructions by the models proved to be relatively more accurate than satellite observations. WG-EMM-2022/P07 suggested that the random forest model would allow for studying multiple characteristics of phytoplankton dynamics more quantitatively, such as bloom initiation/termination timings and productivity peaks, as well as the variability in time scales of phytoplankton growth.

3.59 In the time available for the meeting, the Working Group was unable to discuss the published papers and invited interested Members to contact the authors directly.

3.60 The Working Group also noted that no projects have been uploaded towards the South Orkney Islands southern shelf MPA. Dr Zhao expressed disappointment over the lack of effort towards updating projects on the CMIR for this MPA in particular.

Vulnerable marine ecosystem data

3.61 WG-EMM-2022/34 presented a proposal for a new site to be considered as a VME off Cape Well-Met in Subarea 48.1. Citizen science was successfully employed with the use of video imagery via a tourist-deployed submarine, which was used to identify a high abundance and diversity of sponges, with species such as hexactinellids archetypical of a VME.

3.62 WG-EMM-2022/46 presented observations of benthic ecosystems collected during 10 submarine dives in Subarea 48.1 in 2022. Seven sites are proposed as VMEs based on high abundances of VME indicator taxa, which in many cases, exceeded abundances of previously registered VMEs. Seven of the 10 dives had characteristics similar to three VMEs registered in 2018 (see WG-EMM-18/35).

3.63 The Working Group noted that these results could be indicative of the presence of additional VMEs in other areas of the Antarctic Peninsula, and that photographs and videos provide baseline information that would be valuable to monitor changes in these communities through time.

3.64 The Working Group noted the utility of citizen science as demonstrated by the study and considered the potential of employing a random sampling design to enable an unbiased study of VME extent and distributions. The Working Group also noted that future citizen science efforts using tourist submarines are in development and that citizen science could be a powerful tool to aid in this work and in the monitoring of VMEs for changes over time.

3.65 The Working Group considered the proposal, noting the abundance of VME indicator taxa discovered, and recommended that these proposed VME sites be included in the CCAMLR VME registry.

3.66 The Working Group further noted the importance of findings of this nature, that they are likely to increase in the future, and agreed that more extensive VME discussions, including to develop standard methodologies and quantitative parameters to monitoring the evolution of those benthic communities, could be progressed through the established 'Vulnerable Marine Ecosystems Review' e-group.

Climate change

4.1 WG-EMM-2022/12 and 2022/13 together presented recent analyses combining observations and model outputs to assess future trends in the southern Indian Ocean due to climate change. The study reported on the projected long-term ocean warming and increased frequency and intensity of marine heatwaves north of the ACC, noting faster projected climate velocities (i.e. drift velocity of isotherms) in mesopelagic than surface waters and increased primary productivity. The authors noted that the choice of mitigation strategies (scenario SSP1-2.6 vs SSP2-4.5) will have significant impacts in the long term.

4.2 The Working Group noted the relevance of this analysis to the work of CCAMLR and encouraged similar studies south of the ACC be conducted (e.g. Montie et al., 2020). It welcomed the compelling, global-scale visuals presented and highlighted the importance of the mesopelagic zone to Antarctic krill early life history, noting that in addition to temperature, climate-change induced ocean acidification was an issue of concern for Antarctic krill early life stages (e.g. Kawaguchi et al., 2013). The Working Group noted that it was timely to consider projected climate change impacts in the current context of the revision of the krill fishery management approach, and that CCAMLR should aim to develop management approaches that incorporate the effects of climate change.

4.3 WG-EMM-2022/20 reported on the update by SCAR to its Antarctic Climate Change and the Environment decadal report, to draw the Working Group's attention to the evidence for, and implications of, climate change impacts on the Antarctic environment. The report includes recommendations on the most urgent research required for the region, and elements of particular relevance to CCAMLR were highlighted.

4.4 The Working Group noted this important report and its relevance to CCAMLR's scientific work.

4.5 WG-EMM-2022/19 presented a proposal for WG-EMM and WG-FSA to consider contributing to the development of a workshop which would focus on the integration of research on climate change and ecosystem interactions within CCAMLR's scientific work. The authors requested feedback on the draft structure and on the proposed terms of reference of the workshop.

4.6 The Working Group welcomed the proposal and received an update of an upcoming proposal to the Scientific Committee for a joint SC-CAMLR–CEP climate change workshop based on the recommendations from the previous joint workshop held in 2016. In addition, the Working Group also noted a Southern Ocean Observing System workshop to be held in 2023 where these topics could also be discussed.

4.7 The Working Group supported these collaborative workshop ideas as a means to assist in defining necessary monitoring efforts, as well as clearly identifying topics to be addressed by working groups under their relevant agenda items. While welcoming the invitation of external experts and observers, the Working Group indicated that organisers would benefit from developing a workshop proposal that includes all the necessary information needed by the Scientific Committee before the 2022 meeting to ensure approval. The Working Group noted that such a workshop would enhance international collaboration and data sharing. Furthermore, if the workshops were to be held virtually and clearly defined series of sessions were organised, it would enhance opportunities for Member participation.

4.8 The Working Group agreed that CCAMLR scientists should collaborate on the development of indicators using available information and analyses (e.g. from scientific surveys, satellite observations, model outputs, fishery data and CEMP data) to monitor and document the status of the ecosystem in general and its marine living resources in particular. Such work, conducted by Members with support from the Secretariat, would be made publicly available.

4.9 The Working Group noted the existence of a 'Climate change impacts and CCAMLR' e-group to initiate discussion and collaborations to develop the workshop and related climate change work.

Other business (incl. review of the terms of reference and Scientific Committee draft work plan and WG-EMM priorities)

Chair's report of the Scientific Committee Symposium

5.1 On behalf of the Chair of the Scientific Committee, Dr Parker presented the report of the CCAMLR Scientific Committee Symposium, which was held virtually on 8 and 10 February 2022 (WG-ASAM-2022/01). The informal Scientific Committee meeting discussed the progress and outcomes from the first CCAMLR Scientific Committee's workplan (SC-CAMLR-XXXVI/BG/40) and provided an opportunity for participants to propose long-term priorities and strategies to inform the development of the next five-year strategic plan (2023–2027). Recommendations and plans will be refined during the intersessional period by all working groups and agreed at SC-CAMLR-41 according to the Scientific Committee's Rules of Procedure. Additionally, the terms of reference for WG-EMM were presented and discussed to identify if they were still fit for purpose.

5.2 The Working Group welcomed and endorsed such an approach that will enable the working groups and the Scientific Committee to identify and focus their efforts on priority work. The Working Group undertook to review the priority research topics presented in Table 2 of the document (WG-ASAM-2022/01) and preliminary discussions and recommendations for work sequencing took place. However, due to the time constraints of the meeting, the review of the priority research tasks was only partially completed.

5.3 The Working Group noted that the WG-EMM terms of reference pre-dated both WG-SAM and WG-ASAM, had been formulated when WG-EMM was created by combining WG-Krill and WG-CEMP, and were still relevant given the current workplan of the Working Group. It further noted that a holistic approach to reviewing the terms of reference for all CCAMLR working groups by the Scientific Committee was a desirable approach as the Scientific Committee is ultimately responsible for tasking the working groups to manage cross-cutting issues.

5.4 The Working Group recommended that the Scientific Committee allocate topics to specific working groups to aid Members in scheduling work and making sure scientists with appropriate expertise are available at the appropriate working groups.

5.5 The Working Group undertook to continue progressing the review of tasks related to WG-EMM, develop a sequence of tasks for WG-EMM over the next five years, and suggest revisions to the WG-EMM terms of reference (including recommendations from paragraph 2.18) through the 'Scientific Committee Symposium 2022' e-group, with results to be integrated from WG-ASAM, WG-SAM and WG-EMM by the Chair of the Scientific Committee along with direct advice from WG-IMAF and WG-FSA and presented at SC-CAMLR-41.

5.6 The Working Group also noted the advantages of detailed articulation of complicated arguments in the report text, especially when different views existed, in aiding of mutual understanding and expediting report adoption.

Data access rules (Data Services Advisory Group)

5.7 The Working Group noted WG-ASAM-2022/15 which describes the implementation of the Rules for Access and Use of CCAMLR Data (hereafter referred to as 'the Rules') in CCAMLR data request procedures, and the procedure for publication of derived materials in the public domain.

5.8 The Working Group welcomed the paper and recalled that the paper had previously been discussed during the SC Symposium, WG-ASAM and WG-SAM (WG-ASAM-2022/01, paragraphs 5.1 to 5.7; WG-SAM-2022, paragraphs 8.1 to 8.3) and is open for consideration in the 'Data Services Advisory Group' e-group.

5.9 The Working Group discussed assigning digital object identifiers (DOIs) to data extracts and noted that this would be a practical approach to create a stable citable reference to the specific subset of data that was used to conduct analyses whether presented in a working group paper or a peer-reviewed paper. The Working Group further noted that assigning a DOI to a dataset or data extract requires the creation of a public metadata record but does not require the data themselves to be publicly available.

5.10 The Working Group discussed data use and noted that upon release the data are only authorised for use for the purposes cited in the data request that was presented to the data owners for approval.

5.11 The Working Group considered whether the Rules should include guidelines towards handling of personal private information, and noted that discussion on this topic should not be guided by specific regulations that apply to one specific region.

5.12 The Working Group agreed that for compliance data (including Catch Documentation Scheme for *Dissostichus* spp. and transhipment data) endorsement for the request and approval for release are to be sought from the Commissioner or an alternate appointed by the Commissioner.

5.13 The Working Group recommended that:

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

(ii) the Secretariat reduces the length of the data request procedure to two weeks after the abovementioned alternate representatives have been identified

(iii) the Rules be modified to explicitly clarify the restrictions for using the data and the responsibilities of the data requester.

Other business

5.14 WG-EMM-2022/23 Rev. 1 presented results from a fishery-dependent study of zooplankton to document species composition and abundance in Subareas 48.1, 88.1 and 88.2. Results agreed with those typical of Antarctic waters, indicating copepods (and copepod eggs) to be the most diverse group, followed by Euphausiacea.

5.15 The Working Group welcomed the presentation of research on zooplankton, a key component of energy transfer in the ecosystem, noting that species identification is a very time-consuming and specialist task, and that sampling zooplankton requires significant sampling effort given their patchy distribution. The Working Group noted that the high abundances of copepod early life stages and eggs were potentially informative of linkages between the Weddell Sea and the Bransfield Strait. While noting the ongoing development of genetic identification methods by Korea and New Zealand, the Working Group encouraged the collaborative development and updating of species identification keys for the Southern Ocean by CCAMLR scientists. The Working Group further noted SCAR's compilation of identification keys (https://www.biodiversity.aq/find-data/identification-keys-resources/) as well as the existence of other sources (e.g. NIWA, ANARE and the Boltovskoy key for the South Atlantic). The Working Group also highlighted the important role that the CCAMLR General Science Capacity Fund has played in supporting such studies.

5.16 WG-EMM-2022/24 presented results from oceanographic research undertaken in the Weddell Sea from 2018 to 2021. The utility of surveys using fishing vessels was emphasised given the ease of gathering data without specialised equipment. A decrease in average water temperature in Subareas 48.1 and 48.2 was noted, however, further investigation was deemed necessary.

5.17 The Working Group thanked the authors for presenting the study and noted the excellent collaboration between the fishing industry and scientists in using fishing vessels as research platforms as evidenced in both WG-EMM-2022/23 Rev. 1 and 2022/24.

5.18 The Working Group discussed the proposed workplan to develop data collection needs for CCAMLR krill fisheries (WG-EMM-2022/39, paragraphs 2.9 and 2.10), noting that the timing and content for the proposed workshops were uncertain due to COVID restrictions in the krill observer workshop host country (China), and that both WG-IMAF-2022 and WG-FSA-2022 may request additional data collection requirements. The Working Group agreed to progress with the workplan and identify the number and venues for the necessary workshops in a dedicated e-group.

5.19 Dr N. Kelly (Australia) provided an update on recent IWC–CCAMLR collaboration, noting the attendance of Dr D. Welsford (Chair of the Scientific Committee), Mr N. Walker (New Zealand) and Dr Parker at the IWC SC68D meeting, and that discussions regarding whale by-catch in the krill fishery were undertaken in the IWC Human Induced Mortality (HIM) subgroup. Dr Kelly further noted that the aim of the collaboration would be to facilitate information exchange, to help facilitate both desk-based and fieldwork opportunities for collaboration between CCAMLR and IWC scientists, and that these could be further developed in an e-group. Dr Kelly also encouraged delegations to involve cetacean scientists from their own countries in CCAMLR activities as appropriate.

5.20 The Working Group noted that the IWC HIM subgroup has undertaken to submit a report to WG-IMAF regarding the whale by-catch events, and that following the discussions at SC-CAMLR-40, cetacean experts could attend WG-IMAF as part of CCAMLR Member delegations.

Advice to the Scientific Committee and future work

Future work

6.1 The Working Group requested that the Scientific Committee consider incorporating the following topics into the strategic workplan for WG-EMM:

Krill management –

(i) update the CCAMLR gear library for krill (paragraph 2.23)

(ii) acquire and incorporate data from surveys conducted by Peru (paragraphs 2.29 and 2.48)

(iii) progress the development of biomass estimates for strata and subareas (paragraphs 2.34 and 2.35)

(iv) progress data collection protocols to support the krill management approach (paragraphs 2.10 and 2.61)

(v) convene a workshop to develop a krill stock hypothesis (paragraphs 2.43 and 2.89) which would provide:

(a) a framework for interpreting patterns observed in survey and fishery data
(b) a tool to direct surveys and analytical efforts

(vi) coordinate with the CEP on a climate change workshop (paragraphs 4.6 to 4.8)

(vii) collaborate with the IWC to better include cetacean expertise in future working group meetings (paragraph 3.23).

Ecosystem monitoring –

(viii) convene a workshop to update CEMP to support fishery management and MPA objectives (paragraph 2.95)

(ix) develop integrated ecosystem reporting mechanisms (paragraphs 2.18 and 4.8).

Advice to the Scientific Committee

6.3 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) krill workplan and workshop (paragraphs 2.10, 2.43 and 2.44)

(ii) focus topic cycling and reporting (paragraphs 2.18 and 5.4)

(iii) gear library update (paragraph 2.23)

(iv) revise catch limits for krill (paragraphs 2.29, 2.34 and 2.35)

(v) include SSI fur seals in risk analysis and D1MPA proposal (paragraph 2.80)

(vi) revision of CM 51-07 and krill stock hypothesis workshop (paragraphs 2.43, 2.89 and 2.90)

(vii) CEMP workshop and funding mechanisms (paragraphs 2.95 and 2.99)

(viii) ATCM and marine ASPAs (paragraphs 3.3 and 3.6)

(ix) scholarship scheme (paragraph 3.16)

(x) IWC collaboration (paragraph 3.23)

(xi) protection of fish nesting areas (paragraph 3.28)

(xii) consider VME designation (paragraph 3.65)

(xiii) consider developing a workshop on climate change (paragraphs 4.6 and 4.7)

(xiv) data access rules (paragraphs 5.12 and 5.13).

Adoption of the report

7.1 The report of the meeting was adopted.

7.2 At the close of the meeting, Dr Cárdenas thanked all participants for their hard work and collaboration that had contributed greatly to the successful outcomes from WG-EMM this year, and the Secretariat, the stenographers and the Interprefy support team for their assistance. Dr Cárdenas further noted that although the length of the meeting had been shorter than an in-person event, a large body of work had been accomplished through the e-groups and a considerable future workplan developed for WG-EMM.

7.3 On behalf of the Working Group, Dr Watters thanked Dr Cárdenas for his guidance during this foreshortened meeting, the Secretariat for its work compiling the report, and the stenographer and the Interprefy team for the technical support provided. The Working Group acknowledged the successful use of the Interprefy platform for hosting the meeting, and the provision of advice to the Scientific Committee.

References

de la Mare, W.K. 1994. Estimating krill recruitment and its variability. *CCAMLR Science*, 1: 55–69.

Kawaguchi, S., A. Ishida, R. King, B. Raymond, N. Waller, A. Constable, S. Nicol, M. Wakita and A. Ishimatsu. 2013. Risk maps for Antarctic krill under projected Southern Ocean acidification. *Nature Clim. Change*, 3: 843–847, doi: https://doi.org/10.1038/nclimate1937.

Krüger, L., M.F. Huerta, F. Santa Cruz and C.A. Cárdenas. 2021. Antarctic krill fishery effects over penguin populations under adverse climate conditions: Implications for the management of fishing practices. *Ambio*, 50: 560–571, doi: 10.1007/s13280-020-01386-w.

Montie, S., M. Thomsen, W. Rack and P. Broady. 2020. Extreme summer marine heatwaves increase chlorophyll a in the Southern Ocean. *Ant. Sci.*, 32(6): 508–509, doi: 10.1017/S0954102020000401.

Plaganyi, E.E. and D. Butterworth. 2012. The Scotia Sea krill fishery and its possible impacts on dependent predators: modelling localized depletion of prey. *Ecol. Appl.*, 22: 748–761.

Watters, G.M., S.L. Hill, J.T. Hinke, J. Matthews and K. Reid. 2013. Decision-making for ecosystem-based management: evaluating options for a krill fishery with an ecosystem dynamics model. *Ecol. Appl.*, 23: 710–725.

Watters, G.M., J.T. Hinke and C.S. Reiss. 2020. Long-term observations from Antarctica demonstrate that mismatched scales of fisheries management and predator-prey interaction lead to erroneous conclusions about precaution. *Scientific Reports*, 10, doi: 10.1038/s41598-020-59223-919.

Table 1: Updated strata krill biomass estimates based on Table 2.6 in WG-EMM-2021/05 Rev. 1 and SC-CAMLR-40/11 using the strata area calculation method provided in WG-ASAM-2022/02. The revised values are shown in **bold**. Where multiple surveys, the overall coefficients of variation (CVs) were calculated as in WG-EMM-21/05 Rev. 1. Time periods: yall: all available years 1996–2020, y5107 = since implementation of CM 51-07 (2009–2020) and y5 = 5 years (2015–2020). Modified from WG-ASAM-2022, Table 9, after removal of option 'y3'.

Strata	Density gm^{-2}	Variance of weighted density	CV of weighted density (%)	**Revised strata area based on WG-ASAM-2022/02**	**Biomass (tonnes) based on revised strata area**	CV biomass %	Years included for averaging biomass	Number of years with surveys	Number of surveys
Joinville (JI)[1]	83.01	723.28	32.40	**23 001**	**1 909 313**	32.40	y5	1	1
Joinville (JI)	51.85	750.75	47.60	**23 001**	**1 192 602**	47.60	y5107	4	4
Joinville (JI)	37.42	410.24	46.86	**23 001**	**860 697**	49.51	yall	8	11
Elephant (EI)	85.48	253.13	22.31	**51 648**	**4 414 871**	22.31	y5	2	2
Elephant (EI)	78.45	250.21	18.64	**51 648**	**4 051 786**	18.65	y5107	5	5
Elephant (EI)	65.49	487.64	26.69	**51 648**	**3 382 428**	26.92	yall	18	27
Bransfield (BS)	54.36	204.27	30.30	**34 732**	**1 888 032**	30.30	y5	5	6
Bransfield (BS)	39.85	154.41	32.35	**34 732**	**1 384 070**	33.81	y5107	9	11
Bransfield (BS)	34.19	343.83	41.28	**34 732**	**1 187 487**	42.83	yall	21	30
South Shetland Islands West (SSIW)	47.08	166.29	26.93	**47 066**	**2 215 867**	29.85	y5	5	6
South Shetland Islands West (SSIW)	41.05	109.99	23.68	**47 066**	**1 932 059**	25.30	y5107	9	10
South Shetland Islands West (SSIW)	53.45	326.48	32.86	**47 066**	**2 515 678**	36.27	yall	21	29
Gerlache Strait (GS)[2]	58.53	**1364.31**	63.11	**44 198**	**2 586 908**	63.11	yall	1	1
Powell Basin (PB)[1]	**32.73**	**155.74**	**38.13**	**144 680**	**4 735 100**	**38.13**	yall	1	1
Drake Passage (DP)[1]	**41.53**	**40.56**	**15.33**	**294 531**	**12 233 000**	**15.33**	yall	1	1

[1] Single survey: 2019 Area 48 large-scale survey (WG-ASAM-2019).
[2] Single survey: 2020 *Atlantida* survey (WG-ASAM-2021/04 Rev. 1).

Appendix A

List of Registered Participants

Working Group on Ecosystem Monitoring and Management
(Virtual Meeting, 4 to 11 July 2022)

Convener	Dr César Cárdenas Instituto Antártico Chileno (INACH)
Argentina	Mrs Marina Abas Argentine Ministry of Foreign Affairs, Trade and Worship
	Ms Andrea Capurro Private Consultant
	Dr Dolores Deregibus Instituto Antártico Argentino/CONICET
	Dr Marco Favero National Research Council (CONICET, Argentina)
	Ms Marcela Mónica Libertelli Instituto Antártico Argentino
	Dr Enrique Marschoff Instituto Antártico Argentino
	Dr Emilce Florencia Rombolá Instituto Antártico Argentino
Australia	Dr Jaimie Cleeland Institute for Marine and Antarctic Studies (IMAS), University of Tasmania
	Dr Louise Emmerson Australian Antarctic Division, Department of the Environment and Energy
	Dr So Kawaguchi Australian Antarctic Division, Department of Agriculture, Water and the Environment
	Dr Nat Kelly Australian Antarctic Division, Department of Agriculture, Water and the Environment

	Mr Dale Maschette Institute for Marine and Antarctic Studies (IMAS), University of Tasmania
	Dr Cara Miller Australian Antarctic Division, Department of Agriculture, Water and the Environment
	Dr Colin Southwell Australian Antarctic Division, Department of the Environment and Energy
	Dr Leonie Suter Australian Antarctic Division
	Dr Simon Wotherspoon Australian Antarctic Division
	Dr Philippe Ziegler Australian Antarctic Division, Department of Agriculture, Water and the Environment
Belgium	Ms Zephyr Sylvester University of Colorado Boulder
	Dr Anton Van de Putte Royal Belgian Institute for Natural Sciences
Chile	Professor Patricio M. Arana Pontificia Universidad Catolica de Valparaíso
	Dr Lucas Krüger Instituto Antártico Chileno (INACH)
	Mr Mauricio Mardones Instituto de Fomento Pesquero
	Dr Lorena Rebolledo Instituto Antártico Chileno (INACH)
	Dr Carla Ximena Salinas Ministerio de Relaciones Exteriores
	Mr Francisco Santa Cruz Instituto Antartico Chileno (INACH)
China, People's Republic of	Mr Hongliang Huang East China Sea Fisheries Research Institute, Chinese Academy of Fishery Science

Dr Lu Liu
Yellow Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences

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 Qing Chang XU
Yellow Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences

Dr Yi-Ping Ying
Yellow Sea Fisheries Research Institute, Chinese Academy of Fishery Science

Dr Xianyong Zhao
Yellow Sea Fisheries Research Institute, Chinese Academy of Fishery Science

Mr Jichang Zhang
Yellow Sea Fisheries Research Institute, Chinese Academy of Fishery Science

Dr Yunxia Zhao
Yellow Sea Fisheries Research Institute, Chinese Academy of Fishery Science

Professor Guoping Zhu
Shanghai Ocean University

Mr Jiancheng Zhu
Yellow Sea Fisheries Research Institute, Chinese Academy of Fishery Science

France

Mrs Clara Azarian
Centre interministériel de gestion des ingénieurs des ponts, des eaux et des forêts (CEIGIPEF)

Dr Marc Eléaume
Muséum national d'Histoire naturelle

Professor Philippe Koubbi
Sorbonne Université

Germany	Professor Thomas Brey Alfred Wegener Institute for Polar and Marine Research
	Ms Patricia Brtnik German Oceanographic Museum
	Dr Jilda Caccavo Institute Pierre-Simon Laplace
	Dr Ryan Driscoll Alfred Wegener Innstitute
	Dr Stefan Hain Alfred Wegener Institute for Polar and Marine Research
	Professor Bettina Meyer Alfred Wegener Institute 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)
	Dr Laura Ghigliotti National Research Council of Italy (CNR)
	Dr Marino Vacchi IAS – CNR
Japan	Dr Taro Ichii Fisheries Resources Institute, Japan Fisheries Research and Education Agency
	Mr Tatsuya ISODA Institute of Cetacean Research
	Mr Taiki KATSUMATA Institute of Cetacean Research
	Dr Hiroto Murase Tokyo University of Marine Science and Technology
	Dr Tsutomu Tamura The Institute of Cetacean Research
Korea, Republic of	Dr Sangdeok Chung National Institute of Fisheries Science (NIFS)

	Dr Ah Ran Kim Pukyong National University
	Mr Yoonhyung Kim Dongwon Industries
	Dr Jeong-Hoon Kim Korea Polar Research Institute (KOPRI)
	Dr Hyoung Sul La Korea Ocean Polar Research Institute (KOPRI)
	Dr Haewon Lee National Institute of Fisheries Science
	Mr Kanghwi Park Jeong Il Corporation
	Dr Jinku Park Korea Polar Research Institute
	Mr Sang Gyu Shin National Institute of Fisheries Science (NIFS)
	Dr Hyoung Chul Shin Korea Polar Research Institute (KOPRI)
Netherlands, Kingdom of the	Dr Fokje Schaafsma Wageningen Marine Research
New Zealand	Mr Adam Berry Ministry for Primary Industries
	Dr Jennifer Devine National Institute of Water and Atmospheric Research Ltd. (NIWA)
	Mr Alistair Dunn Ocean Environmental
	Ms Alexandra Macdonald Department of Conservation
	Mr Enrique Pardo Department of Conservation
	Dr Matt Pinkerton NIWA

	Mr Nathan Walker Ministry for Primary Industries
Norway	Dr Martin Biuw Institute of Marine Research
	Mr Elling Deehr Johannessen Norwegian Polar Institute
	Dr Bjørn Krafft Institute of Marine Research
	Dr Cecilie von Quillfeldt Norwegian Polar Institute
Russian Federation	Dr Svetlana Kasatkina AtlantNIRO
	Mr Oleg Krasnoborodko FGUE AtlantNIRO
	Mr Aleksandr Sytov FSUE VNIRO
South Africa	Mr Makhudu Masotla DFFE
	Ms Zoleka Filander Department of Forestry, Fisheries and the Environment
	Dr Azwianewi Makhado Department of Environmental Affairs
	Dr Chris Oosthuizen University of Cape Town
	Mr Sobahle Somhlaba Department of Agriculture, Forestry and Fisheries
Spain	Dr Andrés Barbosa Museo Nacional de Ciencias Naturales, CSIC
	Mr Roberto Sarralde Vizuete Instituto Español de Oceanografía
Sweden	Dr Thomas Dahlgren University of Gothenburg

Ukraine	Dr Kostiantyn Demianenko Institute of Fisheries and Marine Ecology (IFME) of the State Agency of Melioration and Fisheries of Ukraine
	Professor Gennadii Milinevskyi Taras Shevchenko National University of Kyiv, National Antarctic Scientific Center
	Mr Valeriy PARAMONOV Institute of Fisheries and Marine Ecology
	Dr Leonid Pshenichnov Institute of Fisheries and Marine Ecology (IFME) of the State Agency of Fisheries of Ukraine
	Dr Larysa SAMCHYSHYNA Institute of Fisheries and Marine Ecology, Institute of Fisheries, NAAS
	Mr Illia Slypko Institute of Fisheries and Marine Ecology (IFME) of the State Agency of Fisheries of Ukraine
	Mr Pavlo Zabroda Institute of Fisheries and Marine Ecology (IFME) of the State Agency of Fisheries of Ukraine
United Kingdom	Dr Rachel Cavanagh British Antarctic Survey
	Dr Martin Collins British Antarctic Survey
	Dr Chris Darby Centre for Environment, Fisheries and Aquaculture Science (Cefas)
	Dr Tracey Dornan British Antarctic Survey
	Dr Timothy Earl Centre for Environment, Fisheries and Aquaculture Science (Cefas)
	Dr Sophie Fielding British Antarctic Survey
	Dr Simeon Hill British Antarctic Survey

Dr Matthew Kerr
Centre for Environment, Fisheries and Aquaculture Science (CEFAS)

Dr Jessica Marsh
Centre for Environment, Fisheries and Aquaculture Science (Cefas)

Ms Ainsley Riley
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

Dr Vicky Warwick-Evans
BAS

United States of America

Dr Jefferson Hinke
National Marine Fisheries Service, Southwest Fisheries Science Center

Dr Christopher Jones
National Oceanographic and Atmospheric Administration (NOAA)

Dr Doug Kinzey
National Oceanographic and Atmospheric Administration (NOAA)

Dr Douglas Krause
National Marine Fisheries Service, Southwest Fisheries Science Center

Ms Allyson Kristan
National Science Foundation

Dr Polly A. Penhale
National Science Foundation, Division of Polar Programs

Dr Christian Reiss
National Marine Fisheries Service, Southwest Fisheries Science Center

Dr Andrew Titmus
National Science Foundation

Dr George Watters
National Marine Fisheries Service, Southwest Fisheries Science Center

Uruguay

Mr Eduardo Juri
FUNDACIBA

Mrs Ana Laura Machado
Instituto Antártico Uruguayo

Dr Yamandú Marín
DINARA

Professor Oscar Pin
Direccion Nacional de Recursos Acuaticos (DINARA)

Professor Alvaro Soutullo
Universidad de la Republica

CCAMLR Secretariat

Belinda Blackburn
Publications Officer

Daphnis De Pooter
Science Data Officer

Gary Dewhurst
Data and Information Systems Manager

Doro Forck
Communications Manager

Isaac Forster
Fisheries and Observer Reporting Coordinator

Mitchell John
Technical Business Analyst

Angie McMahon
Human Resources Officer

Ian Meredith
Systems Analyst

Dr Steve Parker
Science Manager

Alison Potter
Data Administration Officer

Dr Stephane Thanassekos
Fisheries and Ecosystems Analyst

Thomas Williams
Database Administrator/Technical Analyst

Claire van Werven
Research, Monitoring and Compliance Analyst

Appendix B

Agenda

Working Group on Ecosystem Monitoring and Management
(Virtual meeting, 4 to 11 July 2022)

1. Opening of the meeting

2. Krill management

   2.1 Krill fishery status
   2.2 WG-ASAM advice and considerations on the krill management strategy (Biomass estimations and confidence intervals)
   2.3 WG-SAM advice and considerations on the krill management strategy (Advice on the Grym to subareas derived from exploitation rates)
   2.4 Advice from the meeting on the details of the risk analysis for Subarea 48.1, data layers, catch scenarios
   2.5 Advice to the Scientific Committee on the review of CM 51-07 and implementation of the krill management for other subareas
   2.6 CEMP

3. Spatial management

   3.1 Data analysis supporting spatial management approaches in CCAMLR
   3.2 Research and Monitoring Plans
   3.3 VME data

4. Climate change

5. Other business (incl. review of the terms of reference and Scientific Committee draft work plan and WG-EMM priorities)

6. Advice to the Scientific Committee and future work

7. Adoption of the report.

Appendix C

List of Documents

Working Group on Ecosystem Monitoring and Management
(Virtual Meeting, 4 to 11 July 2022)

WG-EMM-2022/01	Recruitment variability along the Antarctic Peninsula: What's the best way forward C.S. Reiss and G.M. Watters
WG-EMM-2022/02	Recruitment variability in Antarctic krill in Subarea 48.1 expressed as 'proportional recruitment' D. Kinzey, J.T. Hinke, C.S. Reiss and G.M. Watters
WG-EMM-2022/03	Remote visual techniques for research and monitoring of marine communities in fast ice-covered coastal areas of the Ross Sea Region MPA E. Carlig, L. Ghigliotti, S. Canese, D. Di Blasi, M. Vacchi and S. Grant
WG-EMM-2022/04	Density and distribution of krill larvae and salps in the Mar de la Flota/Bransfield Strait and Elephant Island surroundings during the summer seasons of 2019 and 2020 E. Rombolá, M. Sierra, J. Seco, F. Capitanio, B. Meyer, C. Reiss and E. Marschoff.
WG-EMM-2022/05	A practical revision to CM 51-07 that distributes catches and increases catch limits in Subarea 48.1 G.M. Watters and J.T. Hinke
WG-EMM-2022/06	Report of On-line Krill Ageing Workshop (August and November 2021) S. Kawaguchi, C. Reiss, B. Krafft, T. Ichii, G. Zhu, P. Hollyman and R. Kilada
WG-EMM-2022/07	SCAR Krill Action Group Meeting 2022 Report B. Meyer, S. Kawaguchi, S. Hill, A. Atkinson, J. Arata, R. Driscoll, J. Conroy, Z. Sylvester and K. Bernard
WG-EMM-2022/08	Management Plan for Antarctic Specially Protected Area No. 145 Port Foster, Deception Island, South Shetland Islands Delegations of Chile and Spain
WG-EMM-2022/09	Chilean operation in the Antarctic krill fishery, years 2020–2021 P.M. Arana and R. Rolleri

WG-EMM-2022/10	Online sub-Antarctic workshop on pelagic regionalisation – 1 June 2022 A.B. Makhado, J.A. Huggett, K.M. Swadling, P. Koubbi, C. Cotté, M.A. Lea and workshop participants
WG-EMM-2022/11	The potential of using fishing vessels as a research platform to address knowledge gaps in krill biology for supporting krill management B. Meyer, J. Arata, A. Atkinson, D. Bahlburg, K. Bernard, R. Driscoll, S. Hill, L. Hüppe, T. Ichii, S. Kawaguchi, B. Krafft, E. Murphy, C. Reiss, E. Rombola, Z. Silvester, S. Thorpe and X. Zhao
WG-EMM-2022/12	Climate change patterns in the southern Indian Ocean: warming and marine heatwaves C. Azarian, L. Bopp and F. d'Ovidio
WG-EMM-2022/13	Climate change patterns in the Southern Indian Ocean: primary production changes A. Nalivaev, C. Azarian, L. Bopp and F. d'Ovidio
WG-EMM-2022/14	Overview of the new scientific information from PNRA supported research since the establishment of the RSRMPA L. Ghigliotti, M. Azzaro and M. Vacchi
WG-EMM-2022/15	Icefish spawning aggregation in the southern Weddell Sea K. Teschke, R. Konijnenberg, S. Hain, P. Brtnik and T. Brey
WG-EMM-2022/16	Predicting the presence and abundance of Antarctic krill (*Euphausia superba*) in the waters of the South Orkney Island Archipelago J.J. Freer, V. Warwick-Evans, G. Skaret, B.A. Krafft, A. Lowther, S. Fielding and P.N. Trathan
WG-EMM-2022/17	Implementing the risk assessment in Subarea 48.1 at a scale relevant to fishery operations V. Warwick-Evans, M. Collins and P. Trathan
WG-EMM-2022/18	British Antarctic Survey: Ecosystem Monitoring in Area 48 (2021/22) C. Waluda, A. Bennison, R. Cavanagh, M. Dunn, T. Dornan, S. Fielding, J. Forcada, S. Grant, J. Jackson, N. Johnston, S. Hill, P. Hollyman, E.J. Murphy, R.A. Phillips, N. Ratcliffe, G.A. Tarling, S.E. Thorpe, P.N. Trathan, V. Warwick-Evans, A. Wood and M.A. Collins

WG-EMM-2022/19	Proposed workshop on integrating climate change and ecosystem interactions into CCAMLR science R. Cavanagh, M. Collins, C. Darby, T. Dahlgren, M. Eléaume, S. Hill, P. Hollyman, S. Kawaguchi, B. Krafft, E. Pardo, M. Pinkerton, P. Trathan, A. van de Putte, N. Walker, G. Watters and P. Ziegler
WG-EMM-2022/20	Informing climate change discussions: Antarctic Climate Change and the Environment Decadal Synopsis R. Cavanagh, C. Darby, S. Grant, N. Walker and G. Watters
WG-EMM-2022/21	Options for the interim revision of CM 51-01 and CM 51-07 to progress the new krill management approach in 2022 X. Zhao and Y. Ying
WG-EMM-2022/22	Preliminary information on the results of observations at CEMP sites PTI, YAL and Gai in the season 2021/22 Delegation of Ukraine
WG-EMM-2022/23 Rev. 1	Composition and abundance of zooplankton collected from Ukrainian longline fishery vessels in CCAMLR Statistical Subareas 88.1, 88.2 and 48.1 during the 2020/21 summer season L. Samchyshyna, E. Pakhomov, P. Zabroda, I. Slypko and T. Pestovskyi
WG-EMM-2022/24	Some results of the oceanological research in the Weddell Sea (Statistical Subareas 48.1 and 48.2) by Ukraine in 2018–2021 V. Paramonov and P. Zabroda
WG-EMM-2022/25 Rev. 1	Updates on krill biomass estimates for the combined strata in Subarea 48.1 X. Wang, X. Zhao, Y. Zhao and Y. Ying
WG-EMM-2022/26 Rev. 1	Return of the giants: Summer abundance of fin whales in the Scotia Sea M. Biuw, U. Lindstrøm, J.A. Jackson, M. Baines, N. Kelly, G. McCallum, G. Skaret and B.A. Krafft
WG-EMM-2022/27	Comments and proposals on the development of management strategy for krill fishery: Risk assessment framework to allocate catch in Subarea 48.1 Delegation of the Russian Federation
WG-EMM-2022/28	Comparison analysis of krill length compositions from catches obtained by research and commercial gears S. Kasatkina and S. Sergeev

WG-EMM-2022/29	Review of the trawl systems used in the Antarctic krill fishery S. Sergeev and S. Kasatkina
WG-EMM-2022/30	Distribution and size composition of salpa according to research data on the RV *Atlántida* in 2020 A.M. Sytov, D.A. Kozlov and S.V. Popov
WG-EMM-2022/31	Comparative analysis of the distribution and biology of Antarctic krill according to the data of the synoptic survey CCAMLR-2000 and Russian studies on the RV *Atlántida* (2020) A. M. Sytov and D.A. Kozlov
WG-EMM-2022/32	Preliminary results on the length-weight relationship of fresh Antarctic krill with weight-at-length based on multiple individuals Y. Ying, G. Fan, J. Zhu and X. Zhao
WG-EMM-2022/33	Nimble marine biodiversity expeditions to the Southern Ocean: the Belgica 121 expedition concept B. Danis, B. Wallis, C. Moreau, C. Guillaumot, F. Pasotti, H. Robert, H. Christiansen, Q. Jossart and T. Saucède
WG-EMM-2022/34	Evidence of a vulnerable marine ecosystem documented via tourist submarine off Cape Well-Met, Vega Island, Eastern Antarctic Peninsula (Subarea 48.1) S.J. Lockhart and R.C. Izendooren
WG-EMM-2022/35	First biological description of Welchness Cape, Dundee Island M. Abas, M.L. Abbeduto, M. Juáres, M. Libertelli, J. Negrete and M. Díaz
WG-EMM-2022/36	Mapping research capabilities of CCAMLR Members in Domain 1 with focus on the D1MPA Research and Monitoring Plan Delegations of Argentina and Chile
WG-EMM-2022/37	Summary of the CCAMLR MPA Information Repository (CMIR) Secretariat
WG-EMM-2022/38 Rev. 2	Summary of CCAMLR Ecosystem Monitoring Program (CEMP) data holdings through the 2021/22 monitoring season Secretariat
WG-EMM-2022/39	Proposed workplan for developing and implementing data collection needs for CCAMLR krill fisheries, and re-scoping of the Krill Observer Workshop S. Kawaguchi, G. Zhu and CCAMLR Secretariat

WG-EMM-2022/40	Hot spots in the ice: revealing the importance of polynyas for sustaining present and future Antarctic marine ecosystems Z. Sylvester, C. Brooks, A. DuVivier, K. Krumhardt, L. Landrum, M. Holland, M. Long, S. Jenouvrier, L. Bourreau and S. Labrousse
WG-EMM-2022/41	Connecting observer data to fishery management needs: A comparison of two concurrent datasets from the Norwegian krill fishing vessel *Antarctic Endurance* R. Driscoll, B. Meyer, L. Hüppe, D. Bahlburg, S. Kawaguchi and B. Kraft
WG-EMM-2022/42 Rev. 1	South Shetland Island fur seals: conservation status and distribution updates D.J. Krause and G.W. Watters
WG-EMM-2022/43	The Eastern Weddell Sea Observation System (EWOS): A multinational initiative that provides coordinated and systematic observations of the Antarctic marine ecosystem C.D. Jones, M. Bach, D.K.A. Barnes, K. Beyer, L. Chakrabarti, G.E. Cassola, B. Feij, H. Flores, C. Gebhardt, C. Held, M.E. Kaufmann, S. Kempf, N. Koschnick, S. Kühn, K. Leuenberger, H. Link, F.C. Mark, A. Meijboom, M. Pallentin, C. Papetti, D. Piepenburg, M. Powilleit, A. Purser, F. Schaafsma, H. Schröder, A. V de Putte, M. v Dorssen and M. Vortkamp
WG-EMM-2022/44	Adélie penguins of King George Island depend on resources in CCAMLR Subarea 48.1 in summer, but Subareas 48.5 and 48.2 in winter A. Soutullo, A.L. Machado-Gaye, Z. Zajkova, A. Kato and Y. Ropert-Coudert
WG-EMM-2022/45	ASPA No. XXX Western Bransfield Strait and Eastern Dallmann Bay for Review by CCAMLR P. Penhale
WG-EMM-2022/46 Rev. 1	Vulnerable marine ecosystems documented via submarine in the Bransfield Strait and the Eastern Antarctic Peninsula (Subarea 48.1) S.J. Lockhart, R. Downey, R. García-Roa, J. Hocevar and L. Meller
WG-EMM-2022/47	Korean Antarctic research and monitoring in the Ross Sea region in support of Conservation Measure 91-05 J.-H. Kim, H.S. La, K. Lee, H.-C. Kim, J.-U. Kim, J. Park, H. C. Shin, D.N. Kim and S. Chung

Other Documents

WG-EMM-2022/P01	Long-term variation in the breeding diets of macaroni and eastern rockhopper penguins at Marion Island (1994–2018) F.E. Dakwa, P.G. Ryan, B.M. Dyer, R.J.M. Crawford, P.A. Pistorius and A.B. Makhado *Afr. J. Mar. Sci.*, 43 (2) (2021): 187–199, doi: 10.2989/1
WG-EMM-2022/P02	Conservation in the Scotia Sea in light of expiring regulations and disrupted negotiations G.M. Watters and J.T. Hinke *Conserv. Biol.* (2022): e13925, doi: https://doi.org/10.1111/cobi.13925
WG-EMM-2022/P03	Standing stock of Antarctic krill (*Euphausia superba* Dana, 1850) (Euphausiacea) in the Southwest Atlantic sector of the Southern Ocean, 2018–19 B.A. Krafft, G.J. Macaulay, G. Skaret, T. Knutsen, O.A. Bergstad, A. Lowther, G. Huse, S. Fielding, P. Trathan, E. Murphy, S.-G. Choi, S. Chung, I. Han, K. Lee, X. Zhao, X. Wang, Y. Ying, X. Yu, K. Demianenko, V. Podhornyi, K. Vishnyakova, L. Pshenichnov, A. Chuklin, H. Shyshman, M.J. Cox, K. Reid, G.M. Watters, C.S. Reiss, J.T. Hinke, J. Arata, O.R. Godø and N. Home J. Crust. Biol., 41 (3) (2021): 1–17. https://doi.org/10.1093/jcbiol/ruab046
WG-EMM-2022/P04	Distribution of the Mesozooplankton Community in the Western Ross Sea Region Marine Protected Area During Late Summer Bloom S. H. Kim, B. K. Kim, B. Lee, W. Son, N. Jo, J. Lee, S. H. Lee, S.-Y. Ha, J.-H. Kim and H. S. La *Front. Mar. Sci.*, 2022. 9: 860025. doi: 10.3389/fmars.2022.860025
WG-EMM-2022/P05	Application of Dual Metabarcoding Platforms for the Meso- and Macrozooplankton Taxa in the Ross Sea J.-H. Lee, H. S. La, J.-H. Kim, W. Son, H. Park, Y.-M. Kim and H.-W. Kim *Genes*, 2022, 13 (5): 922. doi: https://doi.org/10.3390/genes13050922
WG-EMM-2022/P06	Reconstruction of Ocean Color Data Using Machine Learning Techniques in Polar Regions: Focusing on Off Cape Hallett, Ross Sea J. Park, J.-H Kim, H.-C Kim, B.-K. Kim, D. Bae, Y.-H. Jo, N. Jo and S. H. Lee *Remote Sens.*, 2019, 11 (11): 1366, doi: https://doi.org/10.3390/rs11111366

WG-EMM-2022/P07	Data Reconstruction for Remotely Sensed Chlorophyll-a Concentration in the Ross Sea Using Ensemble-Based Machine Learning J. Park, H.-C. Kim, D. Bae and Y.-H. Jo *Remote Sens.*, 2020, 12 (11): 1898; doi: https://doi.org/10.3390/rs12111898
WG-EMM-2022/P08	Bacterial epibiont communities of panmictic Antarctic krill are spatially structured L. Clarke, L. Suter, R. King, A. Bissett, S. Bestley and D. Deagle *Mol. Ecol.*, 2021. 30: 1042-1052, doi: https://doi.org/10.1111/mec.15771
WG-EMM-2022/P09	Spatial and temporal catch concentrations for Antarctic krill: Implications for fishing performance and precautionary management in the Southern Ocean F. Santa Cruz, L. Krüger and C.A. Cárdenas *Ocean and Coastal Management*, 223 (2022): 106146
WG-EMM-2022/P10	Biological-physical processes regulate autumn prey availability of spiny icefish *Chaenodraco wilsoni* in the Bransfield Strait, Antarctic G.P. Zhu, Q.Y. Yang and K. Reid *J. Fish Biol*., 1–13 (2022), doi: 10.1111/jfb.15120
WG-EMM-2022/P11	Influence of tides on mass transport in the northern Antarctic Peninsula G.P. Zhu, X.Q. Zhou and S. Hu *Polar Science*, 23 (2020): 100506
WG-EMM-2022/P12	Using Antarctic krill (*Euphausia superba*) to reflect regional heterogeneity in marine environments in the northern Antarctic Peninsula, Antarctic G.P. Zhu and D.R. Wang *Ecological Indicators*, 136 (2022): 108596
WG-EMM-2022/P13	A tool to evaluate accessibility due to sea-ice cover: a case study of the Weddell Sea, Antarctica H. Pehlke, T. Brey, R. Konijnenberg and K. Teschke *Ant. Sci*., 34 (1) (2022): 97–104, https://doi.org/10.1017/S0954102021000523

WG-EMM-2022/P14	A vast icefish breeding colony discovered in the Antarctic A. Purser, L. Hehemann, L. Boehringer, S. Tippenhauer, M. Wege, H. Bornemann, S.E.A. Pineda-Metz, C.M. Flintrop, F. Koch, H.H. Hellmer, P. Burkhardt-Holm, M. Janout, E. Werner, B. Glemser, J. Balaguer, A. Rogge, M. Holtappels and F. Wenzhoefer *Current Biology*, 32 (4) (2022): 842–850, https://doi.org/10.1016/j.cub.2021.12.022
WG-EMM-2022/P15	The rapid population collapse of a key marine predator in the northern Antarctic Peninsula endangers genetic diversity and resilience to climate change D.J. Krause, C.A. Bonin, M.E. Goebel, C.S. Reiss and G.M. Watters *Front. Mar. Sci.*, 8 (2022): 796488, doi:10.3389/fmars.2021.796488
WG-EMM-2022/P16	Krill finder: Spatial distribution of sympatric fin (*Balaenoptera physalus*) and humpback (*Megaptera novaeangliae*) whales in the Southern Ocean F. Alvarez and J.L. Orgeira *Polar Biol*. (accepted)

Appendix D

Terms of Reference for the Proposed Krill Observer Workshop

1. Reassess time allocations and instructions for krill observer data collection requirements for krill length frequency to adequately address the needs of the Scientific Committee. Training corresponding to data collection changes for observers to be provided if necessary.

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

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

Annex 8

Report of the Working Group
on Incidental Mortality Associated with Fishing
(Hobart, Australia, 10 to 14 October 2022)

Content

Report of the Working Group on Incidental Mortality Associated with Fishing
(Hobart, Australia, 10 to 14 October 2022)

Opening of the meeting

1.1 The meeting of the Working Group on Incidental Mortality Associated with Fishing (WG-IMAF) was held in Hobart, Australia, from 10 to 14 October 2022.

1.2 The Co-conveners, Dr M. Favero (Argentina) and Mr N. Walker (New Zealand), opened the meeting and welcomed participants, including the invited experts Dr I. Debski, Dr J. Arata, Mr R. Arangio and Mr R. Leaper.

Adoption of the agenda

2.1 The provisional agenda for the meeting was discussed and adopted with minor amendments (Appendix A).

2.2 The participants thanked Dr Favero and Mr Walker for their work in preparing for the meeting.

2.3 The report was prepared by J. Barrington (Australia), J. Clark (Norway), S. Kawaguchi and N. Kelly (Australia), A. Lowther (Norway), E. O'Shea (Secretariat), E. Pardo (New Zealand), R. Phillips (UK), C. Van Werven (Secretariat) and includes a List of Registered Participants (Appendix B) and a List of Documents considered at the meeting (Appendix C).

2.4 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

3.1 WG-IMAF-2022/07 presented a summary of incidental mortalities of seabirds and marine mammals associated with fishing during the 2021/22 season from data reported by the vessels and Scheme of International Scientific Observation (SISO) observers. The extrapolated total of 15 seabirds caught as of 12 September 2022 is the lowest total on record. One humpback whale (*Megaptera novaeangliae*) was recorded as incidental mortality in krill fisheries in 2022. The paper also presented a review of incidental mortality since 2012 as reported to CCAMLR. Overall, the number of seabirds caught in longline fisheries shows a declining trend since 2012, whilst extrapolated numbers of warp strikes fluctuate between seasons, potentially because of the low observation effort issues.

3.2 The Working Group welcomed the presentation of WG-IMAF-2022/07 by the Secretariat and noted the utility of the plots showing the numbers of seabirds caught by subarea and season. The Working Group requested that the Secretariat include similar graphical analyses in any future iterations of the paper, and present marine mammal mortalities and warp strike data at subarea and season scale. The Working Group also requested that warp strike rates (birds-per-unit of observed effort (BPUE)) be presented in tables and figures, distinguishing each category of warp observation (shooting, towing, hauling etc.) and that the capture rates of birds in the net should be presented separately.

3.3 The Working Group further requested that the Secretariat present the spatial occurrence of mortality events at subarea scale in the Fishery Report IMAF summary sections as this would increase the accessibility of IMAF information to Members.

3.4 The Working Group welcomed provisional data indicating the lowest-ever estimated seabird mortality numbers recorded in CCAMLR longline fisheries in 2022, noting that fishing operations were still ongoing in Subareas 48.3 and 58.6, and Divisions 58.5.1 and 58.5.2, therefore IMAF numbers for 2022 were incomplete.

3.5 The Working Group noted that extrapolated seabird mortalities during the period 2012−2022 were highest in Division 58.5.1 and noted that understanding any operational differences in this fishery may be useful for elucidating the causes of higher seabird by-catch rates.

3.6 The Working Group noted the occurrence of nine southern elephant seal (*Mirounga leonina*) mortalities across Divisions 58.5.1 and 58.5.2 and one humpback whale mortality in krill fisheries in Subarea 48.2 during the 2021/22 season. The Working Group reflected that the nine southern elephant seal mortalities were an increase on previous CCAMLR seasons.

3.7 The Working Group noted that SISO observer protocols in CCAMLR trawl fisheries only recommend one 15-minute warp strike observation period per day, which focused on high-risk trawling periods (e.g. net setting or high-risk events). The low rate of observation for warp strikes during towing may lead to high uncertainty in extrapolated warp strikes.

3.8 The Working Group further noted that continuous beam trawling vessels tow two nets simultaneously. This can result in up to 48 hours of trawl time per day, which results in lower coverage and greater uncertainties when extrapolating warp strike numbers when only one 15-minute observation per day is conducted by the SISO observer.

3.9 The Working Group considered that the collection of additional environmental information and bird abundance data during warp strike observation periods may assist in understanding potential contributory factors that drive warp strike events.

3.10 The Working Group recalled that in CCAMLR krill trawl fisheries, the SISO observation protocol did not require observers to record the severity of warp strikes, therefore the total numbers of warp strikes could not be used to assess overall seabird mortalities.

3.11 The Working Group recommended the reintroduction of recording severity of warp strikes on krill vessels using the protocols required for SISO observers on finfish trawl vessels.

3.12 The Working Group noted that the current requirement of 1 warp strike observation per day equates to approximately 0.5% of coverage of trawling time in continuous trawl and 1.9% for conventional trawl; a suggested increase to four warp observation periods per day would equate to approximately 2.1% of coverage of trawling time for continuous trawl and 7.7% for conventional trawl. The Working Group noted that the SISO observer protocols need to be modified to reflect any decision on a different minimum number of required observations.

3.13 The Working Group recommended the Scientific Committee consider an increase in the number of warp strike observation periods conducted by SISO observers on trawl vessels to reduce the potential uncertainties in extrapolated warp strikes. The Working Group noted that observer workload and tasking would need to be considered.

3.14 The Working Group also recommended future research to refine the required number of warp strike observation periods per day conducted by SISO observers for finfish trawl fisheries (Table 1) and krill fisheries (SC-CAMLR-41/16 Rev 1).

3.15 The Working Group recommended the correction of the SISO warp strike observation data from the Korean vessels *Adventure* and *Maestro* in the 2011/12 season, by the Secretariat as this data appears erroneous.

Marine mammal incidental mortality

Population status of marine mammals in the CAMLR Convention Area

4.1 WG-EMM-2022/26 Rev. 1 presented a multi-vessel, single-platform cetacean sighting survey undertaken as part of the International 2019 Area 48 survey for krill (see WG-EMM-2022, paragraphs 3.20 and 3.21). The paper reported a design-based abundance estimate of 53 873 (CV = 0.152) fin whales (*Balaenoptera physalus*) for a combined survey area of 2 101 000 km^2, which roughly overlapped with Subareas 48.1, 48.2, 48.3 and 48.4. Comparison to a fin whale abundance estimate of around 4 600 (CV = 0.424; Reilly et al., 2004) across a similar region, but a slightly smaller area of 1 637 500 km^2, from the CCAMLR-2000 Survey, indicates a substantial increase in fin whale abundance throughout Subareas 48.1, 48.2, 48.3 and 48.4 over the past two decades.

4.2 The Working Group noted the importance of recent cetacean abundance estimates for regions within the Convention Area to assist in providing management advice for the krill fishery.

4.3 Annex 1 of WG-IMAF-2022/08 provided a summary of the status and trends of baleen whales in Area 48. Baleen whales were heavily exploited throughout the twentieth century, particularly across Area 48, but in the decades since the cessation of commercial whaling, there are indications of recovery for some species, such as humpback whales and fin whales, whilst others have only displayed modest increases, such as Antarctic blue whales (*Balaenoptera musculus intermedia*) and southern right whales (*Eubalaena australis*). Antarctic minke whales (*B. bonaerensis*) may have declined in Area 48 since the mid-1980s.

4.4 The Working Group discussed the potential decline of Antarctic minke whale numbers in Area 48 over the past few decades, and that whilst the International Whaling Commission (IWC) considered the decline was likely to be real, the precise mechanism for that decline was not known.

4.5 WG-IMAF-2022/12 reported on varying levels and types of marine mammal sighting effort undertaken on a Patagonian toothfish fishing vessel operating near South Georgia in the winter of 2021. A total of 2 086 minutes of survey effort was undertaken over 117 n miles of track, yielding around 150 marine mammal sightings, including humpback whales and sperm whales (*Physeter macrocephalus*).

4.6 The Working Group noted that such marine mammal sighting data is of value for understanding the interaction of fishing and predator populations, but also that it can be difficult for non-standardised sighting effort on fishing vessels to yield enough data to undertake distance sampling analyses.

Incidental mortality and risk assessments of marine mammals in CCAMLR fisheries

Review of whale entanglement information

4.7 WG-IMAF-2022/01 presented on the three incidental mortalities of humpback whales during the 2020/21 fishing season (see also SC-CAMLR-40/BG/27) and one incidental mortality reported from Subarea 48.2 during the 2021/22 season. All incidental mortalities were from vessels using the continuous trawling system in the krill fishery. The paper also included descriptions of both existing and proposed whale entanglement mitigation approaches for the continuous trawl krill fishery. After the third incidental mortality of a humpback whale in the 2020/21 season, an extra-large exclusion mesh constructed from Spectra rope was placed at the mouth of the trawl, in addition to existing pinniped exclusion nets. The expectation was that the stronger material would withstand interactions with large cetaceans. Despite this addition, a dead humpback whale was discovered in the trawl mouth of the *Saga Sea* during the 2021/22 fishing season, after which the exclusion net was moved further forward, attached to the trawl mouth opening and the tension in the ropes was increased to reduce any slack (Appendix D). No subsequent incidents have been recorded. The paper detailed additional mitigation measures that could be used in the future such as acoustic deterrent devices, modifications of the marine mammal exclusion device or other gear, such as monitoring of the trawl codend, and direct underwater video surveillance or echosounders at the trawl mouth to detect encounters. Further approaches to better understanding the ultimate causes of whale encounters such as studies of whale behaviour at different spatial scales, and whale population size and spatio–temporal distribution, demographics and energetics were proposed. The implications for move-on rules were briefly summarised, as was the need to standardise reporting of data for future encounters and development of photographic documentation.

4.8 The Working Group recalled that the presence of any of the three dead humpback whales during the 2020/21 fishing season (SC-CAMLR-40, paragraph 3.114) were not detected by the crew using the net monitoring system connected by the net monitoring cable (allowed at present under a derogation of Conservation Measure (CM) 25-03), and noted that given there was no real-time detection of the presence of the whales within or on the nets, it was not possible to estimate when the animals became entangled during trawl operations.

4.9 The Working Group noted that whilst observed whale by-catch in the krill fishery was considered small at present, it may increase with any increase in whale population size or krill fishing effort, particularly noting that both baleen whales and the krill fishery target krill aggregations. The Working Group further noted that the number of cryptic mortalities as a result of whales interacting with krill trawls would be an important parameter to estimate.

4.10 The Working Group commended Norway and industry experts for rapidly seeking to improve mitigation methods after the whale by-catch incidents and encouraged further development of devices that would exclude marine mammals from entering the trawl net.

4.11 WG-IMAF-2022/08 reported on the outcomes of the IWC Scientific Committee intersessional group on whale entanglement in the Southern Ocean krill fishery, which formed during the virtual meeting of the IWC-SC 68D (25 April to 13 May 2022; IWC, 2023, section 12.2.2) after receiving a request for advice from the Scientific Committee (Welsford et al., 2022). Prior to providing advice on whale entanglements, the intersessional group concluded it was highly unlikely that the whales entered the trawls after death, and that the reported lengths of the entangled whales (7–10 m) were consistent with the lengths of dependent, or newly independent, calves. The IWC intersessional group reviewed existing literature on large whale interactions with other trawl fisheries; data collection needs from entangled whales; whale abundance and distribution in Area 48; and collection of relevant data from whale observations. The paper made several recommendations regarding entanglement/by-catch mitigation for continuous trawling in the krill fishery, including avoidance of whales by fishing vessels, technologies such as excluder devices, and management measures such as 'move-on' rules. The IWC intersessional group also noted the lack of information to understand whether close encounters of whales with fishing vessels are due to whales feeding on the same swarms of krill that are being fished, the fishing operations using whales as a cue for the location of krill swarms, that whales may be attracted to the trawl vessels, or a combination of these points.

4.12 The Working Group considered the IWC intersessional group's recommendations on data to be collected by observers and vessel crew in the event of future whale entanglements in krill trawl nets. The Working Group agreed that data collection efforts at the time a whale is detected in trawl nets be improved.

4.13 The Working Group recognised the potential utility of the suggested data template, but also noted varying degrees of difficulty in collecting some of these data, particularly collection of physical samples if the whale carcass cannot be safely accessed and recommended that data collection be prioritised and ranked. The Working Group also noted the potential considerable paperwork required to import whale samples because of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), and the need for preservatives or dedicated freezer space. Delays in obtaining CITES permits, which in some countries are required for individual shipments, might mean that samples have to be stored on vessels for long periods.

4.14 The Working Group also considered the potential time lag between an entanglement incident and its detection, noting that recording of information such as extant whale densities around the vessel, may not match the conditions at the time of the incident.

4.15 The Working Group considered the possibility of using natural markings, or a human-made markings, on whale carcases to assist in judging whether it had been sighted previously.

4.16 The Working Group recommended that an intersessional working group including experts from the IWC Scientific Committee intersessional group on whale entanglement in the Southern Ocean krill fishery, be tasked with developing a data collection template and accompanying instructions for vessels to report standardised data in the event of a whale mortality (Table 1).

4.17 The Working Group recommended that the following data and samples, based on the advice from the IWC, be collected (noting two tiers of data collection where i–iv: highest priority and v–vi: moderate priority):

(i) whale species and length

(ii) fishing operation (e.g. vessel and fishing gear specifications, time and location where a net was deployed, time and location where the entangled whale was discovered, average trawl depth)

(iii) photographic records

(iv) wound details following IWC entanglement response data form (detailed in Table 1 of WG-IMAF-2022/08)

(v) blubber thickness

(vi) tissue samples (e.g. skin, blubber, baleen plates); presence (and collection) of whale lice.

Review of recent high rates of seal by-catch reported

4.18 WG-IMAF-2022/07 presented a summary of marine mammal mortalities in CCAMLR fisheries from the last decade (2012–2022). The paper noted that the southern elephant seal was the most common marine mammal species caught in CCAMLR longline fisheries with approximate annual by-catch rates of 2–3 animals per year. In CCAMLR trawl fisheries, the Antarctic fur seal (*Arctocephalus gazella*) was the most commonly caught species, with numbers fluctuating annually over the last decade.

4.19 The Working Group noted that seal mortality events were very rare and no method for determining a seal by-catch rate had been developed and implemented at CCAMLR. The Working Group further noted that information in the SISO observer reports detailed that seal mortalities occur primarily from external net entanglements when trawl nets were at the surface, or from failures in the seal exclusion devices that are required to be fitted in CCAMLR trawl fisheries.

4.20 Dr Y. Ying (China) noted that a two-year observation project was conducted on Chinese trawl vessels, where it was identified that many Antarctic fur seal interactions took place around the codend of the net due to the attraction of prey. The study also noted that seals demonstrated more intensive foraging behaviours towards the net being retrieved on the surface when krill aggregations were deeper, than when krill swarms were located near the surface, suggesting that prey availability was driving attraction to fishing vessels.

4.21 The Working Group reflected that combining studies of fur seal behaviour with krill population dynamics and environmental variables may elucidate factors leading to seal mortality events.

4.22 The Working Group recommended that additional data on sex and total body length for incidental seal mortalities recovered on board vessels be recorded by SISO observers, to determine if incidental seal mortalities in fisheries have adverse effects on particular sex or maturity cohorts in seal populations.

4.23 The Working Group recommended that supporting material should be developed and training provided to enable observers to perform these tasks and asked Members with expertise on the subject to contribute to that end (Table 1).

Mitigation methods for marine mammals

4.24 As recommended by the Scientific Committee in 2021 when WG-IMAF was reconvened (SC-CAMLR-40, paragraph 3.135), some Members and invited experts investigated and documented the use of mitigation devices to reduce marine mammal entrapment in continuous krill trawl nets. The Working Group commended these parties for their efforts and requested them to continue reporting on the efficacy of marine mammal exclusion devices.

4.25 WG-IMAF-2022/09 presented details of how observed New Zealand sea lion by-catch in the southern squid fishery was reduced and noted that these experiences potentially have relevance to CCAMLR krill fisheries. Sea lion exclusion devices (SLEDs) were developed after substantial New Zealand sea lion captures were detected and such devices are now used in 100% of tows, with a minimum of 90% observer coverage across all tows in this fishery. As a consequence, sea lion mortality has been significantly reduced. The use of SLEDs has generated uncertainties about the relative significance of the different types of interactions that an animal can have with the device, including traumatic brain injuries, post-escape drowning and loss of drowned animals after interaction, referred to as 'cryptic mortality'. Recommendations outlined in WG-IMAF-2022/09 include:

(i) by-catch mitigation devices are further improved and trialled in CCAMLR krill fisheries

(ii) estimated cryptic mortality rates are considered when by-catch mitigation devices are used

(iii) where mitigation devices are used, mitigation device standardisation and certification processes are developed

(iv) a minimum rate for scientific observer coverage is developed to support the evaluation of marine mammal by-catch mitigation methods.

4.26 The Working Group discussed the recommendations in the paper and on reflected the need for further consideration of these recommendations in the intersessional period.

4.27 The Working Group noted that in typical finfish trawl nets, a seal exclusion device is a sloped or vertical mesh barrier within the net with an opening at the top to allow an animal to escape. In other designs, the exclusion device is typically a mesh net covering the mouth of the trawl as a barrier to marine mammals entering the net.

4.28 The Working Group recommended that the Secretariat develop a library of the different exclusion devices used across different trawl vessels within the Convention Area in consultation with Members (Table 1).

4.29 The Working Group noted the estimation of cryptic mortality needs to consider the specific characteristics of the fishing operations and gear configuration, for example the higher speed in the southern squid fishery compared to the krill fishery. The Working Group further noted that trawl speed could be a variable affecting the degree of injury to marine mammals such as whales, given the current difficulty in directly observing interactions.

4.30 The Working Group noted the use of acoustic pingers during the 2021/22 fishing year, however, considered there is ambiguous evidence concerning the efficacy of acoustic pingers to alert baleen whales to the presence of the net (WG-IMAF-2022/01 and 2022/08). In contrast, the Working Group noted the potential harms that can be inflicted by acoustic harassment devices, either through hearing damage, or that it might cause the animal to be trapped through disorientation.

4.31 The Working Group noted the advice from the IWC expert panel that the whale excluder grid installed near the mouth of the continuous trawl net after the humpback whale entanglement incident in 2021/22 (which differs from the other seal excluder grid) may still allow a whale to be pressed and trapped against the grid, whereas a modification of this net to pull the grid forward into a conical formation may result in a passive whale being deflected away from the mouth of the net.

4.32 Dr U. Lindstrøm (Norway) suggested that before any further modifications to the exclusion devices used in the 2021/22 fishing season are undertaken, a more detailed study of the way baleen whales interact with krill trawling nets would be beneficial.

4.33 The Working Group recognised the importance of understanding environmental variation and whale behaviour over multiple spatio–temporal scales to understand how they interact with krill swarms, and with fishing vessels more broadly.

4.34 The Working Group considered the likely benefits of video surveillance of trawl nets to study whale interactions and potentially detect cryptic mortality events. The Working Group noted that studying small-scale whale movements around, and direct interactions with, trawl nets will not be a trivial observation process to implement, and that considerable technical development will be required. However, the relatively shallow krill trawls should allow for less turbidity to occlude underwater camera vision.

4.35 The Working Group noted the potential benefit of a system to detect direct contact of whales with krill trawl nets to alert the vessel crew. Such a net alarm would require technological development but would be beneficial in understanding exactly when whale interactions with the trawl net occurred and potentially allow the vessel crew to take action to aid the whale in detangling from the net. The Working Group also noted that short-duration suction-cup tags may contribute to quantifying fine-scale movements of whales interacting with trawl nets.

4.36 The Working Group also considered the likely complexity of move-on rules, given the current lack of understanding of the functional relationship between whale densities and krill trawl intensity, and any concomitant relationship with the risk of whale entanglements. The Working Group noted that move-on rules form part of CCAMLR management of other fisheries for other issues.

4.37 The Working Group considered whether marine mammal exclusion devices currently deployed in CCAMR krill fisheries may allow penguins to escape from entanglement. The Working Group noted that whilst the net gauge size of 300 mm used in one of the exclusion devices reviewed could theoretically allow a penguin to breach the device, there are no reports of penguins being by-caught in deployed krill trawl nets (as opposed to documented cases of penguin entanglement when the net is at the surface).

4.38 The Working Group discussed the level of detail on exclusion devices provided in the fishery notifications for krill (under CM 21-03), with reference being made to the need for detailed specification and certification for exclusion devices, as referred in WG-IMAF-2022/09 (see paragraph 4.25iii). An example of the recent modification to a whale exclusion device on a continuous krill trawling net is given in Appendix D.

4.39 The Working Group discussed whether it was appropriate to apply recent developments in exclusion devices in the continuous krill trawling fishery to traditional trawling systems. It noted that while trawl net mouth size was much larger in traditional trawling systems, all krill vessels currently in use implement a somewhat similar (in design) marine mammal exclusion device. The Working Group also noted that there was no evidence at this time to conclude that traditional krill trawling systems posed similar whale entanglement risks compared to continuous krill trawling systems.

4.40 The Working Group discussed the role of the SISO observers in confirming the presence, specification and proper use of exclusion devices on krill trawling operations. The Secretariat reported that observers are not required to test exclusion devices against any specifications provided in the vessel notification to fish, but that they do note and photograph the devices in their observer reports. The Working Group further noted that it is not appropriate that observers be required to offer advice to trawl fishery operators on the use of exclusion devices.

4.41 The Working Group recommended the following advice for krill trawling operators to minimise the risk of whale entanglement in krill trawling operations:

(i) krill fishing operators consider adopting Norway's modifications to the marine mammal exclusion device for its continuous krill trawling nets

(ii) the development of technology to study how whales are interacting with krill trawling nets

(iii) the further development of mitigation measures to decrease the risk of entanglement and by-catch of marine mammals, and the presentation of these developments to future meetings of WG-IMAF or WG-FSA for consideration.

Seabird incidental mortality

Population status of seabird species in the CAMLR Convention Area

5.1 WG-IMAF-2022/03 presented an update from the Agreement on the Conservation of Albatrosses and Petrels (ACAP) on the conservation status of albatrosses and petrels in the CAMLR Convention Area. The report highlighted that there is ongoing serious concern about the global impact of incidental mortality in longline and trawl fisheries on seabirds, especially albatrosses and large petrels, which are among the most-threatened groups of birds globally. Of the 31 ACAP-listed species, there are 12 albatross and four petrel species that breed and/or forage in the CAMLR Convention Area. The Red List of Threatened Species of the International Union for the Conservation of Nature and Natural Resources (IUCN) lists one species as Critically Endangered, five as Endangered, four as Vulnerable, three as Near Threatened and three as Least Concern. The conservation status for nine of these species has been declining over the past 20 years, two are stable, two are unknown and three are increasing. There are seven ACAP High Priority Populations that breed and/or forage in the CAMLR Convention Area, each representing more than 10% of the species' global population, and which are declining at more than 3% annually over a 20-year period for which a major underlying cause was incidental mortality in fisheries. These comprise: (i) wandering albatross (*Diomedea exulans*), (ii) black-browed albatross (*Thalassarche melanophris*) and (iii) grey-headed albatross (*Thalassarche chrysostoma*) at South Georgia; (iv) sooty albatross (*Phoebetria fusca*) at Crozet Island; (v) Indian yellow-nosed albatross (*Thalassarche carteri*) at Amsterdam Island; (vi) Tristan albatross (*Diomedea dabbenena*) at Gough Island; and (vii) Antipodean albatross (*Diomedea antipodensis*) at Antipodean Island.

5.2 The Working Group noted the relatively low-level of incidental mortalities of seabirds within the CAMLR Convention Area, compared to these levels in adjacent fisheries, and highlighted the importance of cooperation with regional fishery bodies outside the Convention Area to address the cumulative effect of seabird by-catch across fisheries, to reverse the steep population declines affecting the seven ACAP High Priority Populations.

5.3 The Working Group noted that ACAP produces a range of advice, guidelines and resources aimed at furthering the conservation of seabirds, including a range of best-practice advice and fact sheets concerning mitigating seabird by-catch, including for demersal longline, and demersal and pelagic trawl fisheries (presented in WG-IMAF-2022/02 and 2022/06), and data collection guidelines (presented in WG-IMAF-2022/04).

5.4 The Working Group recommended that the Secretariat incorporate the guidelines for the safe handling and release of live-caught seabirds hooked or entangled in longline fishing gear into the SISO manuals and publish the guideline sheets on the CCAMLR website for Members to access (WG-IMAF-2022/05).

Seabird incidental mortality and risk assessments in CCAMLR fisheries

5.5 WG-IMAF-2022/P01 reported on the effects of by-catch mitigation measures on the demography of white-chinned petrels (*Procellaria aequinoctialis*) at Possession Island (Crozet Islands). This population declined by 40% from 1983 to 2004 because of by-catch in longline and trawl fisheries, and reduced breeding success resulting from predation by rats. Both modelled population growth rate and observed breeding densities increased after the mid-2000s, which could be explained by the improvement in survival following implementation of by-catch mitigation measures, in breeding success following local control of rats, and changes in climatic conditions on foraging grounds.

5.6 The Working Group recognised that the study was particularly valuable in demonstrating the conservation benefit of effective fisheries by-catch mitigation for a wide-ranging seabird species that overlapped extensively with fishing fleets in local and international waters. A low by-catch rate of white-chinned petrels, which are active during both daylight and darkness, and capable of diving to >10 m, likely also indicated low by-catch rates of other, more susceptible, seabird species.

5.7 The Working Group noted that it took several years for the recommended mitigation measures to be fully effective, and that it required the implementation of the seasonal closure in Division 58.5.1 in 2010 for seabird by-catch to be reduced to very low levels. By comparison, seabird by-catch dropped substantially in Subarea 58.6 without a seasonal closure.

5.8 The Working Group also recognised that there were potentially lessons to be learned by CCAMLR from the further development of mitigation methods in fisheries in the French exclusive economic zone, such as the reportedly longer aerial extent of streamer lines achieved on some vessels.

5.9 The Working Group also noted that some fishing operators were finding it difficult to get integrated weight longlines containing lead recycled, and that it would be desirable to find an alternative to lead for use in demersal longline fisheries.

5.10 The Working Group recommended that the Scientific Committee highlight the recovery of the white-chinned petrel population at Possession Island (Crozet Islands) since the mid-2000s, which had occurred through a combination of implementation of effective seabird by-catch mitigation measures at sea (paragraph 5.7), control of rats on land and changes in climatic conditions on foraging grounds.

Mitigation methods for seabirds

5.11 WG-IMAF-2022/02 presented the ACAP review of mitigation measures and best-practice advice for reducing the impact of demersal longline fisheries on seabirds. The criteria used by ACAP to decide on best practice are that the technologies and techniques are shown by experimental research to significantly reduce the rate of seabird incidental mortality to the lowest achievable levels; have clear and proven specifications and minimum performance standards for their deployment and use; be demonstrated to be practical, cost effective and widely available; to the extent practicable, maintain catch rates of target species; to the extent practicable, not increase the by-catch of other taxa; and have minimum performance standards and methods of ensuring compliance is provided and clearly specified.

5.12 The Working Group noted that requirements under the current CCAMLR conservation measures for demersal longline fisheries match closely with ACAP best-practice guidelines. The Working Group noted the distinction between methods for which there was insufficient evidence of effectiveness, that these may be helpful under certain circumstances but do not meet all the criteria to be considered as best-practice.

5.13 WG-IMAF-2022/05 presented the ACAP safe handling and release guidelines for seabirds. These emphasise the importance of careful handling of live-caught seabirds by crew to maximise the likelihood of survival. The guidelines provide information on materials required to remove hooks, how to bring the hooked bird on board, restrain the bird, remove the hook or minimise the length of the trailing line if the hook cannot be removed, management of the bird if waterlogged and how best to release it. The ACAP guidelines are available as factsheets in various languages. A modified version tailored for birds caught in trawl fisheries is being developed. The Secretariat offered to make the guidelines available on the CCAMLR website and incorporate them into the SISO manuals, providing benefits both for the caught birds and from the perspective of crew and observer safety (paragraph 5.3).

5.14 WG-IMAF-2022/06 presented the ACAP review of mitigation measures and best-practice advice for reducing the impact of pelagic and demersal trawl fisheries on seabirds. These had been developed using the same criteria as for the longline fisheries (paragraph 5.11).

5.15 The Working Group recognised that globally, trawl fisheries are diverse in operation and vessel design, and that the focus of ACAP when developing its guidelines was mainly on large finfish trawl vessels which differ operationally from krill trawl vessels, in particular the continuous trawl vessels.

5.16 The Working Group noted that mitigation of net entanglements is challenging, and that it was important to minimise the time the net is at the surface during hauling. The ACAP guidelines include the design for streamer lines for trawl cables, with a critical consideration being to discourage birds from entering the area where the warps make contact with the sea surface.

5.17 The Working Group recognised the importance of discriminating seabird by-catch associated with cable strikes versus net entanglement, given that different approaches to mitigation are required for these interactions. The Working Group also noted that ACAP may be able to provide advice to CCAMLR on seabird by-catch mitigation specific to the krill trawl fishery.

Review of net monitoring cable trial

5.18 WG-IMAF-2022/10 presented the results of the net monitoring trial in the 2020/21 season from three Norwegian-flagged vessels (two side beam-trawl vessels (*Antarctic Endurance* and *Antarctic Sea*) and one stern beam-trawl vessel (*Saga Sea*)) using the continuous fishing method in Area 48. The trial was undertaken following the requirements of the Scientific Committee (SC-CAMLR-38, paragraph 5.14) and data were collected according to standard SISO protocols, with the addition of video monitoring. Abundance estimates of birds were also obtained. Seabird mitigation measures used on all three vessels followed the ACAP best-practice guidelines and on the side beam-trawl vessels consisted of a set of streamer curtains that surrounded the warps and the net monitoring cable that ran parallel to the warps. The stern beam-trawl vessel used a Brady baffler which was deployed from the stern of the vessel with limited effect. An additional measure was developed for the second trial, a 'sock' which enclosed both the net monitoring cable and the warp which was shown to be effective. A combination of deck observations and video monitoring were used to observe warps and monitoring cables, totalling 1 839 hours of at-sea observations, representing 7.1% coverage of the total fishing time. Four 15-minute video observations were performed at set times each day in addition to three standard deck observations. To increase coverage, 180 hours of onshore observations were conducted from footage taken from the *Antarctic Endurance* and the *Saga Sea* during fishing from early April to early June, raising overall coverage to ~20% on one net during this time period. All sets and hauls were also monitored. A total of 304 contacts were observed, of which 187 were with the net monitoring cable. The remaining 117 were with the warps or the mitigation device. There was only one observed mortality (Antarctic petrel (*Thalassoica antarctica*)) following contact with a trawl warp. Figure 1 and Annex 1 of WG-IMAF-2022/10 provided diagrams and photos of the warp and net monitoring cable configuration along with the mitigation devices used in the trial.

5.19 WG-IMAF-2022/11 presented interim results for the 2021/22 season from the Norwegian vessels engaged in the fishery. Based on the agreed observation effort distribution (in the case of vessels deploying two trawl nets simultaneously, it was based on the observation of a single trawl net) the total trawling time during observations was 3 643 hours and the total observation time 825 hours, leading to a total observation effort of 22.6%. During this period, 77 strikes were observed with a single mortality (cape petrel (*Daption capense*)). Sixty-two strikes were observed on the net monitoring cable, the majority of which were aerial strikes where the bird flew away apparently unharmed. Of these, 52 occurred over a three-day period on one vessel (*Saga Sea*) when one of the mitigation measures (the 'sock') had to be removed due to technical difficulties. A further four strikes were observed on the warp on this vessel during this time without mitigation.

5.20 The Working Group noted that of the 77 strikes observed in the 2021/22 season, 69 met the definitions of a heavy strike. In the 2020/21 season, there were a total of 304 strikes observed, and 220 of those were heavy strikes. The Working Group noted that heavy strikes can be considered as a proxy for mortality.

5.21 The Working Group noted that the majority of strikes reported in WG-IMAF-2022/11 occurred during a period when the sock mitigation device was removed for repair on the *Saga Sea* and recommended that multiple replacement devices should be carried on board to facilitate more rapid redeployment.

5.22 The Working Group discussed that while the trials conducted by Norway have focused on the hazard of the net monitoring cable to seabirds, the occurrence of warp strikes on birds suggests the deployment of mitigation measures on all trawl vessels should be considered more explicitly (WG-IMAF-2022/07, Table 6) (Table 1).

5.23 Mr Clark presented a video to the Working Group displaying the potential application of computer vision and artificial intelligence methods to detect potential bird strikes through the analysis of video data. The Working Group agreed that developing new technological approaches to expand observation coverage is useful and should be further explored, and welcomed the progress made on developing these approaches.

5.24 The Working Group recalled the priorities set by the Scientific Committee for WG-IMAF in the context of standardised approaches to calculating extrapolated bird strike numbers from observational data and subsequently implementing an assessment of risk to seabird populations to these extrapolated levels (SC-CAMLR-40, paragraphs 3.135(i) and (iv) respectively). Dr Debski noted that while the development of a Southern Hemisphere seabird risk assessment process is underway, the species that comprise the bird strikes reported in WG-IMAF-2022/10 and 2022/11 are not included within this process, suggesting that further work is required in terms of data collation to conduct an appropriate assessment (Table 1).

5.25 Considering the outcomes of the net monitoring trials in the context of providing advice to the Scientific Committee on the derogation in CM 25-03, Annex 25-03/A, the Working Group recommended that the existing derogation on the use of net monitoring cables in CM 25-03 be extended under the following conditions:

(i) The three vessels (*Antarctic Endurance*, *Saga Sea* and *Antarctic Sea*) which use a net monitoring cable and have provided a detailed report of trials of mitigation devices as specified in CM 25-03, Annex 25-03/A, continue to utilise and refine current mitigation measures in use and achieve on-vessel observation coverage of at least 5% of total active fishing time. Such vessels should provide a report on the development and use of mitigation measures to WG-IMAF-2023.

(ii) For vessels which use a net monitoring cable and have not undergone trials of mitigation devices specified in CM 25-03, Annex 25-03/A, they must undertake a trial following these specifications, and report the results of this trial to the next meeting of WG-IMAF. These vessels should additionally provide advance notice to the Secretariat about any net monitoring mitigation technology or technique to be employed to reduce the risk of bird strikes, drawing upon the approaches identified from existing trials for reducing the risk of bird strikes, and outlining how it will respond to any operational difficulties arising during their use.

(iii) Members with vessels participating in this trial should present specifications under which the net monitoring cable mitigation devices could be used effectively, for review by this Working Group.

5.26 The Working Group noted that progress towards the specification of effective mitigation measures will be reviewed at future WG-IMAF meetings, along with the terms of this derogation for the use of net monitoring cables.

Observer reports and data collection

6.1 SC-CAMLR-41/16 Rev. 1 outlined the proposed work plan for developing data collection needs for krill fisheries and the options for re-scoping the krill fishery observer workshop proposed to be held in China.

6.2 The Working Group was invited to: (i) to review the data collection needs laid out in Table 1 of the paper; (ii) consider the terms of reference in Annex 2 of the paper developed for recording marine mammal interactions and bird strikes; and (iii) review the options for the timing and venue for the workshop, which have still to be agreed. The Working Group's advice would be passed onto the Scientific Committee for consideration.

6.3 The Working Group considered how information for issues regarding marine mammal interactions and sampling, and bird warp strikes in Table 1 of SC-CAMLR-41/16 Rev. 1 could be updated. In light of discussions by WG-IMAF on marine mammal by-catch (paragraphs 4.12 to 4.16), the Working Group agreed that intersessional work on instructions and types of samples required for marine mammal mortalities would take place (Table 1).

6.4 The Working Group agreed to the reintroduction of recording severity of warp strike events on krill vessels from the 2023/24 season (paragraph 3.11), using existing protocols for

SISO observers on finfish trawl vessels (*Scientific Observer's Manual – Finfish Fisheries – Version 2023*). The Working Group also agreed to undertake intersessional work on further refinements of the existing protocol (Table 1).

6.5 The Working Group considered that the outcomes of this workshop, and IMAF requirements in general, could provide information for the upcoming CCAMLR Ecosystem Monitoring Program (CEMP) review. The Working Group noted that there is currently little information on marine mammal interactions with fishing vessels and risk assessments developed for warp strikes. These data requirements should be considered and integrated into any monitoring program outlined in SC-CAMLR-41/16 Rev. 1.

6.6 WG-IMAF-2022/04 presented recommendations on data collection guidelines for observers and electronic monitoring programs to effectively monitor seabird interactions, including levels of observer coverage sufficient to assess by-catch rates across fisheries and guidelines produced by ACAP, including warp strike protocols and electronic monitoring. The paper emphasised that it is important to standardise procedures across fisheries, however, customisation of bird groups according to the species present in the relevant fishery was advisable.

6.7 The Working Group noted that in CCAMLR longline and trawl fisheries, data collection requirements cover variables across all of the recommended ACAP categories with the exception of weather-related information and bird abundance. The Working Group highlighted the benefits of recording weather conditions and bird abundance to better understand how seabirds interact with fishing gear and mitigation devices under different wind and swell conditions. While these data may not be useful in a general IMAF summary report, they may be useful explanatory variables when modelling detailed aspects of bird behaviour.

6.8 SC-CAMLR-41/BG/32 examined ways in which electronic monitoring could be applied across CCAMLR fisheries. The paper highlighted how electronic monitoring can be used to enhance the work of the observer, rather than replace them, and can increase observer safety by allowing remote monitoring of some tasks. The paper considered the data collection requirements for each of the working groups and the Standing Committee on Implementation and Compliance and how electronic monitoring could enhance the collection of these data. The paper further examined fishery-specific data collection requirements under SISO and provided recommendations on which elements would potentially benefit from electronic monitoring.

6.9 The Working Group considered the relevance of the paper to IMAF and agreed that it aligned well with ACAP requirements and could be cross-referenced with the ACAP guidance outlined in WG-IMAF-2022/04. The Working Group also considered the implementation plan and how this could be used to harmonise the uptake of electronic monitoring across fisheries, not just within CCAMLR but within different fisheries outside of CCAMLR. This may be particularly relevant for distant-water fleets operating on the high seas.

6.10 WG-EMM-18/33 presented approaches for collecting and analysing data to quantify the overlap between krill fisheries and pelagic krill predators. The paper described three different levels of data collection that could be undertaken by SISO observers depending on particular scientific questions that need answering. These ranged from level 1: simple presence of absence; level 2: quantifying the number of individuals; and level 3: quantifying activity (feeding or not feeding). The paper also suggested more complex data collection techniques that could be implemented during fishery-independent krill surveys using survey transects and dedicated marine mammal observers.

6.11 The Working Group expressed caution at potentially overtasking SISO observers whilst recognising that recording of marine mammal sightings was already being undertaken in CCAMLR longline fisheries, as well as on board krill vessels operating in Subarea 48.3. Standardised counts of birds around vessels have also been useful to inform management decisions in other fisheries.

Collaboration with relevant organisations

7.1 The Co-convener, Mr Walker, initiated a discussion on mechanisms to potentially streamline effective collaboration with other relevant intergovernmental and industry organisations, noting that the current process of registering invited experts for WG-IMAF and providing access to documents was not straightforward as no procedure for such collaboration has been defined by the Scientific Committee.

7.2 The Working Group reflected that the collaboration with invited experts at the meeting had greatly improved the understanding of participants on relevant issues and had enhanced the provision of advice to the Scientific Committee. The Working Group also 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).

7.3 The Working Group further noted the increasing level and importance of cooperation with other regional organisations (e.g. relevant regional fisheries bodies, BirdLife International, the Scientific Committee on Antarctic Research Expert Group on Birds and Marine Mammals, the International Association of Antarctica Tour Operators and the Convention on the Conservation of Migratory Species of Wild Animals) to reduce the incidental mortality of seabirds and marine mammals within fisheries bordering the Convention Area.

7.4 The Working Group requested the Scientific Committee consider a standing invitation for experts from the following organisations ACAP, the Association of Responsible Krill harvesting companies (ARK), the Coalition of Legal Toothfish Operators (COLTO) and IWC to attend WG-IMAF, noting the valuable contributions made by experts intersessionally and during WG-IMAF-2022.

Future intersessional work

8.1 The Working Group requested that the Scientific Committee consider the potential future tasks for future intersessional work, as described in Table 1.

8.2 The Working Group recommended that an e-group be established to advance intersessional collaborative work on the tasks outlined in the workplan for WG-IMAF (Table 1).

Other business

9.1 The Working Group noted WG-IMAF-2022/08 which outlined a proposal for a workshop to enhance CEMP based on recommendations arising from WG-EMM-2022, in addition to discussions occurring within the CEMP e-group. The proposal included a background to the program alongside draft terms of reference for the workshop/s and future work proposed.

9.2 The Working Group considered CCAMLR-41/08 which presented an overview of the implementation of the Rules for Access and Use of CCAMLR Data in CCAMLR data request procedures, and the procedure for publication of derived materials in the public domain. The Working Group noted the paper and recalled that the paper had previously been discussed during the Scientific Committee Symposium, WG-ASAM and WG-SAM (WG-ASAM-2022/01, paragraphs 5.1 to 5.7; WG-SAM-2022, paragraphs 8.1 to 8.3), and is open for consideration in the 'Data Services Advisory Group' e-group.

Review of the Scientific Committee Strategic Plan

9.3 The Chair of the Scientific Committee, Dr D. Welsford (Australia), presented the report of the CCAMLR Scientific Committee Symposium that met virtually on 8 and 10 February 2022 (WG-ASAM-2022/01). The informal Scientific Committee meeting discussed the progress and outcomes from the first CCAMLR Scientific Committee's workplan (SC-CAMLR-XXXVI/BG/40) and provided an opportunity for participants to propose long-term priorities and strategies to inform the development of the next five-year Strategic Plan (2023–2027). The Working Group noted that the recommendations and plans are being refined during the intersessional period by all working groups and agreed at SC-CAMLR-41, according to the Scientific Committee's Rules of Procedure. During its meeting, WG-IMAF reviewed its terms of reference and considered priority work items as per the recommendation from the Symposium (Table 1).

9.4 The Working Group noted that many issues were cross cutting in nature among the working groups of the Scientific Committee and agreed that issues of marine debris, climate change impacts on Antarctic marine living resources, data collection plans and all administrative matters identified were important for the consideration of the Working Group.

9.5 The Working Group agreed to the items of the Scientific Committee Strategic Plan that were of the remit of the Working Group and should be considered in the development of future work plans (Table 2).

Review of WG-IMAF terms of reference

9.6 The Working Group reviewed its terms of reference and priorities that were endorsed by the Scientific Committee at SC-CAMLR-40 (SC-CAMLR-40, paragraph 3.135 and Annex 9). The Working Group agreed to update the reference regarding collaboration and coordination with other organisations. The updated WG-IMAF terms of reference are listed in Appendix E.

9.7 The Working Group further agreed to extend this collaboration to all organisations that the Commission has a recognised cooperative arrangement with, including invited experts, as required.

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) Recording of warp strike severity on krill vessels (paragraph 3.11)

(ii) Frequency of warp strike observation periods conducted by SISO observers on trawl vessels (paragraphs 3.13 and 3.14)

(iii) Correction of erroneous SISO warp strike observation data from 2012 for two vessels (paragraph 3.15)

(iv) Standardised sample collection and data reporting in the event of a whale mortality based on advice from IWC (paragraphs 4.16 and 4.17)

(v) Increased data collection and reporting by SISO observers for incidental seal mortalities recovered on board vessels (paragraph 4.22)

(vi) Development of educational material and training resources for SISO observers to assist in the sampling and collection of data from incidental seal mortalities (paragraph 4.23)

(vii) The development of an exclusion device library for trawl vessels (paragraph 4.28)

(viii) Advice for krill trawling operators to minimise whale entanglement (paragraph 4.41)

(ix) Incorporation of ACAP guidelines for safe handling and release of live-caught seabirds hooked or entangled in longline fishing gear into the SISO manual (paragraph 5.4)

(x) Note the successful recovery of the white-chinned petrel population at Possession Island (Crozet Islands) (paragraph 5.10)

(xi) Extend and review the existing net monitoring cable derogation (paragraphs 5.25 and 5.26)

(xii) Consider a standing invitation for experts from ACAP, ARK, COLTO and IWC to attend WG-IMAF (paragraph 7.4)

(xiii) Establishment of an e-group to progress IMAF tasks intersessionally (paragraph 8.2)

(xiv) Consider the updated WG-IMAF Terms of Reference (paragraph 9.4 and Appendix E).

Adoption of the report

11.1 The report of the meeting of WG-IMAF was adopted.

Close of the meeting

12.1 At the close of the meeting, Mr Walker and Dr Favero thanked all participants, including invited experts, for their patience and hard work that had allowed the Working Group to make significant progress in addressing the priorities of the Scientific Committee, notably through the effective collaboration between participants. They also thanked the rapporteurs and the Secretariat for their efficiency and support throughout the meeting.

12.2 On behalf of the Working Group, Mr I. Forster (Secretariat), thanked Mr Walker and Dr Favero for their helpful guidance during the meeting and their contribution to the development of a significant workplan for WG-IMAF.

References

IWC. 2023. Report of the Scientific Committee of the International Whaling Commission. *J. Cetacean Res. Manage.* (Supplement) 24. (in prep).

Reilly, S., S. Hedley, J. Borberg, R. Hewitt, D. Thiele, J. Watkins and M. Naganobu. 2004. Biomass and energy transfer to baleen whales in the South Atlantic sector of the Southern Ocean. *Deep-Sea Res. II*, 51 (12–13): 1397–1409, doi: 10.1016/j/dsr2.2004.06.008.

Welsford, D., N. Walker, M. Favero, B. Krafft, C. Darby and S. Parker. 2022. CCAMLR-IWC coordination: incidents of whale by-catch in the Antarctic krill fishery. Paper *SC/68D/HIM/04* presented to the Scientific Committee of the International Whaling Commission, 48 pp.

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	Development of a web-based tool to allow examination of interactions and incidental mortality data across CCAMLR fisheries and areas 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
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 (2023)	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)	Medium	Dr Kelly, Dr Lowther and Dr Lindstrøm	-
	2.3	Development of protocols for pinniped sex and length sampling and training materials	Short	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	Refine design of MMED, considering a convex shape to the exclusion mesh to deflect whales (and seals) away from the net mouth	Medium/ Long	Dr Kelly, Dr Lowther and Dr Lindstrøm	-
	4.2	Develop specifications for MMED in use in CCAMLR trawl fisheries	Short/ Medium	Mr Pardo	-
	4.3	Undertake experiments into effectiveness of different MMED designs (for various species)	Medium/ Long	Dr Kelly, Dr Lowther and Dr Lindstrøm	-
5. Seabirds – incidental mortality	5.1	Power analysis of required observer sampling required for warp strikes	Short	Dr Kelly, Dr Hinke and Mr Walker	-
	5.2	Redesign the warp strike observation protocols	Short (2023)	Dr Debski	-

(continued)

Table 1 (continued)

Theme	Task		Timeframe	Contributors	Secretariat participation
	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	
7. Seabirds – mitigation	7.1	Improve design and develop specification of ‘sock’	Short		-
	7.2	Consider performance of trawl warp/cable strike mitigation approaches utilised by continuous trawl vessels (including environmental conditions and other factors)	Short	Dr Debski and Dr Arata	-
	7.3	Review existing use of and consider mitigation requirements in conventional trawl vessels	Short	Dr Debski and Dr Arata	-
	7.4	Review developments in demersal longline mitigation (streamer lines, etc.)	Short	Mr Barrington, Dr Debski and Mr Arangio/ Mr McNeill	-
8. Observer reports and data collection	8.1	Consider IMAF-related tasks for observers in the various CCAMLR fisheries	Medium	Mr Clark	Yes
	8.2	Consider use of EM and AI to add further data collection to aid observers	Medium/ Long	Mr Clark	-
9. Marine debris effects on seabirds and marine mammals	9.1	Review information on the effect of marine debris on marine mammals and seabirds in the Convention Area	Short	Mr Barrington	Yes
10. Light pollution effect on seabirds	10.1	Consider options for the management of light pollution for vessels fishing in the Convention Area	Short	Mr Barrington	-

Table 2: Items tasked to WG-IMAF from the Scientific Committee Strategic Plan (WG-ASAM-2022/01). Numbers refer to the numbering in the original tables.

Table 1: High-priority scientific issues for the Scientific Committee to progress 2023–2027	Providing the scientific advice that underpins an integrated, ecosystem-based approach to fisheries	3. Develop data collection plans to inform and support refined management approaches
		5. Develop methods to detect ecosystem changes and provide advice on adaptive management (e.g. through CEMP and WG-IMAF)
		7. Ensure the effects of fishing on by-catch, dependent, or related species are consistent with Article II
	Addressing cross-cutting scientific topics	2. Improve integrated approaches to fund and build science capacity within CCAMLR, including linkages with external organisations
		4. Review performance of CEMP and SISO data collection programs relative to the Strategic Plan
		5. Collaborate with other organisations (e.g. CEP, SCAR) to provide a synthesis of the state and trajectory of Antarctic marine living resources
Table 2: Priority research topics	1. Target species	(a) Develop methods to estimate biomass for krill (iii) Data collection – SISO, vessels and CEMP (2) Develop diagnostic approaches for data quality Urgency: High
		(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
		(b) Develop stock assessments to implement decision rules for krill (iii) Develop ecosystem indicators to inform risk assessment framework Urgency: Low
		(b) Develop stock assessments to implement decision rules for krill (iv) Methods to account for uncertainty in stock status (2) Spatial structure within subareas Urgency: High
	2. Ecosystem impacts	(a) Ecosystem monitoring (Second Performance Review, Recommendation 5) (i) Structured ecosystem monitoring programs (CEMP, fishery) (2) Fishery via SISO Urgency: Medium

(continued)

Table 2 (continued)

		(a) Ecosystem monitoring (Second Performance Review, Recommendation 5) (i) Structured ecosystem monitoring programs (CEMP, fishery) (3) Research Surveys Urgency: Low
		(a) Ecosystem monitoring (Second Performance Review, Recommendation 5) (iv) Marine debris monitoring Urgency: Low
		(c) By-catch risk assessment for krill and finfish fisheries (i) Monitoring status and trends Urgency: High
		(c) By-catch risk assessment for krill and finfish fisheries (i) Monitoring status and trends (1) Implement whale sighting protocols Urgency: High
		(c) By-catch risk assessment for krill and finfish fisheries (ii) By-catch species catch limits Urgency: High
		(c) By-catch risk assessment for krill and finfish fisheries (iii) By-catch mitigation methods Urgency: Low
		(c) By-catch risk assessment for krill and finfish fisheries (iv) Incidental mortality Urgency: Low
		(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) Urgency: Medium
	Administrative topics	All listed for WG-IMAF Urgency: variable

Appendix A

List of Registered Participants

Working Group on Incidental Mortality Associated with Fishing
(Hobart, Australia, 10 to 14 October 2022)

Co-conveners	Dr Marco Favero National Research Council (CONICET, Argentina)
	Mr Nathan Walker Ministry for Primary Industries
Invited experts	Mr Rhys Arangio COLTO
	Dr Javier Arata Association of Responsible Krill harvesting companies (ARK) Inc.
	Dr Igor Debski ACAP Seabird Bycatch Working Group (SBWG)
	Mr Russell Leaper Non-deliberate Human Induced Mortality Sub-committee of the IWC Scientific Committee
Argentina	Ms Marcela Mónica Libertelli Instituto Antártico Argentino
	Mrs Marina Abas Argentine Ministry of Foreign Affairs, Trade and Worship
	Dr Emilce Florencia Rombolá 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 Malcolm McNeill Australian Longline Pty Ltd
	Dr Dirk Welsford Australian Antarctic Division, Department of Climate Change, Energy, the Environment and Water
	Dr Cara Miller Australian Antarctic Division, Department of Climate Change, Energy, the Environment and Water
China, People's Republic of	Mr Gangzhou Fan Yellow Sea Fisheries Research Institute
	Dr Yi-Ping Ying Yellow Sea Fisheries Research Institute
	Dr Xianyong Zhao Yellow Sea Fisheries Research Institute, Chinese Academy of Fishery Science
	Mr Jiancheng Zhu Yellow Sea Fisheries Research Institute, Chinese Academy of Fishery Science
	Professor Guoping Zhu Shanghai Ocean University
France	Dr Marc Eléaume Muséum national d'Histoire naturelle
	Dr Clara Péron Muséum national d'Histoire naturelle
Japan	Dr Taro Ichii Fisheries Resources Institute, Japan Fisheries Research and Education Agency
	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 Yang-Sik Cho TNS Industries Inc.
	Mr Sang Gyu Shin National Institute of Fisheries Science (NIFS)
New Zealand	Mr Enrique Pardo Department of Conservation
Norway	Mr James Clark MRAG
	Dr Ulf Lindstrøm Institute of Marine Research
	Dr Andrew Lowther Norwegian Polar Institute
Russian Federation	Dr Svetlana Kasatkina AtlantNIRO
South Africa	Mrs Melanie Williamson CapMarine Environmental
Ukraine	Dr Kostiantyn Demianenko Institute of Fisheries and Marine Ecology (IFME) of the State Agency of Melioration and Fisheries of Ukraine
	Dr Leonid Pshenichnov Institute of Fisheries and Marine Ecology (IFME) of the State Agency of Melioration and Fisheries of Ukraine
	Mr Pavlo Zabroda Institute of Fisheries and Marine Ecology (IFME) of the State Agency of Melioration and Fisheries of Ukraine
United Kingdom	Dr Chris Darby Centre for Environment, Fisheries and Aquaculture Science (Cefas)
	Dr Timothy Earl Centre for Environment, Fisheries and Aquaculture Science (Cefas)
	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
	Ms Allyson Kristan National Science Foundation
	Dr George Watters National Marine Fisheries Service, Southwest Fisheries Science Center

Secretariat

Executive Secretary	Dr David Agnew
Science	
Science Manager	Dr Steve Parker
Fisheries and Observer Reporting Coordinator	Isaac Forster
Science Data Officer	Daphnis De Pooter
Fisheries and Ecosystems Analyst	Dr Stephane Thanassekos
Fisheries Monitoring and Compliance	
Fisheries Monitoring and Compliance Manager	Todd Dubois
Compliance Officer	Eldene O'Shea
Fisheries Monitoring and Compliance Data Officer	Henrique Anatole
Research, Monitoring and Compliance Analyst	Claire van Werven
Data Administration Officer	Alison Potter
Finance, Administration and Human Resources	
Finance, Administration and Human Resources Manager	Deborah Jenner
Finance Support Officer	Christine Thomas
Human Resources Officer	Angie McMahon
Administrative Services Officer	Amelia Stoneham
Administration Support	Rebecca Stride
Communications	
Communications Manager	Doro Forck
Publications Officer	Belinda Blackburn
French Translator/Team Coordinator	Floride Pavlovic
French Translator	Marie Lecomte
Russian Translator/Team Coordinator	Olga Kozyrevitch
Russian Translator	Anar Umerkhanova
Spanish Translator/Team Coordinator	Jesús Martínez
Spanish Translator	Facundo Alvarez
Data and Information Systems	
Data and Information Systems Manager	Gary Dewhurst
Database Administrator/Technical Analyst	Thomas Williams
Systems Analyst	Ian Meredith
IT Support Officer	James Eisenhower
Software Developer	Mingyun Qie
Technical Business Analyst	Mitchell John
Web Project Officer	Dane Cavanagh

Appendix B

Agenda

Working Group on Incidental Mortality Associated with Fishing
(Hobart, Australia, 10 to 14 October 2022)

1. Opening of the meeting
2. Adoption of the agenda
3. Review of incidental mortality in CCAMLR fisheries
4. Marine mammal incidental mortality
   - 4.1 Population status of marine mammals in the CAMLR Convention Area
   - 4.2 Incidental mortality and risk assessments of marine mammals in CCAMLR fisheries
     - 4.2.1 Review of whale entanglement information
     - 4.2.2 Review of recent high rates of seal by-catch reported
   - 4.3 Mitigation methods for marine mammals
5. Seabird incidental mortality
   - 5.1 Population status of seabird species in the CAMLR Convention Area
   - 5.2 Seabird incidental mortality and risk assessments in CCAMLR fisheries
   - 5.3 Mitigation methods for seabirds
     - 5.3.1 Review of net monitoring cable trial
6. Observer reports and data collection
7. Collaboration with relevant organisations
8. Future intersessional work
9. Other business
   - 9.1 Review of the Scientific Committee Strategic Plan
   - 9.2 Review of WG-IMAF terms of reference
10. Advice to the Scientific Committee
11. Adoption of the report
12. Close of the meeting.

List of Documents

Working Group on Incidental Mortality Associated with Fishing
(Hobart, Australia, 10 to 14 October 2022)

WG-IMAF-2022/01	Develop methods for the co-existence of large baleen whales with a sustainable krill fishery B.A. Krafft, U. Lindstrøm, M. Biuw M and A. Lowther
WG-IMAF-2022/02	ACAP review of mitigation measures and best practice advice for reducing the impact of demersal longline fisheries on seabirds Submitted by the Invited Expert Igor Debski
WG-IMAF-2022/03	Update on the conservation status of albatrosses and petrels in the CCAMLR area Submitted by the Invited Expert Igor Debski
WG-IMAF-2022/04	Data collection guidelines for observer and electronic monitoring programs to improve knowledge of fishery impacts on seabirds Submitted by the Invited Expert Igor Debski
WG-IMAF-2022/05	Safe handling and release guidelines for seabirds Submitted by the Invited Expert Igor Debski
WG-IMAF-2022/06	ACAP review of mitigation measures and best-practice advice for reducing the impact of pelagic and demersal trawl fisheries on seabirds Submitted by the Invited Expert Igor Debski
WG-IMAF-2022/07	Summary of incidental mortality associated with fishing activities during the 2022 season, and review of incidental mortality data and warp strike data since 2012 Secretariat
WG-IMAF-2022/08	Report of IWC Scientific Committee intersessional group on whale entanglement in Southern Ocean krill fishery Submitted by the Invited Expert Russell Leaper
WG-IMAF-2022/09	New Zealand sea lion exclusion device as an example of successful by-catch mitigation E. Pardo, G. Lydon, A. Dunn and L. Boren
WG-IMAF-2022/10	Results of the net monitor trial season 2 S. Young, J. Moir Clark, J. Chapman, B. A. Krafft and A. Lowther

WG-IMAF-2022/11	Results of the net monitor trial season 3 S. Young, J. Moir Clark, J. Chapman, B. A. Krafft and A. Lowther
WG-IMAF-2022/12	Observations of marine mammals in Subarea 48.3 of CCAMLR C. Passadore, P. Conti and O. Pin

Other Documents

CCAMLR-41/08	Review of the Rules for Access and Use of CCAMLR Data Chair of the Data Services Advisory Group (DSAG)
SC-CAMLR-41/BG/32	The application of electronic monitoring in CCAMLR fisheries Delegation of the United Kingdom
SC-CAMLR-41/BG/33	Proposal for a Workshop to enhance the CCAMLR Ecosystem Monitoring Program (CEMP) C. Waluda, M. Collins, M. Korczak-Abshire, J.-H. Kim, G. Milinevsky, A. Kato and S. Olmastroni
WG-ASAM-2022/01	Report of the Chair of the Scientific Committee on the CCAMLR Scientific Committee Symposium Chair of the Scientific Committee
WG-EMM-18/33	Approaches to data collection and analysis for detecting and quantifying functional overlap at the scale of the individual vessell M. Söffker and N. Gasco
WG-EMM-2022/26 Rev. 1	Return of the giants: Summer abundance of fin whales in the Scotia Sea M. Biuw, U. Lindstrøm, J.A. Jackson, M. Baines, N. Kelly, G. McCallum, G. Skaret and B.A. Krafft
WG-FSA-2021/04 Rev. 1	Summary of incidental mortality associated with fishing activities collected in scientific observer and vessel data during the 2020 and 2021 seasons Secretariat

Appendix D

Details of marine mammal exclusion device deployed on Norwegian continuous krill trawl nets, with alterations and modifications made in 2021 and 2022

After the third humpback whale entanglement in April 2021, in which the whale broke through the exclusion device, Aker BioMarine added 8, 10 and 12 mm Spectra ropes to the device to increase the breaking strain. The 12 mm rope has a reported breaking strain of 10 tonnes, which is around five times the strength of the previous material. However, despite this modification, another humpback whale entanglement was recorded in January 2022. Although the animal did not break through the net, it was concluded that the fastening of this reinforced exclusion net was incomplete and too far away from the mouth of the net at its lower end. Modifications were made by attaching the exclusion device tightly to the mouth opening and stringing it tighter to increase the tension (Figure 1). No whale entanglement incidents have been reported since then.

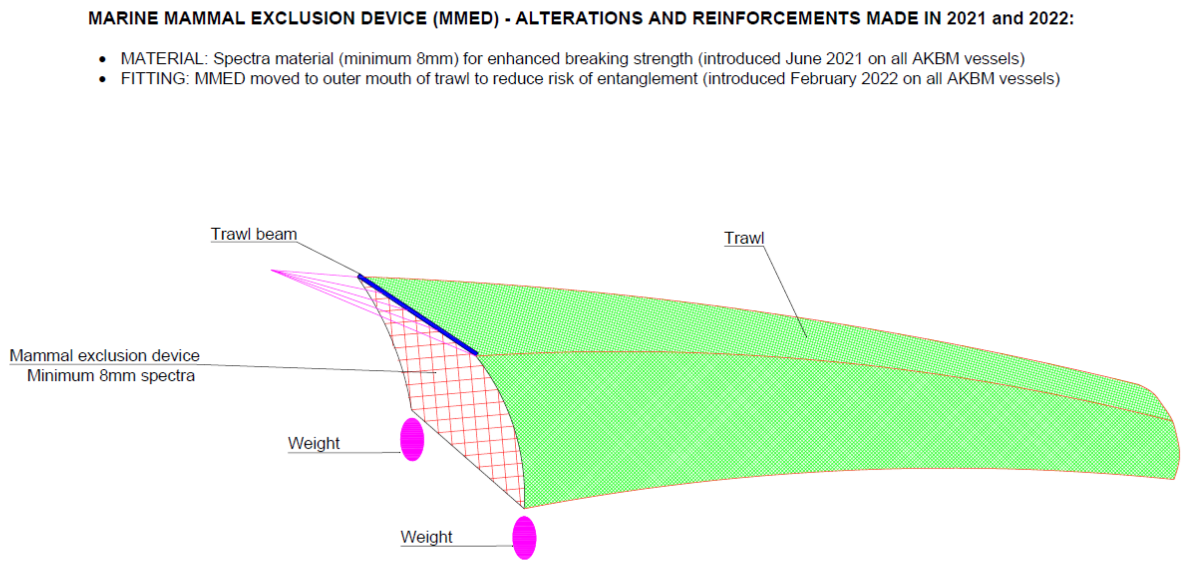


Figure 1: Marine mammal exclusion device deployed on Norwegian continuous krill trawl nets, with alterations and modifications made in 2021 and 2022. For an indication of scale, the mouth of the net is approximately 20 m × 20 m.

Appendix E

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. To achieve this, WG-IMAF will address the following terms of reference:

(i) review and analyse data on the level and significance of direct impacts of interactions and incidental mortality associated with fishing

(ii) review the efficacy of mitigation measures and avoidance techniques currently in use in the Convention Area, and consider improvements to them, taking into account experience both inside and outside the Convention Area

(iii) review and analyse data on the level and significance of direct impacts of marine debris on seabirds and marine mammals within the Convention Area

(iv) collaborate and coordinate with organisations that the Commission has a recognised cooperative arrangement with, including invited experts as required

(v) provide the Scientific Committee with advice for:

(a) improvements and/or additions to the reporting and data collection requirements currently in use in the Convention Area

(b) improvements and/or additions to the measures in use to avoid or mitigate incidental mortality and interactions associated with fisheries within the Convention Area

(c) cooperation with other organisations with relevant expertise

(d) approaches to improve the conservation status of Convention Area seabirds and marine mammals directly impacted by fishing outside the Convention Area, including cooperation with adjacent regional fisheries management organisations (RFMOs).

---

[1] 2022.

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

Contents

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

Opening of the meeting

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

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

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

Adoption of the agenda

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

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

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

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

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

Review of data available

Catch limit management

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Management of krill fishery catches

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

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

Ross Sea region toothfish

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

Ross Sea Data Collection Plan Workshop

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

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

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

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

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

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

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

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

(i) verification of appropriate conversion factor sampling rates (paragraphs 8.18 and 8.20)

(ii) collection of skate biological sampling and caudal thorns from tag recapture sampling.

Amundsen Sea toothfish

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

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

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

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

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

Fish stock assessment and management advice

Icefish (*Champsocephalus gunnari*)

Assessment of *C. gunnari* in Subarea 48.3

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

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

Management advice

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

Assessment of *C. gunnari* in Division 58.5.2

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

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

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

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

Management advice

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

Toothfish (*Dissostichus* spp.)

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

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

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

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

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

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

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

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

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

Workshop on Age Determination Methods

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

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

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

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

(a) processes to:

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

(b) mechanism of ageing validation across laboratories/Members

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Whale depredation

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

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

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

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

Stock assessment of *D. eleginoides* in Subarea 48.3

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

D. eleginoides in Division 58.5.2

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

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

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

Biomass estimation for toothfish from trend analysis

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

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

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

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

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

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

Research fisheries

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

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

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

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

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

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

Area 48

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Area 58

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Subarea 48.2 icefish survey

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

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

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

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

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

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

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

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

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

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

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

Subarea 48.3 icefish survey

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

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

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

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

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

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

Ross Sea shelf survey

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

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

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

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

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

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

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

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

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

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

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

D. mawsoni in Subarea 88.3

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

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

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

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

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

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

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

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

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

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

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

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

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

Subarea 48.1

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

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

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

Non-target catch and incidental mortality associated with fishing

By-catch in krill fisheries

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

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

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

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

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

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

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

By-catch in toothfish fisheries

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

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

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

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

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

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

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

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

Macrourids

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

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

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

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

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

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

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

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

Skates

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

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

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

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

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

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

Management of VMEs and habitats of particular concern

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

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

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

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

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

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

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

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

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

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

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

Ecosystem structure and function

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

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

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

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

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

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

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

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

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

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

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

Antarctic krill (*Euphausia superba*)

Catch recording

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

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

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

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

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

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

Management framework

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

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

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

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

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

(ii) krill acoustic biomass estimates for the agreed strata

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

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

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

Biomass estimates

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

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

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

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

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

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

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

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

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

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

Estimation of gamma

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

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

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

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

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

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

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

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

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

Catch limit allocation

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Scheme of International Scientific Observation

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Krill fishery by-catch sampling

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

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

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

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

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

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

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

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

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

Future work

Chair's report of the Scientific Committee Symposium

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

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

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

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

Data access rules (Data Services Advisory Group)

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

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

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

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

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

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

9.11 The Working Group recommended that:

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

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

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

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

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

Communicating difference in scientific interpretation

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

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

Communicating with the public

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

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

Other business

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

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

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

Advice to the Scientific Committee

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

(i) Ross Sea data collection plan –

 (a) endorse the RSDCP (paragraph 3.22).

(ii) Amundsen Sea toothfish –

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

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

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

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

(iv) Workshop on age determination methods –

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

(v) Subarea 48.3 toothfish –

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

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

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

(vi) Antarctic toothfish in Subarea 48.4 –

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

(vii) Toothfish Division 58.5.2 –

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

(viii) Trend analysis –

(a) update the decision tree (paragraph 4.63)

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

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

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

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

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

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

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

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

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

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

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

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

(xi) By-catch in toothfish fisheries –

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

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

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

(xii) Marine debris –

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

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

(xiii) Monitoring to support management –

(a) convene a CEMP workshop (paragraph 6.43)

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

(xiv) Krill management framework –

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

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

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

(d) catch limit determination (paragraph 7.24)

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

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

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

(xv) Observer work in krill fisheries –

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

(xvi) Terms of reference –

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

(xvii) Data access rules –

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

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

(xviii) Communication –

(a) resolving differences of opinion (paragraph 9.13)

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

Adoption of the report and close of meeting

12.1 The report of the meeting was adopted.

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

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

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

References

Ceballos, S.G., C. Papetti, M. Babbucci, D.A. Fernández, L. Schiavon and C.-H.C. Cheng. 2021 Genome-wide analysis reveals striking lack of genetic differentiation over long distances for the Antarctic toothfish *Dissostichus mawsoni*: high genetic connectivity or shared spawning grounds? *Fish. Res.*, 243, Article 106074, doi: https://doi.org/10.1016/j.fishres.2021.106074.

Everson, I., K.-H. Kock and G. Parkes. 1997. Interannual variation in condition of the mackerel icefish. *J. Fish Biol.,* 51: 146–154, doi: https://doi.org/10.1111/j.1095-8649.1997.tb02520.x.

Nielsen, J., R.B. Hedeholm, J. Heinemeier, P.G. Bushnell, J.S. Christiansen, J. Olsen, C.B. Ramsey, R.W. Brill, M. Simon, K.F. Steffensen and J.F. Steffensen. 2016. Eye lens radiocarbon reveals centuries of longevity in the Greenland shark (*Somniosus microcephalus*). *Science*, 353: 702–704.

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

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

(continued)

Table 1 (continued)

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

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

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

(continued)

Table 2 (continued)

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

(continued)

Table 2 (continued)

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

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

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

(continued)

Table 3 (continued)

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

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

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

(continued)

Table 4 (continued)

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

(continued)

Table 4 (continued)

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

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

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

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

** Catch limit for effort-limited research fishing.

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

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

(continued)

Table 6 (continued)

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

(continued)

Table 6 (continued)

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

(continued)

Table 6 (continued)

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

(continued)

Table 6 (continued)

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

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

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

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

Table 8: Oblique haul locations in decimal degrees.

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

Table 9: Location of acoustic transects extremities points.

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

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

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

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

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

* Note these biomass estimates were the lower one-sided 95% confidence interval due to only having a single survey.
\# The Working Group noted these areas should have a stepwise increase towards the proposed limits (see paragraphs 7.41 and 7.45).

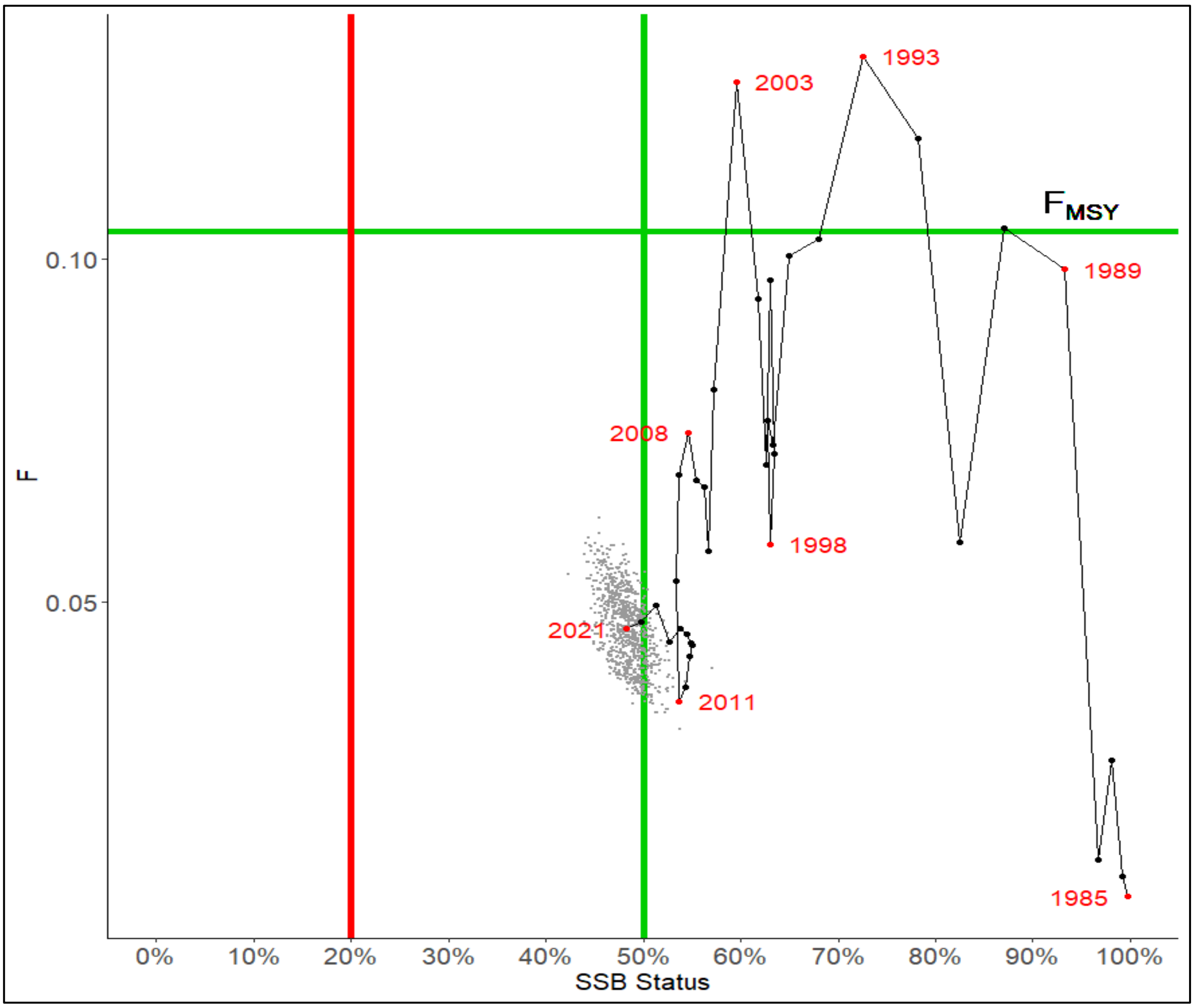


Figure 1: Markov Chain Monte Carlo (MCMC) Kobe plot for Patagonian toothfish (*Dissostichus eleginoides*) in Subarea 48.3 (lines) with the MCMC estimates of uncertainty around the 2021 estimate (points). The green and red vertical lines indicate the target (50% B_0) and limit (20% B_0) reference points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

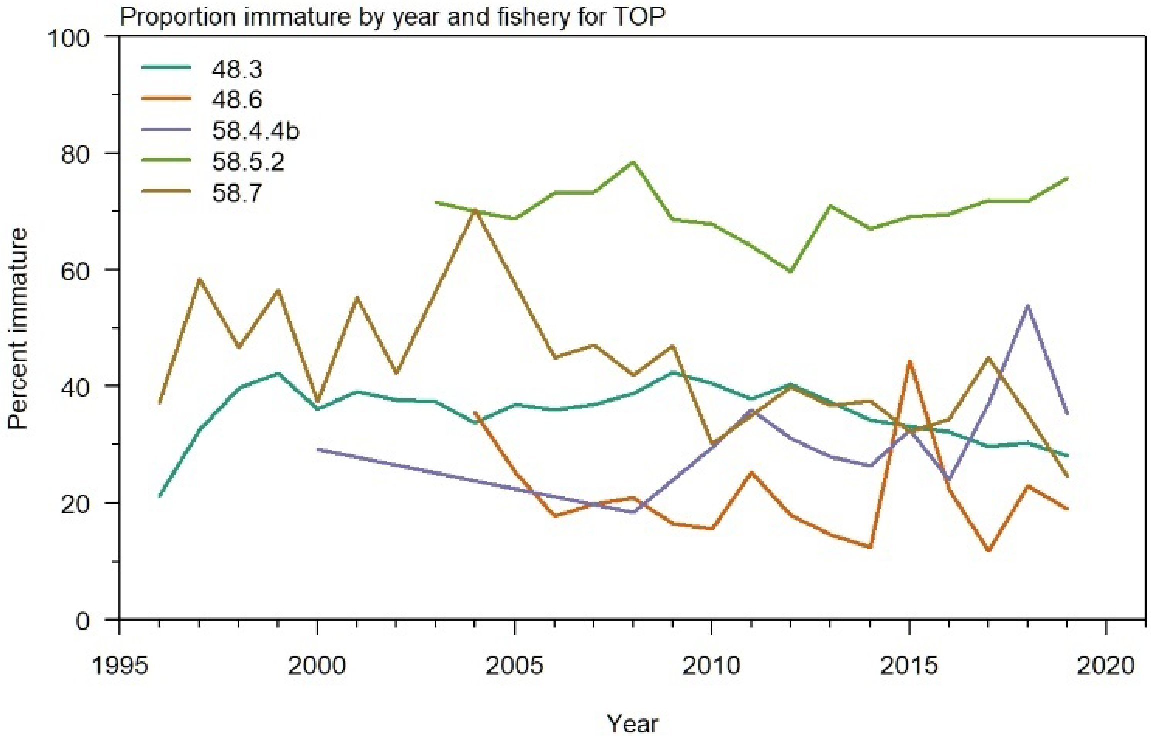


Figure 2: Percent immature fish by year in catches of Patagonian toothfish (*Dissostichus eleginoides*) fisheries across the Convention Area (reproduced from WG-FSA-2019, Figure 5c).

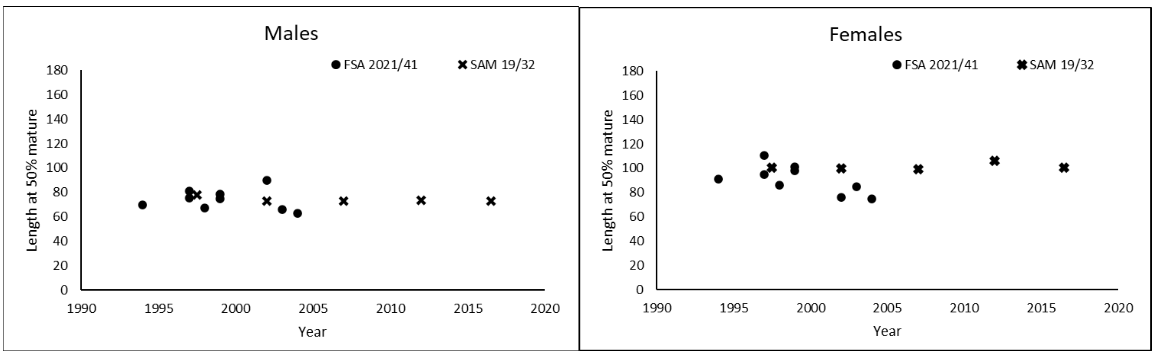


Figure 3: The time series of historic research paper estimates of length at first maturity presented in WG-FSA-2021/41 (circles), plotted with the five-year block estimates from WG-SAM-2019/32, standardised by depth, gear type and sex/depth interactions (reproduced from SC-CAMLR-40/BG/08, Figure 2).

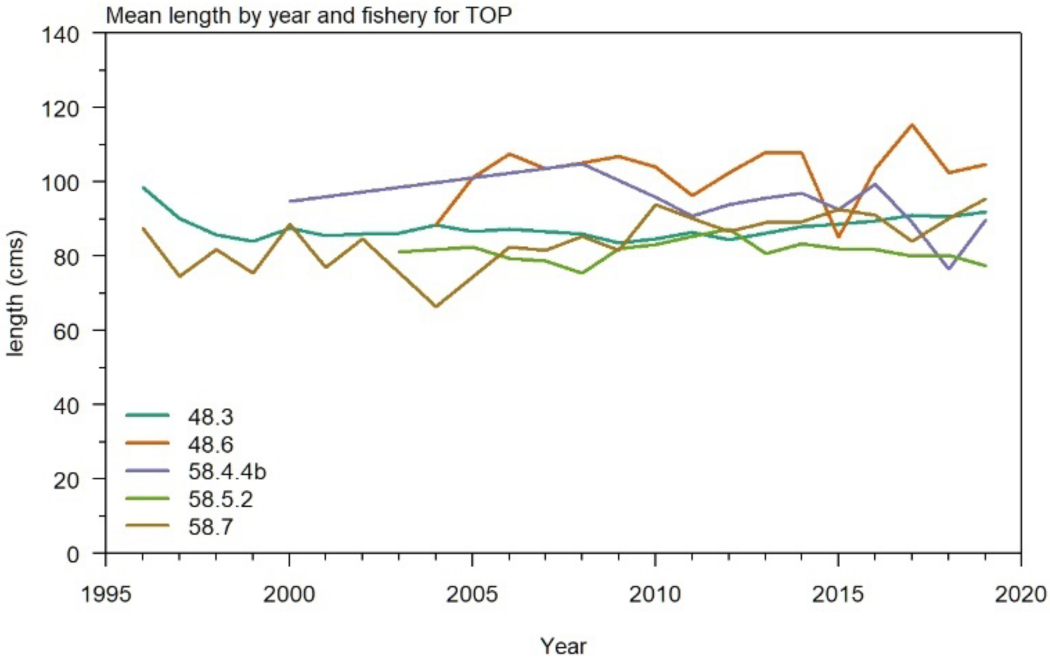


Figure 4: Mean length by year in catches of Patagonian toothfish (*Dissostichus eleginoides*) fisheries across the Convention Area (reproduced from WG-FSA-2019, Figure 4c).

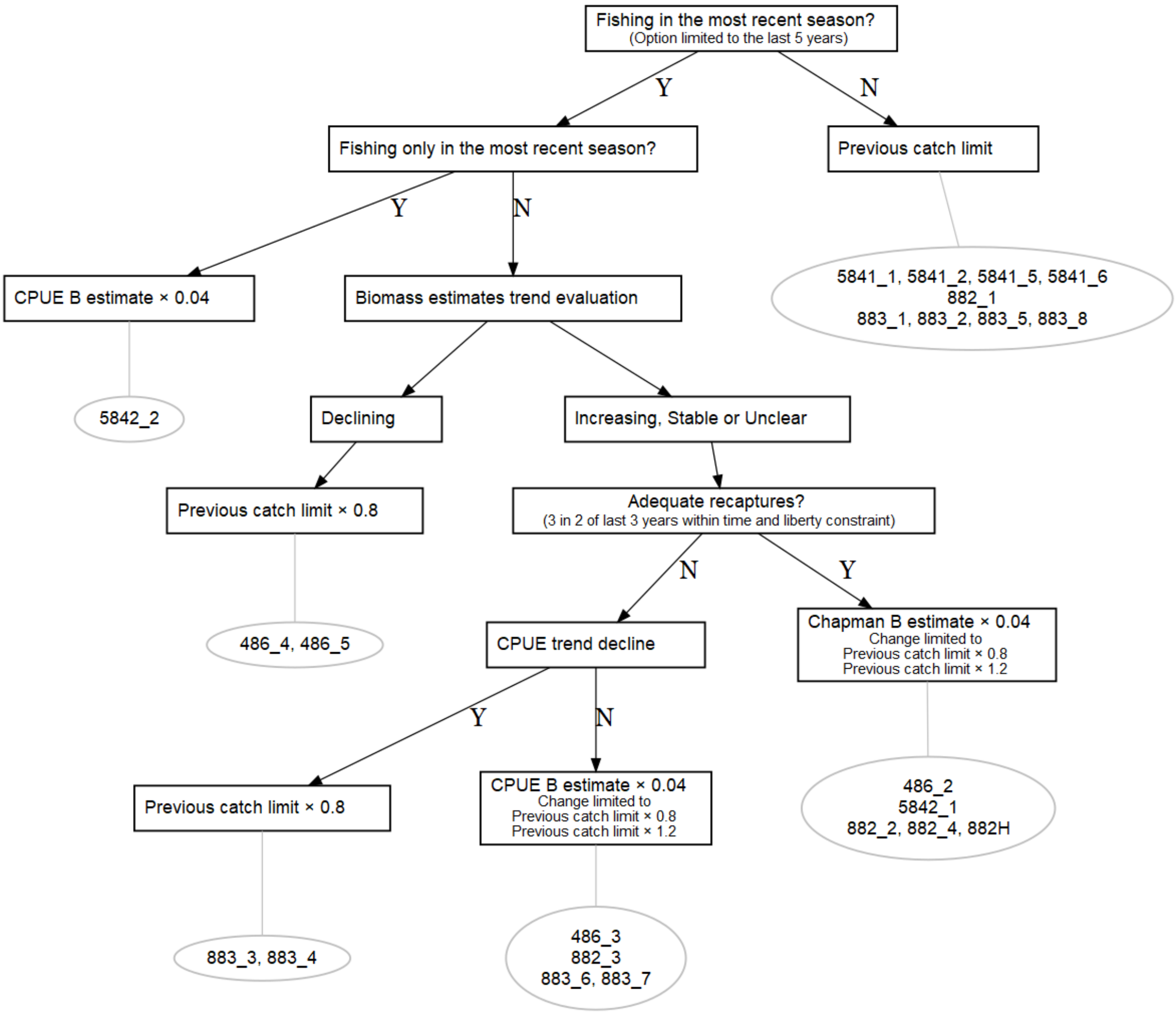


Figure 5: Updated decision tree of the trend analysis used to provide catch advice for research blocks and small-scale research units in data-limited toothfish fisheries (referenced in ovals) for the 2022/23 season.

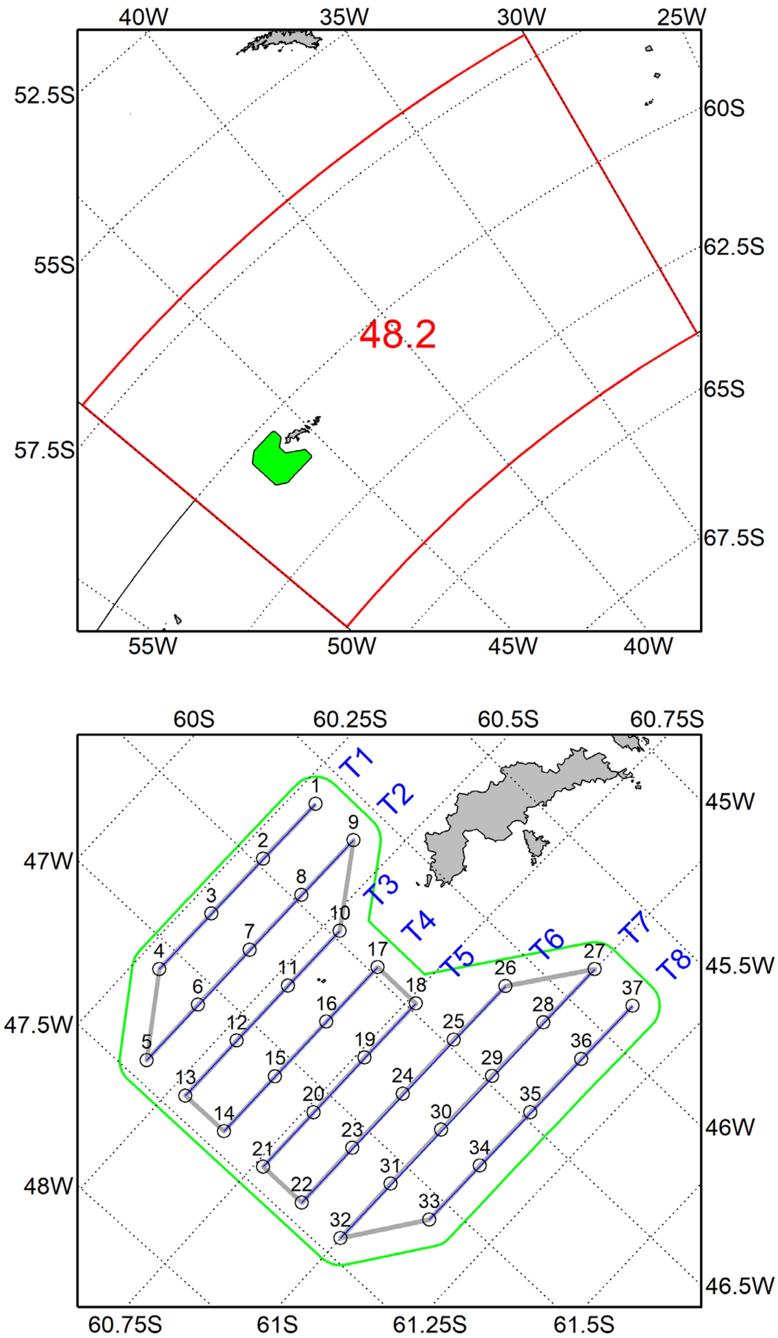


Figure 6: Survey area (green), transects (blue) and oblique haul locations (circles) in Subarea 48.2.

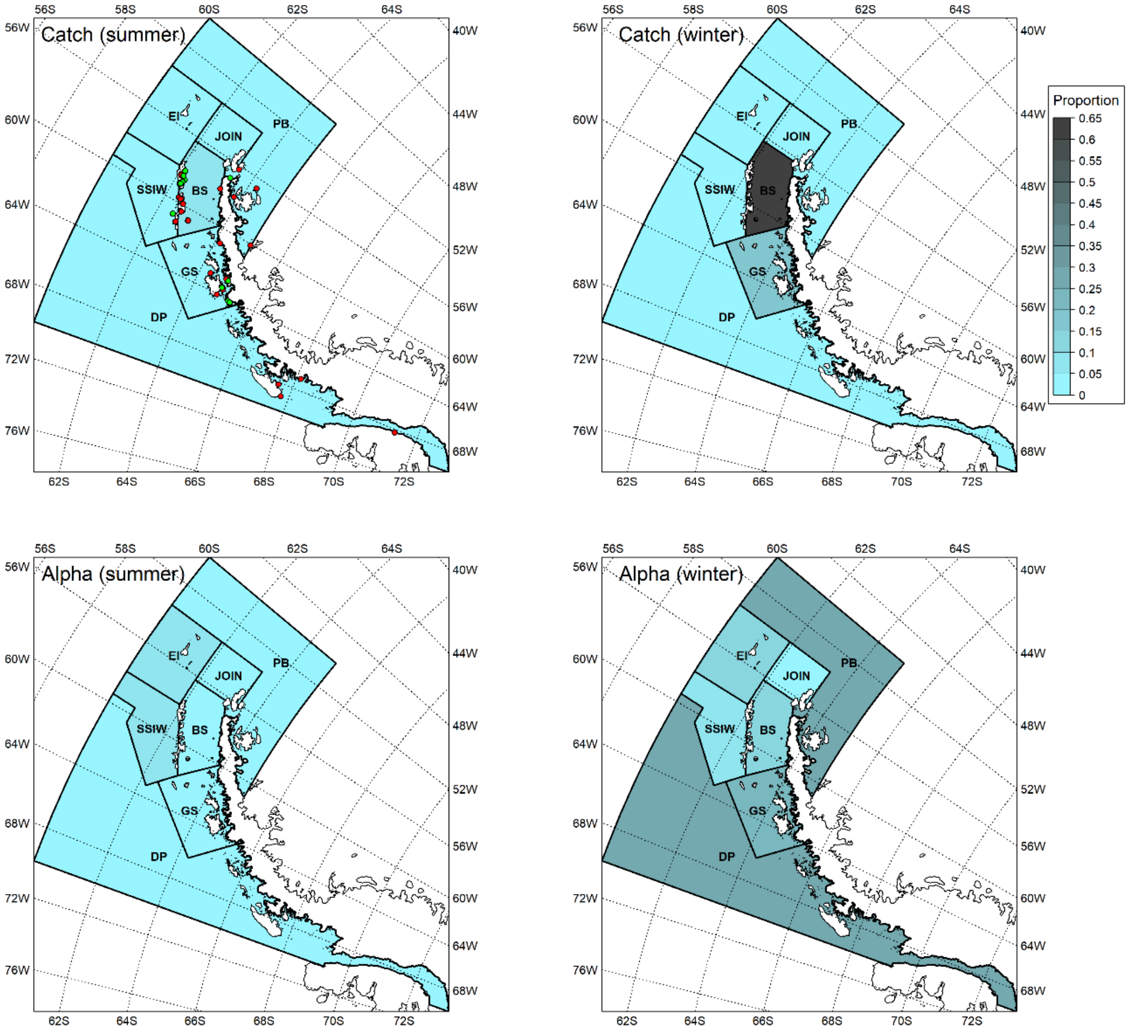


Figure 7: Distribution of krill catch (top) and alphas (bottom) in summer (left) and winter (right) in Subarea 48.1. Catch is shown here as a proportion of the total catch over the last five years (2018–2022), alphas correspond to proportions of the total catch limit for Subarea 48.1. CCAMLR Ecosystem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

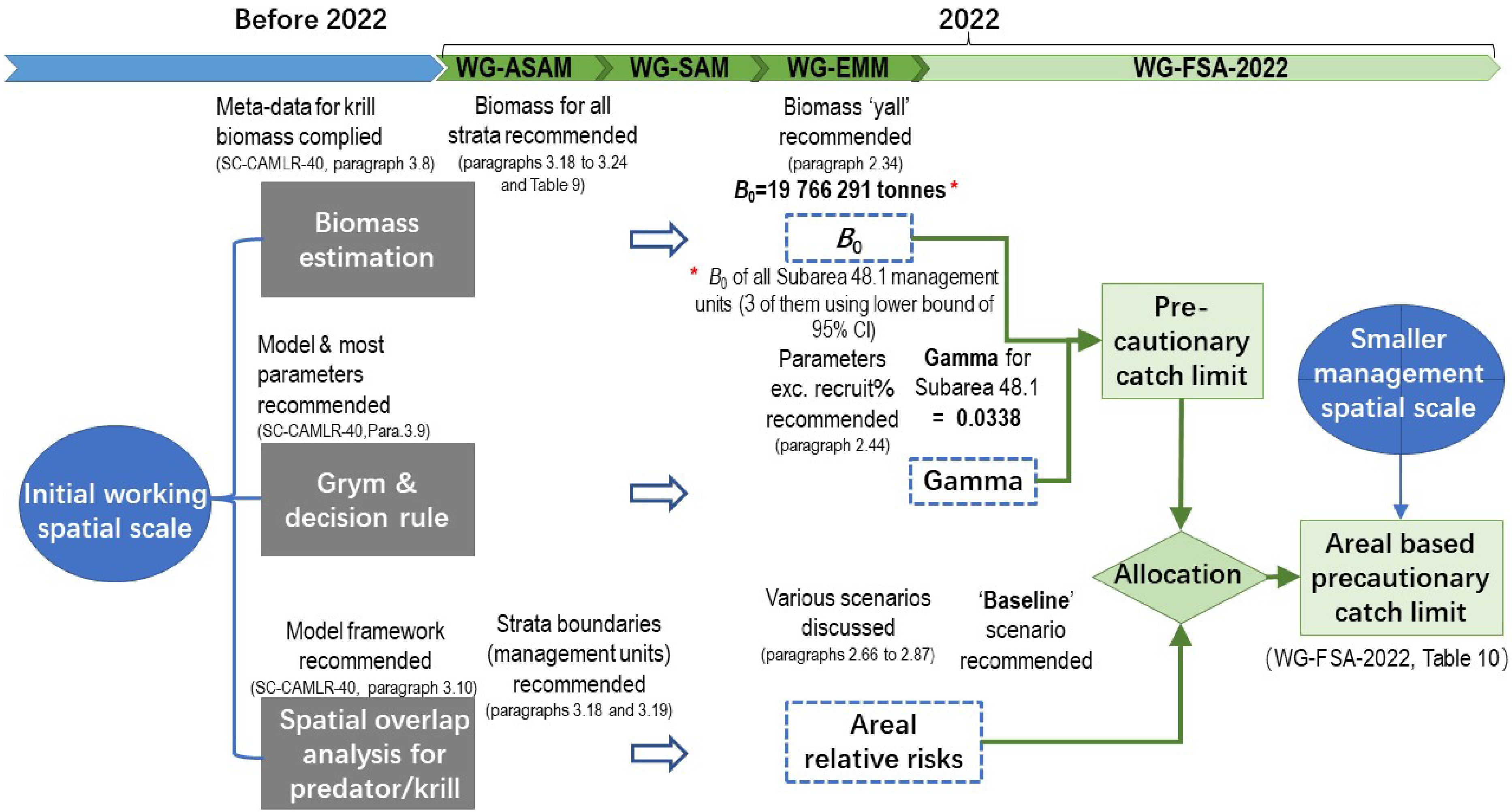


Figure 8: The three components and workflow of the revised krill management approach, as agreed at SC-CAMLR-40, paragraph 3.25, and Annex 8, and subsequent recommendations leading to the WG-FSA-agreed strata catch limits by each working group.

Appendix A

List of Registered Participants

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

Convener	Mr Sobahle Somhlaba Department of Agriculture, Forestry and Fisheries
Argentina	Mrs Marina Abas Argentine Ministry of Foreign Affairs, Trade and Worship
	Mr Javier De Cicco Argentine Ministry of Foreign Affairs, Trade and Worship
	Dr Marco Favero National Research Council (CONICET, Argentina)
	Dr Enrique Marschoff Instituto Antártico Argentino
	Dr Eugenia Moreira Instituto Antártico Argentino / CONICET
	Ms Cynthia Mulville Ministerio de Relaciones Exteriores, Comercio Internacional y Culto
	Mr Manuel Novillo CONICET (Consejo Nacional de Investigaciones Científicas y Técnicas)
	Dr Emilce Florencia Rombolá Instituto Antártico Argentino
Australia	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 Agriculture, Water and the Environment

Mr Dale Maschette
Institute for Marine and Antarctic Studies (IMAS), University of Tasmania

Dr Cara Miller
Australian Antarctic Division, Department of Climate Change, Energy, the Environment and Water

Dr Dirk Welsford
Department of Climate Change, Energy, the Environment and Water

Dr Philippe Ziegler
Australian Antarctic Division, Department of Climate Change, Energy, the Environment and Water

Chile

Professor Patricio M. Arana
Pontificia Universidad Catolica de Valparaíso

Dr César Cárdenas
Instituto Antártico Chileno (INACH)

Mr Mauricio Mardones
Instituto de Fomento Pesquero

Dr Juan-Carlos Quiroz
Instituto de Fomento Pesquero

Dr Lorena Rebolledo
Instituto Antártico Chileno (INACH)

Mr Francisco Santa Cruz
Instituto Antartico Chileno (INACH)

China

Mr Gangzhou Fan
Yellow Sea Fisheries Research Institute

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 Qing Chang XU
Yellow Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences

Dr Yi-Ping Ying
Yellow Sea Fisheries Research Institute

Ms Haiting Zhang
Shanghai Ocean University, IMAS, University of Tasmania

Mr Jichang Zhang
Yellow Sea Fisheries Research Institute

Dr Yunxia Zhao
Yellow Sea Fisheries Research Institute

Dr Xianyong Zhao
Yellow Sea Fisheries Research Institute, Chinese Academy of Fishery Science

Mr Jiancheng Zhu
Yellow Sea Fisheries Research Institute, Chinese Academy of Fishery Science

Professor Guoping Zhu
Shanghai Ocean University

European Union

Dr Sebastián Rodríguez Alfaro
European Union

France

Ms Charlotte Chazeau
Muséum national d'Histoire naturelle

Dr Marc Eléaume
Muséum national d'Histoire naturelle

Ms Johanna Faure
Muséum national d'Histoire naturelle

Mr Nicolas Gasco
Muséum national d'Histoire naturelle

Dr Félix Massiot-Granier
Muséum national d'Histoire naturelle

Dr Clara Péron
Muséum national d'Histoire naturelle

Germany	Dr Jilda Caccavo Institute Pierre-Simon Laplace
	Dr Stefan Hain Alfred Wegener Institute for Polar and Marine Research
	Ms Rebecca Konijnenberg Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research
	Professor Bettina Meyer Alfred Wegener Institute for Polar and Marine Research
Japan	Dr Taro Ichii Fisheries Resources Institute, Japan Fisheries Research and Education Agency
	Dr Takehiro Okuda Fisheries Resources Institute, Japan Fisheries Research and Education Agency
	Dr Kota Sawada Fisheries Resources Institute, Japan Fisheries Research and Education Agency
Korea, Republic of	Mr Gap-Joo Bae Hong Jin Corporation
	Mr Yang-Sik Cho TNS Industries Inc.
	Mr Sang-jin Choi Korea Overseas Fisheries Association
	Mr Hyun Joong Choi TNS Industries Inc.
	Dr Sangdeok Chung National Institute of Fisheries Science (NIFS)
	Mr Dongwon Industries Yoonhyung Kim
	Mr Taebin Jung TNS Industries
	Professor Hyun-Woo Kim Pukyoung National University

	Mr Yoonhyung Kim Dongwon Industries
	Professor Hyuk Je Lee Sangji University
	Dr Jaebong Lee National Institute of Fisheries Science (NIFS)
	Mr Sang Gyu Shin National Institute of Fisheries Science (NIFS)
New Zealand	Dr Jennifer Devine National Institute of Water and Atmospheric Research Ltd. (NIWA)
	Mr Alistair Dunn Ocean Environmental
	Mr Jack Fenaughty Silvifish Resources Ltd
	Mr Nathan Walker Ministry for Primary Industries
Norway	Mr James Clark MRAG
	Dr Ulf Lindstrøm Institute of Marine Research
	Dr Andrew Lowther Norwegian Polar Institute
Poland	Mrs Jolanta Mosor Ministry of Agriculture and Rural Development
Russian Federation	Dr Svetlana Kasatkina AtlantNIRO
	Dr Andrey Petrov Federal Agency for Fisheries
South Africa	Mr Christopher Heinecken Capricorn Fisheries Monitoring
	Mrs Melanie Williamson CapMarine Environmental

Spain	Dr Takaya Namba Pesquerias Georgia, S.L
	Mr Roberto Sarralde Vizuete Instituto Español de Oceanografía
Ukraine	Dr Kostiantyn Demianenko Institute of Fisheries and Marine Ecology (IFME) of the State Agency of Melioration and Fisheries of Ukraine
	Dr Leonid Pshenichnov Institute of Fisheries and Marine Ecology (IFME) of the State Agency of Fisheries of Ukraine
	Mr Pavlo Zabroda Institute of Fisheries and Marine Ecology (IFME) of the State Agency of Fisheries of Ukraine
United Kingdom	Dr Martin Collins British Antarctic Survey
	Dr Chris Darby Centre for Environment, Fisheries and Aquaculture Science (Cefas)
	Dr Tracey Dornan British Antarctic Survey
	Dr Timothy Earl Centre for Environment, Fisheries and Aquaculture Science (Cefas)
	Dr Simeon Hill British Antarctic Survey
	Dr Oliver Hogg Centre for Environment, Fisheries and Aquaculture Science (Cefas)
	Dr Phil Hollyman British Antarctic Survey
	Dr Matthew Kerr Centre for Environment, Fisheries and Aquaculture Science (Cefas)
	Dr Jessica Marsh Centre for Environment, Fisheries and Aquaculture Science (Cefas)

Ms Lisa Readdy
Centre for Environment, Fisheries and Aquaculture Sciences (Cefas)

Ms Ainsley Riley
Centre for Environment, Fisheries and Aquaculture Science (Cefas)

Ms Georgia Robson
Centre for Environment, Fisheries and Aquaculture Science (Cefas)

Mr Peter Thomson
Argos Froyanes

Dr Claire Waluda
British Antarctic Survey

United States of America

Dr Jefferson Hinke
National Marine Fisheries Service, Southwest Fisheries Science Center

Dr Christopher Jones
National Oceanographic and Atmospheric Administration (NOAA)

Dr George Watters
National Marine Fisheries Service, Southwest Fisheries Science Center

Secretariat

Executive Secretary	Dr David Agnew
Science	
Science Manager	Dr Steve Parker
Fisheries and Observer Reporting Coordinator	Isaac Forster
Science Data Officer	Daphnis De Pooter
Fisheries and Ecosystems Analyst	Dr Stephane Thanassekos
Fisheries Monitoring and Compliance	
Fisheries Monitoring and Compliance Manager	Todd Dubois
Compliance Officer	Eldene O'Shea
Fisheries Monitoring and Compliance Data Officer	Henrique Anatole
Research, Monitoring and Compliance Analyst	Claire van Werven
Data Administration Officer	Alison Potter
Finance, Administration and Human Resources	
Finance, Administration and Human Resources Manager	Deborah Jenner
Finance Support Officer	Christine Thomas
Human Resources Officer	Angie McMahon
Administrative Services Officer	Amelia Stoneham
Administration Support	Rebecca Stride
Communications	
Communications Manager	Doro Forck
Publications Officer	Belinda Blackburn
French Translator/Team Coordinator	Floride Pavlovic
French Translator	Marie Lecomte
French Translator	Bénédicte Graham
Russian Translator/Team Coordinator	Olga Kozyrevitch
Russian Translator	Anar Umerkhanova
Russian Translator	Blair Denholm
Spanish Translator/Team Coordinator	Jesús Martínez
Spanish Translator	Facundo Alvarez
Spanish Translator	Alejandra Sycz
Data and Information Systems	
Data and Information Systems Manager	Gary Dewhurst
Database Administrator/Technical Analyst	Thomas Williams
Systems Analyst	Ian Meredith
IT Support Officer	James Eisenhower
Software Developer	Mingyun Qie
Technical Business Analyst	Mitchell John
Web Project Officer	Dane Cavanagh

Appendix B

Agenda

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

1. Opening of the meeting

2. Adoption of the agenda

3. Review of data available

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

4. Fish stock assessment and management advice

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

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

   4.3 Biomass estimation for toothfish from trend analysis

5. Research fisheries

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

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

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

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

7. Krill (*Euphausia superba*)

8. Scheme of International Scientific Observation

9. Future work

10. Other business

11. Advice to the Scientific Committee

12. Adoption of the report and close of meeting.

Appendix C

List of Documents

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

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

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

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

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

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

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

Other documents

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

Appendix D

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

Report of the Co-conveners of the Workshop on the Ross Sea Data Collection Plan 2022

(Virtual Meeting, 11 and 12 August 2022)

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

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

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

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

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

Identify fishery-based medium-term research objectives

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

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

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

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

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

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

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

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

Develop a sampling plan to obtain necessary data

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Identify voluntary programs to test novel data collection mechanisms

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

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

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

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

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

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

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

Next steps

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

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

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

(continued)

Table 1 (continued)

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

(continued)

Table 1 (continued)

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

(continued)

Table 1 (continued)

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

(continued)

Table 1 (continued)

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

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

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

(continued)

Table 2 (continued)

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

(continued)

Table 2 (continued)

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

(continued)

Table 2 (continued)

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

(continued)

Table 2 (continued)

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

(continued)

Table 2 (continued)

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

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

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

(continued)

Table 3 (continued)

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

(continued)

Table 3 (continued)

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

(continued)

Table 3 (continued)

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

(continued)

Table 3 (continued)

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

Attachment I

List of Registered Participants

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

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

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

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

Attachment II

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

Date and location

11 and 12 August 2022

Co-conveners

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

Objective

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

Target attendees

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

Format

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

Outputs

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

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

Financial requirements

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

Agenda

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

1. Identify fishery-based medium-term research objectives

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

2. Develop a sampling plan to obtain necessary data

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

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

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

4. Identify voluntary programs to test novel data collection mechanisms

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

Attachment IV

List of Documents

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

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

Appendix E

Format 1

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

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

(continued)

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

Appendix F

Additional Guidelines for the Icefish Survey in Subarea 48.2

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

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

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

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

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

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

Gridded station trawls

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

Target trawls

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

Stock Assessment Modelling for *Euphausia superba*

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

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

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

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

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

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

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

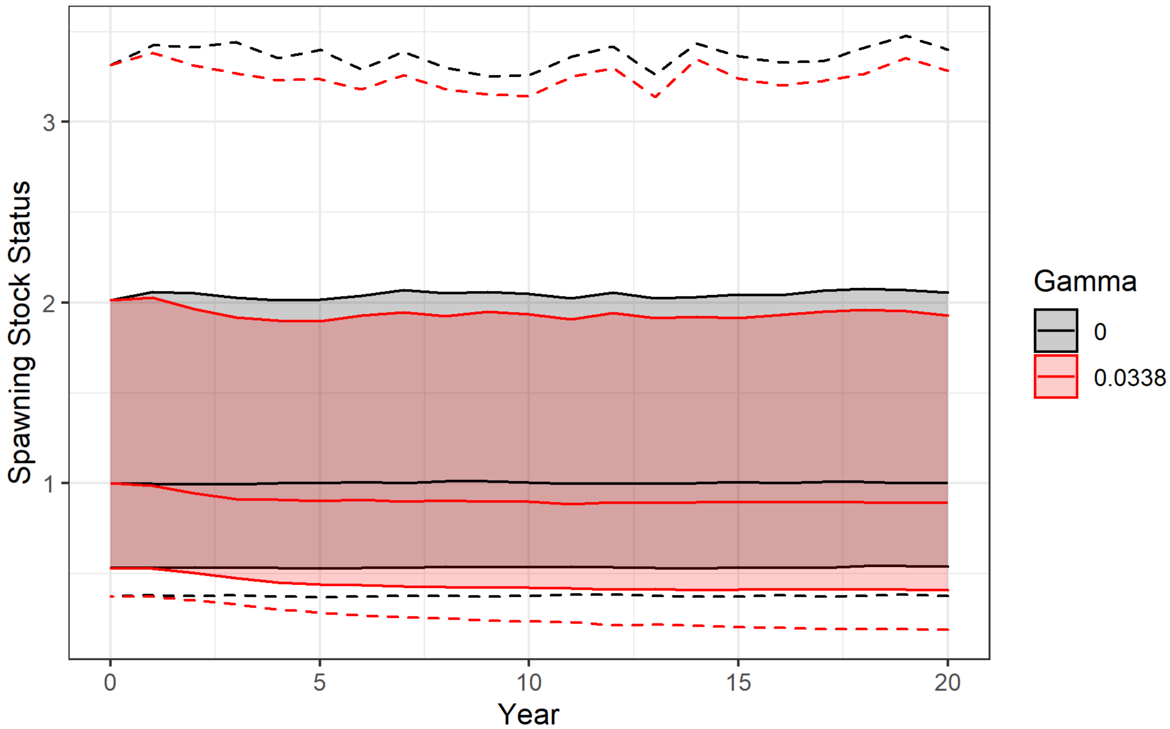


Figure 1: Spawning stock status for 20-year simulated krill population in Subarea 48.1 based on fished and unfished projection, showing median with 90% (shaded) and 97.5% confidence intervals (dashed).

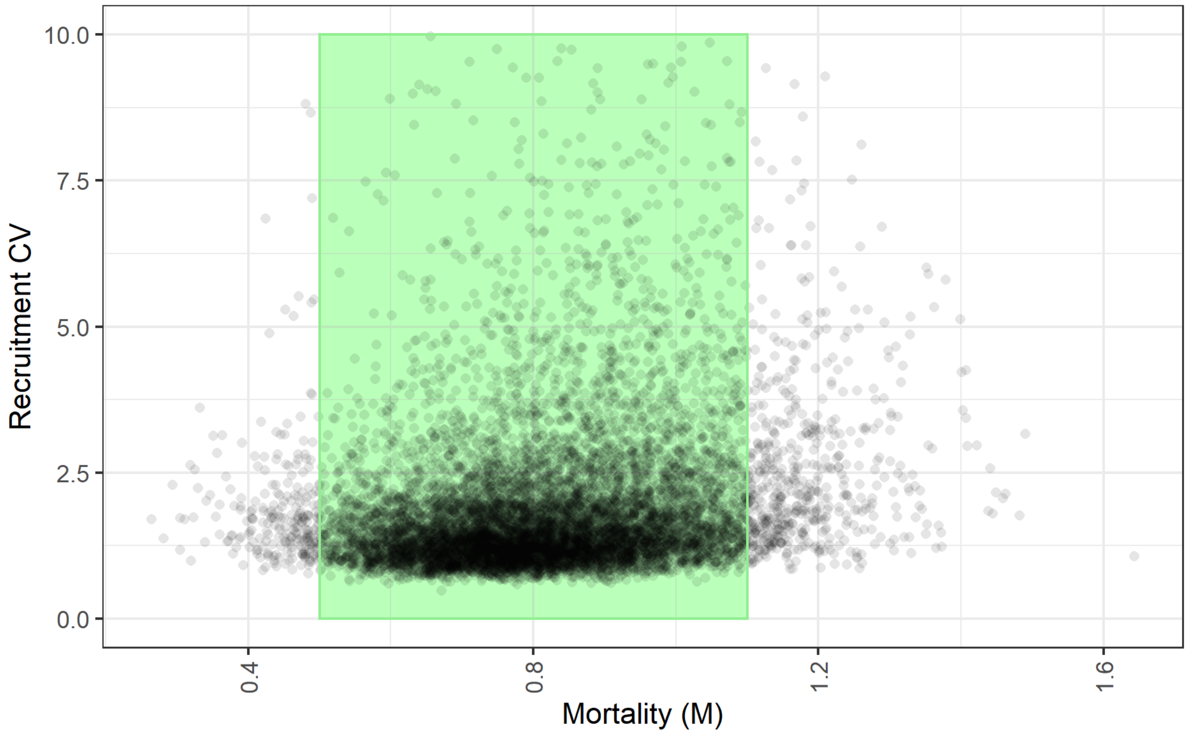


Figure 2: Comparison of mortality and recruitment CV for mean and standard deviation of proportional recruitment using an inverse-beta distribution. Mortality range 0.5–1.1 in green.

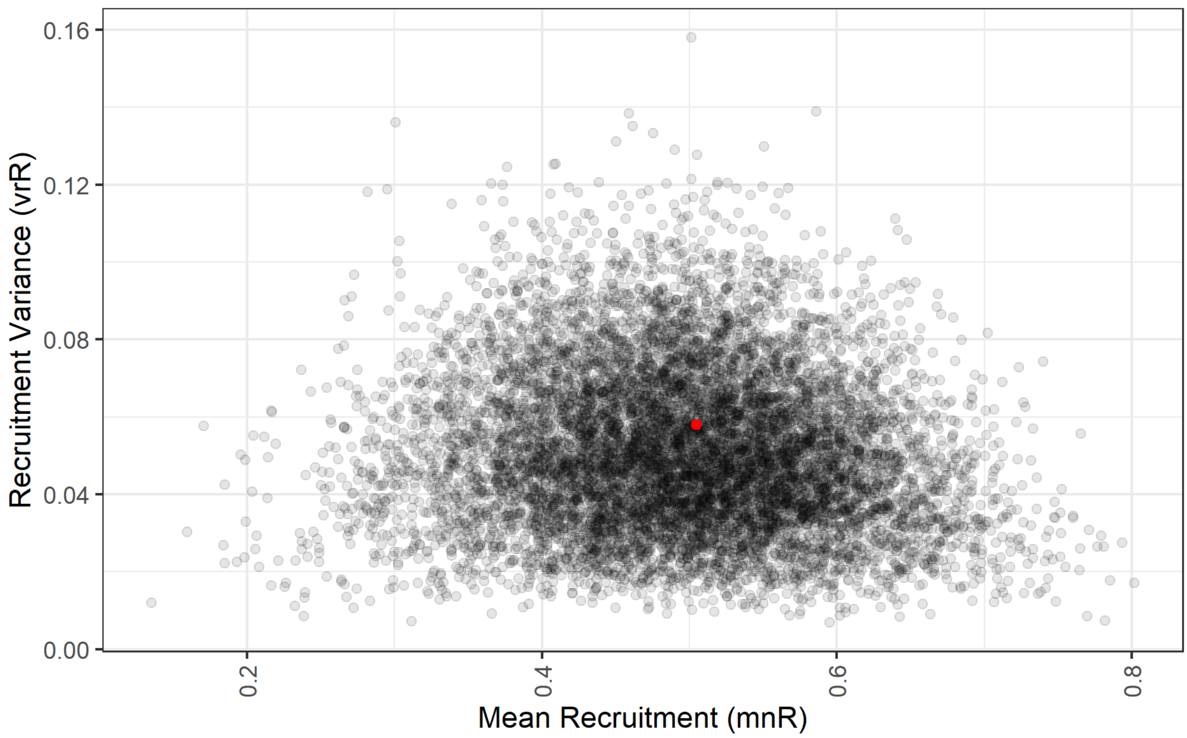


Figure 3: Estimated mean recruitment and recruitment variance for starting mean and standard deviation values for proportional recruitment using an inverse-beta distribution. Starting values for model indicated in red.

The Revised Krill Management Approach

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

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

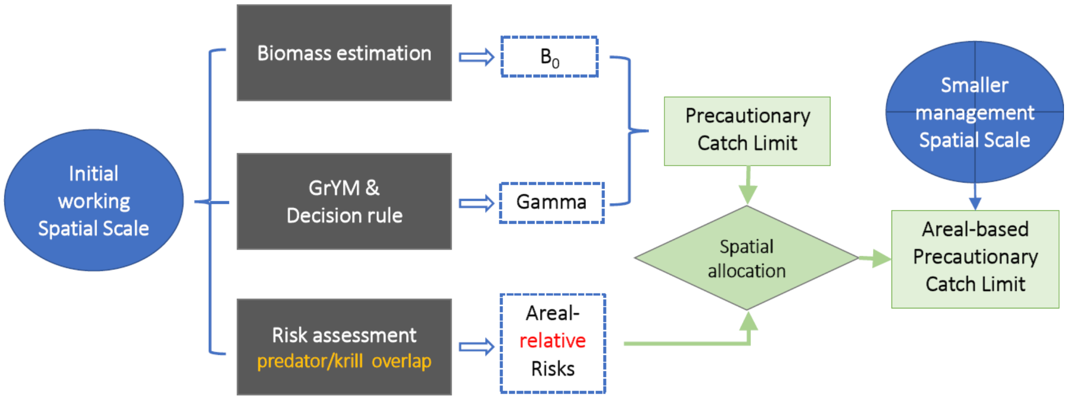


Figure 1: The three components and workflow of the revised krill management approach, as agreed at SC-CAMLR-40, Annex 8 (paragraph 3.25).

Biomass estimation

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

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

Grym model assessment

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

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

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

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

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

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

Spatial overlap analysis framework (formerly called risk assessment)

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

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

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

Appendix I

Amended Terms of Reference for the Proposed Krill Fishery Observer Workshop

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

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

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

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

Appendix J

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

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

Introduction

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

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

Terms of reference and agenda

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

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

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

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

4. The agenda was adopted (Attachment II).

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

Review of onboard sampling procedures

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Development of draft guidelines

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

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

Next steps

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

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

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

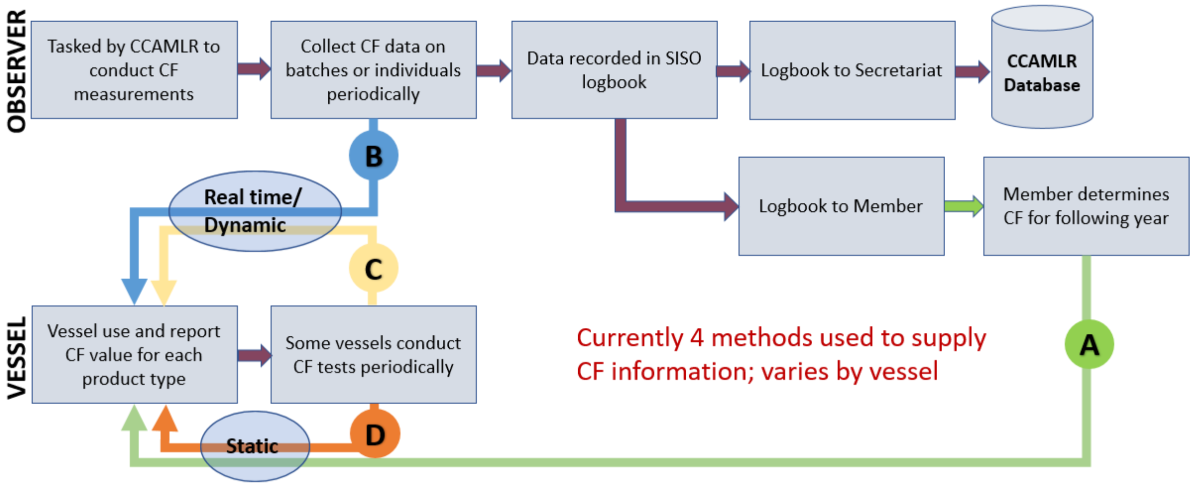


Figure 1: Diagram of the current variations on the use of CF information within CCAMLR. The letters A to D indicate the different pathways for CF data in current use.

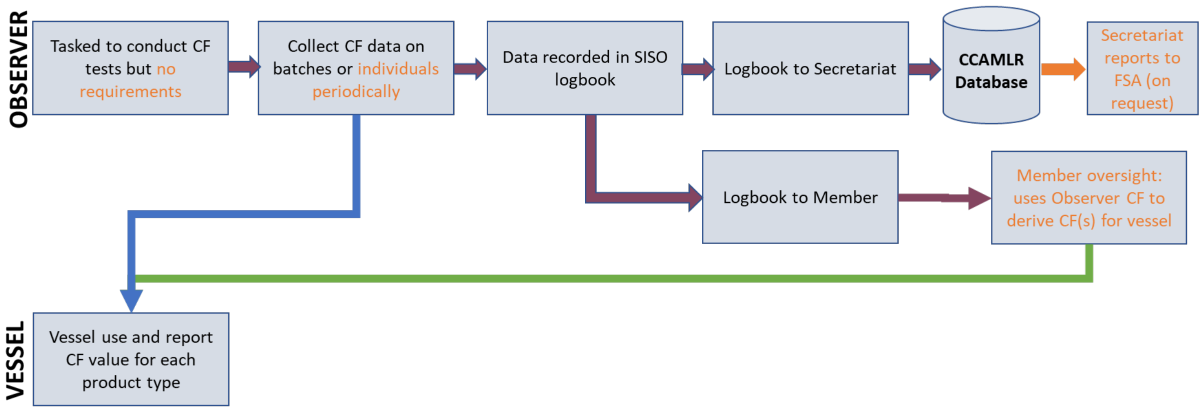


Figure 2: Diagram of the potential data flow for CF data in CCAMLR. The blue arrow indicates a real-time data flow to utilise the CF data. The green arrow would follow a static approach where CFs would be set by Members (or the Secretariat) in advance of each season.

Attachment I

List of Participants

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

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

	Mr Naohisa Miyagawa Taiyo A & F Co. Ltd.
	Dr Takehiro Okuda Fisheries Resources Institute, Japan Fisheries Research and Education Agency
Korea, Republic of	Mr Hyun Joong Choi TNS Industries Inc.
	Dr Sangdeok Chung National Institute of Fisheries Science (NIFS)
	Dr Haewon Lee National Institute of Fisheries Science (NIFS)
	Mr Sang Gyu Shin National Institute of Fisheries Science (NIFS)
New Zealand	Mr Adam Berry Ministry for Primary Industries
	Dr Jennifer Devine National Institute of Water and Atmospheric Research Ltd. (NIWA)
	Mr Jack Fenaughty Silvifish Resources Ltd
	Ms Monique Messina Ministry for Primary Industries
Russian Federation	Dr Svetlana Kasatkina AtlantNIRO
	Mr Oleg Krasnoborodko FGUE AtlantNIRO
	Mr Aleksandr Sytov FSUE VNIRO
South Africa	Mr Richard Ball SA Patagonian Toothfish Industry Association
	Mr Christopher Heinecken Capricorn Fisheries Monitoring
	Mr Sihle Victor Ngcongo Imvelo Blue Environment Consultancy (Pty) LTD

	Mr Sobahle Somhlaba Department of Agriculture, Forestry and Fisheries
	Mrs Melanie Williamson CapMarine Environmental
Ukraine	Dr Kostiantyn Demianenko Institute of Fisheries and Marine Ecology (IFME) of the State Agency of Melioration and Fisheries of Ukraine
	Mr Dmitry Marichev LLC Fishing Company NEPTUNO
	Dr Leonid Pshenichnov Institute of Fisheries and Marine Ecology (IFME) of the State Agency of Fisheries of Ukraine
	Mr Illia Slypko Institute of Fisheries and Marine Ecology (IFME) of the State Agency of Fisheries of Ukraine
	Mr Pavlo Zabroda Institute of Fisheries and Marine Ecology (IFME) of the State Agency of Fisheries of Ukraine
United Kingdom	Mr Joe Chapman MRAG
	Mr James Clark MRAG
	Dr Chris Darby Centre for Environment, Fisheries and Aquaculture Science (Cefas)
	Ms Sue Gregory Foreign and Commonwealth Office
	Mrs Rhona Kent WWF UK
	Ms Georgia Robson Centre for Environment, Fisheries and Aquaculture Science (Cefas)
	Dr Frane Skeljo -

	Mr Peter Thomson Argos Froyanes
	Mr Andrew Watson MRAG Ltd
CCAMLR Secretariat	Isaac Forster Fisheries and Observer Reporting Coordinator
	Eldene O'Shea Compliance Officer
	Dr Steve Parker Science Manager
	Alison Potter Data Administration Officer
	Claire van Werven Research, Monitoring and Compliance Analyst

Attachment II

Agenda

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

1. Welcome

2. Review

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

3. Develop draft guidelines

   3.1 On board sampling
   3.2 Calculation
   3.3 Use of conversion factors

4. Next steps.

Attachment III

List of Documents

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

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

Other Documents

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

Current CCAMLR Conversion Factor Procedure

Conversion factor procedure

Process

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

Number of fish and frequency of sampling

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

Table 1: CF step by step procedure.

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

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

Figure 2: Trunks produced using the HGT processing method.

Appendix K

Updated Terms of Reference for WG-FSA

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

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

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

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

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

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

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

Annex 10

Climate Change Workshop Terms of Reference

Climate Change Workshop Terms of Reference

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 the Scientific Committee and its working groups on adaptive management approaches available to CCAMLR to address climate change impacts on marine living resources.

Annex 11

Terms of Reference of CCAMLR Working Groups to the Scientific Committee

Terms of Reference of CCAMLR Working Groups to the Scientific Committee

1. The terms of reference for Working Groups on Acoustic Survey and Analysis Methods (WG-ASAM), Statistics, Assessments and Modelling (WG-SAM), Ecosystem Monitoring and Management (WG-EMM), Fish Stock Assessment (WG-FSA) and Incidental Mortality Associated with Fishing (WG-IMAF) were revised and are given below.

2. In addition to the terms of reference for the working groups, the Scientific Committee requested that all working groups include consideration of the impact of climate and environmental change, where relevant, in their advice.

Working Group on Acoustic Survey and Analysis Methods (WG-ASAM)

The purpose of the Working Group on Acoustic Survey and Analysis Methods (WG-ASAM) is to contribute to the conservation of Antarctic Marine Living Resources through the provision of expert advice to the Scientific Committee, its Members, and its working groups on issues relating to research using hydro-acoustic technologies. To achieve this, WG-ASAM will address the following terms of reference:

1. To provide advice to the Scientific Committee, its Members, and its working groups on:

   (i) new and standard acoustic methodology and protocols for the research and monitoring of Antarctic marine living resources, including survey design

   (ii) acoustic survey biomass estimates of Antarctic marine living resources

   (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.

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

Working Group on Statistics, Assessments and Modelling (WG-SAM)

The purpose of the Working Group on Statistics, Assessments and Modelling (WG-SAM) is to contribute to the conservation of Antarctic Marine Living Resources through the provision of expert advice to the Scientific Committee and its working groups on issues relating to quantitative methods associated with the application of statistics, assessments and modelling. To achieve this, WG-SAM will address the following terms of reference:

1. To provide advice to the Scientific Committee, its Members, and its working groups on:

   (i) quantitative assessment methods (including stock assessment methods and management strategy methods), statistical procedures, and modelling approaches for the conservation of Antarctic marine living resources

   (ii) the implementation and data requirements for such methods, procedures and approaches

   (iii) review of research plans and proposals

   (iv) sampling design of research fishing and surveys.

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.

Working Group on Ecosystem Monitoring and Management (WG-EMM)

The purpose of the Working Group on Ecosystem Monitoring and Management (WG-EMM) is to contribute to the conservation of Antarctic Marine Living Resources through the provision of expert advice to the Scientific Committee and its working groups on issues relating to the maintenance of ecological relationships within krill-centric ecosystems as well as other ecosystems between harvested, dependent and related populations, the restoration of depleted populations, and the minimisation of the risk of irreversible changes in the Antarctic marine ecosystem. To achieve this, WG-EMM will address the following terms of reference:

1. To provide advice to the Scientific Committee, its Members, and its working groups on:

   (i) the status of krill

   (ii) the status and trends of dependent and related populations including the identification of information required to evaluate predator/prey/fisheries interactions and their relationships to environmental features and including the role of fish in the ecosystem

   (iii) environmental features and trends which may influence the abundance and distribution of harvested, dependent, related and/or depleted populations

   (iv) identify, recommend and coordinate research necessary to obtain information on predator/prey/fisheries interactions, particularly those involving harvested, dependent, related and/or depleted populations

   (v) develop, coordinate the implementation of, and ensure continuity in the CCAMLR Ecosystem Monitoring Program (CEMP)

   (vi) spatial management with the aim of conserving marine biodiversity in the Convention Area

(vii) management advice on the status of the Antarctic marine ecosystem and for the management of krill fisheries in full accordance with Convention Article II.

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.

Working Group on Fish Stock Assessment (WG-FSA)

The purpose of the Working Group on Fish Stock Assessment (WG-FSA) is to contribute to the conservation of Antarctic Marine Living Resources through the provision of expert advice to the CCAMLR Scientific Committee and its working groups on the status and management of fish stocks, including consideration of the impacts of climate change on its advice. To achieve this, WG-FSA will address the following terms of reference:

1. To provide advice to the Scientific Committee, its Members, and its working groups on:

(i) the status and management of fish stocks in the Convention Area, including ecological risk assessments

(ii) the status and management of other Antarctic marine living resources (as defined in Article I of the Convention) as requested by the Scientific Committee

(iii) To identify further research and data collection which would be required for improved stock assessment and/or other assessments

(iv) To review and provide advice on research plans and proposals as required by the Scientific Committee.

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.

Working Group on Incidental Mortality Associated with Fishing (WG-IMAF)

The purpose of the Working Group on Incidental Mortality Associated with Fishing (WG-IMAF) is to contribute to the conservation of Antarctic Marine Living Resources through the provision of expert advice to the CCAMLR Scientific Committee and its working groups on issues relating to seabirds and marine mammals. To achieve this, WG-IMAF will address the following terms of reference:

1. To provide advice to the Scientific Committee, its Members, and its working groups on:

(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 on seabirds and marine mammals

(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, 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.

Glossary of Acronyms and Abbreviations used in SC-CAMLR Reports

Glossary of Acronyms and Abbreviations used in SC-CAMLR Reports

AAD	Australian Government Antarctic Division
ACAP	Agreement on the Conservation of Albatrosses and Petrels
ACAP BSWG	ACAP Breeding Sites Working Group (BSWG)
ACC	Antarctic Circumpolar Current
ACW	Antarctic Circumpolar Wave
ADCP	Acoustic Doppler Current Profiler (mounted on the hull)
ADL	Aerobic Dive Limit
AEM	Ageing Error Matrix
AFMA	Australian Fisheries Management Authority
AFZ	Australian Fishing Zone
AIS	Automatic Identification System
AKES	Antarctic Krill and Ecosystem Studies
ALK	Age–length Key
AMD	Antarctic Master Directory
AMES	Antarctic Marine Ecosystem Studies
AMLR	Antarctic Marine Living Resources
AMSR-E	Advanced Microwave Scanning Radiometer – Earth Observing System
ANDEEP	Antarctic Benthic Deep-sea Biodiversity
APBSW	Bransfield Strait West (SSMU)
APDPE	Drake Passage East (SSMU)
APDPW	Drake Passage West (SSMU)
APE	Antarctic Peninsula East (SSMU)
APEC	Asia-Pacific Economic Cooperation
APECS	Association of Polar Early Career Scientists

APEI	Elephant Island (SSMU)
APEME Steering Committee	Steering Committee on Antarctic Plausible Ecosystem Modelling Efforts
APIS	Antarctic Pack-Ice Seals Program (SCAR-GSS)
APW	Antarctic Peninsula West (SSMU)
ARK	Association of Responsible Krill harvesting companies
ASE	Assessment Strategy Evaluation
ASI	Antarctic Site Inventory
ASIP	Antarctic Site Inventory Project
ASMA	Antarctic Specially Managed Area
ASOC	Antarctic and Southern Ocean Coalition
ASPA	Antarctic Specially Protected Area
ASPM	Age-Structured Production Model
ATCM	Antarctic Treaty Consultative Meeting
ATCP	Antarctic Treaty Consultative Party
ATME	Antarctic Treaty Meeting of Experts on the Impacts of Climate Change for Management and Governance of the Antarctic region
ATS	Antarctic Treaty System
ATSCM	Antarctic Treaty Special Consultative Meeting
AVHRR	Advanced Very High Resolution Radiometry
BAS	British Antarctic Survey
BED	Bird Excluder Device
BICS	Benthic Impact Camera System
BIOMASS	Biological Investigations of Marine Antarctic Systems and Stocks (SCAR/SCOR)
BROKE	Baseline Research on Oceanography, Krill and the Environment
BRT	Boosted Regression Trees
CAC	Comprehensive Assessment of Compliance

cADL	calculated Aerobic Dive Limit
CAF	Central Ageing Facility
CAML	Census of Antarctic Marine Life
CAMLR Convention	Convention on the Conservation of Antarctic Marine Living Resources
CAML SSC	CAML Scientific Steering Committee
CAR	Comprehensiveness, Adequacy, Representativeness
CASAL	C++ Algorithmic Stock Assessment Laboratory
CBD	Convention on Biodiversity
CCAMLR	Commission for the Conservation of Antarctic Marine Living Resources
CCAMLR-2000 Survey	CCAMLR 2000 Krill Synoptic Survey of Area 48
CCAMLR-IPY-2008 Survey	CCAMLR-IPY 2008 Krill Synoptic Survey in the South Atlantic Region
CCAS	Convention on the Conservation of Antarctic Seals
CCEP	CCAMLR Compliance Evaluation Procedure
CCSBT	Commission for the Conservation of Southern Bluefin Tuna
CCSBT-ERS WG	CCSBT Ecologically Related Species Working Group
CDS	Catch Documentation Scheme for *Dissostichus* spp.
CDW	Circumpolar Deep Water
CEMP	CCAMLR Ecosystem Monitoring Program
CEP	Committee for Environmental Protection
CF	Conversion Factor
CircAntCML	Circum-Antarctic Census of Antarctic Marine Life
CITES	Convention on International Trade in Endangered Species
CM	Conservation Measure
CMIR	CCAMLR MPA Information Repository

CMIX	CCAMLR's Mixture Analysis Program
CMP	Conservation Management Plan
CMS	Convention on the Conservation of Migratory Species of Wild Animals
COFI	Committee on Fisheries (FAO)
COLTO	Coalition of Legal Toothfish Operators
CoML	Census of Marine Life
COMM CIRC	Commission Circular (CCAMLR)
COMNAP	Council of Managers of National Antarctic Programs (SCAR)
CON	CCAMLR Otolith Network
COTPAS	CCAMLR Observer Training Program Accreditation Scheme
CPD	Critical Period–Distance
CPPS	Permanent Commission on the South Pacific
CPR	Continuous Plankton Recorder
CPUE	Catch-per-unit-effort
CQFE	Center for Quantitative Fisheries Ecology (USA)
CS-EASIZ	Coastal Shelf Sector of the Ecology of the Antarctic Sea-Ice Zone (SCAR)
CSI	Combined Standardised Index
CSIRO	Commonwealth Scientific and Industrial Research Organisation (Australia)
CT	Computed Tomography
CTD	Conductivity Temperature Depth Probe
CV	Coefficient of Variation
C-VMS	Centralised Vessel Monitoring System
CVS	Concurrent Version System
CWP	Coordinating Working Party on Fishery Statistics (FAO)
DCD	*Dissostichus* Catch Document

DMSP	Defense Meteorological Satellite Program
DPM	Dynamic Production Model
DPOI	Drake Passage Oscillation Index
DSAG	Data Services Advisory Group
DQA	Data quality assurance
DVM	Diel vertical migration
DWBA	Distorted wave Born approximation model
EAF	Ecosystem Approaches to Fishing
EASIZ	Ecology of the Antarctic Sea-Ice Zone
E-CDS	Electronic Web-based Catch Documentation Scheme for *Dissostichus* spp.
ECOPATH	Software for construction and analysis of mass-balance models and feeding interactions or nutrient flow in ecosystems (see www.ecopath.org)
ECOSIM	Software for construction and analysis of mass-balance models and feeding interactions or nutrient flow in ecosystems (see www.ecopath.org)
EEZ	Exclusive Economic Zone
EG-BAMM	Expert Group on Birds and Marine Mammals (SCAR)
EIV	Ecologically Important Value
ENFA	Environmental Niche Factor Analysis
ENSO	El Niño Southern Oscillation
EOF/PC	Empirical Orthogonal Function/Principal Component
EoI	Expression of Intent (for activities in the IPY)
EPOC	Ecosystem, productivity, ocean, climate modelling framework
EPOS	European *Polarstern* Study
EPROM	Erasable Programmable Read-Only Memory
eSB	Electronic version of CCAMLR's *Statistical Bulletin*

ESS	Effective Sample Size(s)
FAO	Food and Agriculture Organization of the United Nations
FBM	Feedback Management
FEMA	Workshop on Fisheries and Ecosystem Models in the Antarctic
FEMA2	Second Workshop on Fisheries and Ecosystem Models in the Antarctic
FFA	Forum Fisheries Agency
FFO	Foraging–Fishery Overlap
FIBEX	First International BIOMASS Experiment
FIGIS	Fisheries Global Information System (FAO)
FIRMS	Fishery Resources Monitoring System (FAO)
FMP	Fishery Management Plan
FOOSA	Krill–Predator–Fishery Model (previously KPFM2)
FPI	Fishing-to-Predation Index
FRAM	Fine Resolution Antarctic Model
FV	Fishing Vessel
GAM	Generalised Additive Model
GATT	General Agreement on Tariffs and Trade
GBIF	Global Biodiversity Information Facility
GBM	Generalised Boosted Model
GCMD	Global Change Master Directory
GDM	Generalised Dissimilarity Modelling
GEBCO	General Bathymetric Chart of the Oceans
GEOSS	Global Earth Observing System of Systems
GIS	Geographic Information System
GIWA	Global International Waters Assessment (SCAR)
GLM	Generalised Linear Model

GLMM	Generalised Linear Mixed Model
GLOBEC	Global Ocean Ecosystems Dynamics Research
GLOCHANT	Global Change in the Antarctic (SCAR)
GMT	Greenwich Mean Time
GOOS	Global Ocean Observing System (SCOR)
GOSEAC	Group of Specialists on Environmental Affairs and Conservation (SCAR)
GOSSOE	Group of Specialists on Southern Ocean Ecology (SCAR/SCOR)
GPS	Global Positioning System
GSCF	General Science Capacity Fund
GUI	Graphical User Interface
GRT	Gross Registered Tonnage
GTS	Greene et al., (1990) linear TS versus length relationship
GYM	Generalised Yield Model
HAC	A global standard being developed for the storage of hydroacoustic data
HCR	Harvest Control Rule
HIMI	Heard Island and McDonald Islands
IA	Impact Assessment
IAATO	International Association of Antarctica Tour Operators
IASOS	Institute for Antarctic and Southern Ocean Studies (Australia)
IASOS/CRC	IASOS Cooperative Research Centre for the Antarctic and Southern Ocean Environment
IATTC	Inter-American Tropical Tuna Commission
ICAIR	International Centre for Antarctic Information and Research
ICCAT	International Commission for the Conservation of Atlantic Tunas
ICED	Integrating Climate and Ecosystem Dynamics in the Southern Ocean
ICES	International Council for the Exploration of the Sea

ICESCAPE	Integrating Count Effort by Seasonally Correcting Animal Population Estimates
ICES WGFAST	ICES Working Group on Fisheries Acoustics Science and Technology
ICFA	International Coalition of Fisheries Associations
ICG-SF	Intersessional Correspondence Group on Sustainable Financing
ICSEAF	International Commission for the Southeast Atlantic Fisheries
ICSU	International Council for Science
IDCR	International Decade of Cetacean Research
IFF	International Fishers' Forum
IGBP	International Geosphere-Biosphere Programme
IGR	Instantaneous Growth Rate
IHO	International Hydrographic Organisation
IKMT	Isaacs-Kidd Midwater Trawl
IMAF	Incidental Mortality Associated with Fishing
IMALF	Incidental Mortality Arising from Longline Fishing
IMBER	Integrated Marine Biogeochemistry and Ecosystem Research (IGBP)
IMO	International Maritime Organization
IMP	Inter-moult Period
IOC	Intergovernmental Oceanographic Commission
IOCSOC	IOC Regional Committee for the Southern Ocean
IOFC	Indian Ocean Fisheries Commission
IOTC	Indian Ocean Tuna Commission
IPHC	International Pacific Halibut Commission
IPOA	International Plan of Action
IPOA-Seabirds	FAO International Plan of Action for Reducing Incidental Catch of Seabirds in Longline Fisheries
IPY	International Polar Year

IRCS	International Radio Call Sign
ISO	International Organization for Standardization
ISR	Integrated Study Region
ITLOS	International Tribunal for the Law of the Sea
IUCN	International Union for the Conservation of Nature and Natural Resources – the World Conservation Union
IUU	Illegal, Unreported and Unregulated
IW	Integrated Weight
IWC	International Whaling Commission
IWC-IDCR	IWC International Decade of Cetacean Research
IWC SC	Scientific Committee of the IWC
IWL	Integrated Weighted Line
IYGPT	International Young Gadoids Pelagic Trawl
JAG	Joint Assessment Group
JARPA	Japanese Whale Research Program under special permit in the Antarctic
JGOFS	Joint Global Ocean Flux Studies (SCOR/IGBP)
KPFM	Krill–Predatory–Fishery Model (used in 2005)
KPFM2	Krill–Predatory–Fishery Model (used in 2006) – renamed FOOSA
KYM	Krill Yield Model
LADCP	Lowered Acoustic Doppler Current Profiler (lowered through the water column)
LAKRIS	Lazarev Sea Krill Study
LBRS	Length-bin Random Sampling
LMM	Linear Mixed Model
LMR	Living Marine Resources Module (GOOS)
LSSS	Large-Scale Server System
LTER	Long-term Ecological Research (USA)

M	Natural Mortality
MARPOL Convention	International Convention for the Prevention of Pollution from Ships
MARS	Multivariate Adaptive Regression Splines
MAXENT	Maximum Entropy modelling
MBAL	Minimum Biologically Acceptable Limits
MCMC	Markov Chain Monte Carlo
MCS	Monitoring Control and Surveillance
MDS	Mitigation Development Strategy
MEA	Multilateral Environmental Agreement
MEOW	Marine Ecoregions of the World
MFTS	Multiple-Frequency Method for in situ TS Measurements
MIA	Marginal Increment Analysis
MIZ	Marginal Ice Zone
MLD	Mixed-layer Depth
MODIS	Moderate Resolution Imaging Spectroradiometer
MoU	Memorandum of Understanding
MP	Management Procedure
MPA	Marine Protected Area
MPD	Maximum of the Posterior Density
MRAG	Marine Resources Assessment Group (UK)
MRM	Minimum Realistic Model
MSE	Management Strategy Evaluation
MSY	Maximum Sustainable Yield
MV	Merchant Vessel
MVBS	Mean Volume Backscattering Strength
MVP	Minimum Viable Populations

MVUE	Minimum Variance Unbiased Estimate
NAFO	Northwest Atlantic Fisheries Organization
NASA	National Aeronautical and Space Administration (USA)
NASC	Nautical Area Scattering Coefficient
NCAR	National Center for Atmospheric Research (USA)
NEAFC	North East Atlantic Fisheries Commission
NCP	Non-Contracting Party
NGO	Non-Governmental Organisation
NI	Nearest Integer
NIWA	National Institute of Water and Atmospheric Research (New Zealand)
nMDS	non-Metric Multidimensional Scaling
NMFS	National Marine Fisheries Service (USA)
NMML	National Marine Mammal Laboratory (USA)
NOAA	National Oceanic and Atmospheric Administration (USA)
NPOA	National Plan of Action
NPOA-Seabirds	FAO National Plans of Action for Reducing Incidental Catch of Seabirds in Longline Fisheries
NRT	Net Registered Tonnage
NSF	National Science Foundation (USA)
NSIDC	National Snow and Ice Data Center (USA)
OBIS	Ocean Biogeographic Information System
OCCAM Project	Ocean Circulation Climate Advanced Modelling Project
OCTS	Ocean Colour and Temperature Scanner
OECD	Organisation for Economic Cooperation and Development
OM	Operating Model
PaCSWG	Population and Conservation Status Working Group (ACAP)
PAR	Photosynthetically Active Radiation

PBR	Permitted Biological Removal
PCA	Principal Component Analysis
PCR	Per Capita Recruitment
pdf	Portable Document Format
PF	Polar Front
PFZ	Polar Frontal Zone
PIT	Passive Integrated Transponder
PRP	CCAMLR Performance Review Panel
PS	Paired Streamer Line
PSAT	Pop-up satellite archival tag
PTT	Platform Terminal Transmitter
RES	Relative Environmental Suitability
RFB	Regional Fishery Body
RFMO	Regional Fishery Management Organisation
RMT	Research Midwater Trawl
ROV	Remotely-Operated Vehicle
RPO	Realised Potential Overlap
RTMP	Real-Time Monitoring Program
RV	Research Vessel
RVA	Register of Vulnerable Areas
SACCB	Southern Antarctic Circumpolar Current Boundary
SACCF	Southern Antarctic Circumpolar Current Front
SAER	State of the Antarctic Environment Report
SAF	Sub-Antarctic Front
SBDY	Southern Boundary of the ACC
SBWG	Seabird Bycatch Working Group (ACAP)

SCAF	Standing Committee on Administration and Finance (CCAMLR)
SCAR	Scientific Committee on Antarctic Research
SCAR-ASPECT	Antarctic Sea-Ice Processes, Ecosystems and Climate (SCAR Program)
SCAR-BBS	SCAR Bird Biology Subcommittee
SCAR-CPRAG	Action Group on Continuous Plankton Recorder Research
SCAR-EASIZ	Ecology of the Antarctic Sea-Ice Zone (SCAR Program)
SCAR-EBA	Evolution and Biodiversity in Antarctica (SCAR Program)
SCAR-EGBAMM	Expert Group on Birds And Marine Mammals
SCAR-GEB	SCAR Group of Experts on Birds
SCAR-GOSEAC	SCAR Group of Specialists on Environmental Affairs and Conservation
SCAR-GSS	SCAR Group of Specialists on Seals
SCAR-MarBIN	SCAR Marine Biodiversity Information Network
SCAR/SCOR-GOSSOE	SCAR/SCOR Group of Specialists on Southern Ocean Ecology
SCAR WG-Biology	SCAR Working Group on Biology
SC-CAMLR	Scientific Committee for the Conservation of Antarctic Marine Living Resources
SC CIRC	Scientific Committee Circular (CCAMLR)
SC-CMS	Scientific Committee for CMS
SCIC	Standing Committee on Implementation and Compliance (CCAMLR)
SCOI	Standing Committee on Observation and Inspection (CCAMLR)
SCOR	Scientific Committee on Oceanic Research
SCP	Systematic Conservation planning
SD	Standard Deviation
SDWBA	Stochastic Distorted-wave Born Approximation
SEAFO	South East Atlantic Fisheries Organisation

SeaWiFS	Sea-viewing Wide Field-of-view Sensor
SG-ASAM	Subgroup on Acoustic Survey and Analysis Methods
SGE	South Georgia East
SGSR	South Georgia–Shag Rocks
SGW	South Georgia West (SSMU)
SIBEX	Second International BIOMASS Experiment
SIC	Scientist-in-Charge
SIOFA	Southern Indian Ocean Fisheries Agreement
SIR Algorithm	Sampling/Importance Resampling Algorithm
SISO	Scheme of International Scientific Observation (CCAMLR)
SKAG	SCAR Krill Action Group
SKEG	SCAR Krill Expert Group
SMOM	Spatial Multispecies Operating Model
SNP	Single Nucleotide Polymorphism
SO-CPR	Southern Ocean CPR
SO GLOBEC	Southern Ocean GLOBEC
SOI	Southern Oscillation Index
SO JGOFS	Southern Ocean JGOFS
SOMBASE	Southern Ocean Molluscan Database
SONE	South Orkney North East (SSMU)
SOOS	Southern Ocean Observing System
SOPA	South Orkney Pelagic Area (SSMU)
SOS Workshop	Southern Ocean Sentinel Workshop
SOW	South Orkney West (SSMU)
SOWER	Southern Ocean Whale Ecology Research Cruises
SPA	Specially Protected Area

SPC	Secretariat of the Pacific Community
SPGANT	Ocean Colour Chlorophyll-*a* algorithm for the Southern Ocean
SPM	Spatial Population Model
SPRFMO	South Pacific Regional Fisheries Management Organisation
SRZ	Special Research Zone
SSB	Spawning Stock Biomass
SSG-LS	The Standing Scientific Group on Life Sciences (SCAR)
SSM/I	Special Sensor Microwave Imager
SSMU	Small-scale Management Unit
SSMU Workshop	Workshop on Small-scale Management Units, such as Predator Units
SSRU	Small-scale Research Unit
SSSI	Site of Special Scientific Interest
SST	Sea-Surface Temperature
STC	Subtropical Convergence
SWIOFC	Southwest Indian Ocean Fisheries Commission
TASO	ad hoc Technical Group for At-Sea Operations (CCAMLR)
TDR	Time Depth Recorder
TEWG	Transitional Environmental Working Group
TIRIS	Texas Instruments Radio Identification System
TISVPA	Triple Instantaneous Separable VPA (previously TSVPA)
ToR	Term of Reference
TrawlCI	Estimation of Abundance from Trawl Surveys
TS	Target Strength
TVG	Time Varied Gain
UBC	University of British Columbia (Canada)
UCDW	Upper Circumpolar Deep Water

UN	United Nations
UNCED	UN Conference on Environment and Development
UNCLOS	UN Convention on the Law of the Sea
UNEP	UN Environment Programme
UNEP-WCMC	UNEP World Conservation Monitoring Centre
UNFSA	the United Nations Fish Stock Agreement is the 1995 United Nations Agreement for the Implementation of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks
UNGA	United Nations General Assembly
UPGMA	Unweighted Pair Group Method with Arithmetic Mean
US AMLR	United States Antarctic Marine Living Resources Program
US LTER	United States Long-term Ecological Research
UV	Ultra-Violet
UW	Unweighted
UWL	Unweighted Longline
VME	Vulnerable Marine Ecosystem
VMS	Vessel Monitoring System
VOGON	Value Outside the Generally Observed Norm
VPA	Virtual Population Analysis
WAMI	Workshop on Assessment Methods for Icefish (CCAMLR)
WC	Weddell Circulation
WCO	World Customs Organization
WFC	World Fisheries Congress
WCPFC	Western and Central Pacific Fisheries Commission
WG-ASAM	Working Group on Acoustic Survey and Analysis Methods
WG-CEMP	Working Group for the CCAMLR Ecosystem Monitoring Program (CCAMLR)

WG-EMM	Working Group on Ecosystem Monitoring and Management (CCAMLR)
WG-EMM-STAPP	Subgroup on Status and Trend Assessment of Predator Populations
WG-FSA	Working Group on Fish Stock Assessment (CCAMLR)
WG-FSA-SAM	Subgroup on Assessment Methods
WG-FSA-SFA	Subgroup on Fisheries Acoustics
WG-IMAF	Working Group on Incidental Mortality Associated with Fishing (CCAMLR)
WG-IMALF	ad hoc Working Group on Incidental Mortality Arising from Longline Fishing (CCAMLR)
WG-Krill	Working Group on Krill (CCAMLR)
WG-SAM	Working Group on Statistics, Assessments and Modelling
WMO	World Meteorological Organization
WOCE	World Ocean Circulation Experiment
WSC	Weddell–Scotia Confluence
WS-Flux	Workshop on Evaluating Krill Flux Factors (CCAMLR)
WS-MAD	Workshop on Methods for the Assessment of *D. eleginoides* (CCAMLR)
WSSD	World Summit on Sustainable Development
WS-VME	Workshop on Vulnerable Marine Ecosystems
WTO	World Trade Organization
WWD	West Wind Drift
WWF	World Wide Fund for Nature
WWW	World Wide Web
XBT	Expendable Bathythermograph
XML	Extensible Mark-up Language
Y2K	Year 2000
YCS	Year-class Strength(s)