WG-FSA-IMAF-2024
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Report of the Working Group on Fish Stock Assessment and Incidental Mortality Associated with Fishing
(Hobart, Australia, 30 September to 11 October 2024)

This is a preliminary[1] version of the WG-FSA-IMAF-2024 Report.

1 Preliminary in this case means that further proofreading and verification is still to be done by the Secretariat.

Contents

Opening of the meeting

1.1 The 2024 meeting of the Working Group on Fish Stock Assessment and Incidental Mortality Associated with Fishing (WG-FSA-IMAF) was held in Hobart, Australia, from 30 September to 11 October 2024. While registered participants were able to follow the meeting online through Zoom, only participants who were present in the room were able to directly contribute to the meeting and comment on report text.

Introduction

1.2 In the context of a joint meeting, there were three co-conveners; Mr S. Somhlaba (South Africa), Mr N. Walker (New Zealand) and Dr M. Favero (Argentina). Mr Somhlaba welcomed the participants to Hobart (Appendix A).

1.3 Dr D. Agnew (Executive Secretary) welcomed all participants to the CCAMLR Secretariat. He looked forward to seeing the outcomes of the meeting being presented to the Scientific Committee and the Commission. He also noted the proposed Code of Conduct (CCAMLR-43/39) which will be discussed by the Commission, and encouraged all participants to be considerate in their behaviours at this international forum.

Adoption of the Agenda

1.4 The Working Group noted that this was a joint meeting of WG-FSA and WG-IMAF, and that IMAF topics would be taken as a focus topic in the second week of the meeting to fit within the time available.

1.5 The Working Group reviewed the agenda and recommended that for future meetings, the agenda should include a standing agenda item on climate change, and that advice from WG-FSA relevant to managing the impacts of climate change could be summarised in that section for communication to the Scientific Committee.

1.6 The Working Group agreed that discussions on the development of Management Strategy Evaluations (MSEs) considered within the individual assessment papers would be collated under the heading 'Development of Management Strategy Evaluations'.

1.7 The Working Group adopted the agenda (Appendix B).

1.8 Documents submitted to the meeting are listed in Appendix C. The Working Group thanked all authors for their valuable contributions. A glossary of acronyms and abbreviations used in CCAMLR reports is available online at https://www.ccamlr.org/node/78120.

1.9 In this report, paragraphs dealing with advice to the Scientific Committee have been highlighted. These paragraphs are listed under Item 9 'Advice to the Scientific Committee'.

1.10 The report was prepared by J. Cleeland and M. Collins (United Kingdom (UK)), J. Devine and A. Dunn (New Zealand), T. Earl (UK), I. Forster (Secretariat), M. Eléaume

(France), C. Jones (United States of America (USA)), S. Kawaguchi (Australia), F. Massiot-Granier (France), J. Moir-Clark (Norway), D. Maschette (Australia), M. Mori and T. Okuda (Japan), F. Ouzoulias (France), E. Pardo (New Zealand), S. Parker (Secretariat), L. Readdy (UK), S. Thanassekos and C. van Werven (Secretariat), and P. Ziegler (Australia).

Review of the work plan

1.11 The Working Group reviewed the Terms of Reference developed during SC-CAMLR-41 and distributed in SC-CIRC 23/52. The Working Group noted that the revised Terms of Reference explicitly include consideration of the effects of climate change in the advice provided by the Working Groups.

1.12 The Working Group recalled the revised workplan (SC-CAMLR-42 Annex 15) and agreed to revisit it under 'Future work' to identify tasks that have been completed and new tasks that may arise during the meeting. The Working Group noted that recommendations from WS-CC-2024 were referred to WG-FSA-IMAF by the Scientific Committee and agreed to incorporate these in their workplan discussions under 'Future work'.

Review of CCAMLR fisheries in 2023/2024 and notifications for 2024/2025

1.13 The Working Group noted that the annual papers on Catches in the Convention Area (SC-CAMLR-BG/01) and Fishery Notifications (CCAMLR-43/BG/09) were useful context for its discussions and recommended they be submitted to WG-FSA on an annual basis.

1.14 The Working Group received a verbal update from the Secretariat on Illegal, Unreported and Unregulated (IUU) fishing in the Convention Area, which noted that improved identification of fishing gear originating from CCAMLR vessels would improve the ability to assign recovered or sighted fishing gear to licensed vessels, rather than being reported as IUU gear. The Working Group also noted that some CCAMLR fisheries had been operating for many years with relatively large numbers of vessels, which increases the amount of gear lost and also increases the likelihood of recovering lost gear.

1.15 The Working Group further noted that although the Secretariat paper on IUU fishing (CCAMLR-43/14) was not submitted to WG-FSA-IMAF, issues pertaining to improved gear marking, recovery of marine debris including fishing gears, and mechanisms for improved reporting of recovered fishing gear were under discussion in two CCAMLR e-groups (Intersession Correspondence Group - Marine Debris (ICG-MD) and Unidentified Fishing Gear in the Convention Area). The Working Group further noted that Coalition of Legal Toothfish Operators (COLTO) recently held a workshop on gear marking and minimising gear loss, which is reported to the Scientific Committee in SC-CAMLR-43/BG/02 (paragraph 8.2).

1.16 The Working Group noted that catch removed by lost fishing gear was an important issue for stock assessment and that improved mechanisms for both CCAMLR vessels and efforts from other organisations to report recovered fishing gear, such as using the unidentified gear reporting form, as well as improvements in the ability to identify specific fishing gear lost by CCAMLR vessels should be encouraged.

1.17 The Working Group noted that the information on recovered fishing gear reported as IUU fishing gear to CCAMLR was derived from observer cruise reports or observer logbook data. The Working Group noted that a decision as to whether recovered fishing gear be assigned to the IUU category should not be assigned to Scientific Observers and suggested that recovered gear should be reported initially as 'recovered fishing gear' for later evaluation.

1.18 The Working Group further noted that there was currently no mechanism within CCAMLR for standard reporting of either lost or recovered marine debris, including fishing gear. The Working Group agreed that standard reporting of both lost and recovered marine debris, including lost fishing gear, was very important and should be progressed urgently.

1.19 CCAMLR-43/BG/10 presented the biennial summary of reconciliation analysis of C2 and C1 data with the Catch Documentation Scheme (CDS) system, using criteria of more than a relative (10%) and an absolute (200 kg) difference between the two data sources to identify records requiring further investigation. The analysis showed that at a seasonal level, the difference in catch was < 2% (involving 7.6% of landings) and that further investigations with Members identified the reasons associated with the differences, which were related to catch limit areas spanning Subarea boundaries (e.g. 88.1 and 88.2 – See WG-FSA-2022 paragraph 3.4), vessels processing a much higher proportion of their trawl catch as fillet and therefore not linking to an appropriate product conversion factor, or vessels conducting partial landings during short periods in port.

1.20 The Working Group thanked the Secretariat for the analysis and suggested that to address the trawl finfish conversion factor issue, the C1 form for finfish could be separated from the C1 form for krill and then adapted through consultation between the Secretariat and relevant Members to bring a revised C1 finfish form to WG-SAM-2025 for review.

1.21 CCAMLR-43/BG/09 summarised the fishery notifications for the 2024/25 season.

1.22 The Working Group noted with sadness the tragic loss of the Fishing Vessel (FV) Argos Georgia and that many lives on board were lost at sea.

1.23 The Working Group expressed concern that while some Members are notifying multiple vessels to fish for toothfish in Subareas 88.1 and 88.2, they are not contributing to the development of science and management advice for management of those fisheries.

1.24 The Working Group noted that notifications for research fishing under CM 24-01 are reported differently, and requested that the number of vessels planning to conduct research fishing be included in future iterations of the paper.

1.25 WG-FSA-IMAF-2024/16 presented a draft summary of stock status for CCAMLR fisheries, adapted to the FAO classification of stock status criteria for potential inclusion in the FAO global State of Stocks Index (SOSI) report. The paper summarised how CCAMLR manages its fisheries and used the results of that management approach to classify CCAMLR fisheries using FAO criteria on stock status to fit within the FAO's reporting framework for all stocks globally.

1.26 The Working Group noted that the FAO criteria use different thresholds to classify stock status compared to CCAMLR, and undertook to develop a summary of the status of *Euphausia superba, Champsocephalus gunnari, and Dissostichus* spp. stocks under CCAMLR management that have been or are currently commercially fished (excluding research fisheries). The Working Group developed three categories of CCAMLR stocks based on the information used to manage each fishery and assigned a stock status based in whether the stock was above, near, or below the relevant target stock status (Table 1). The Working Group then translated CCAMLR stock status to the FAO stock status categories using FAO definitions (FAO 2011).

1.27 Dr S. Kasatkina (Russian Federation) noted that the proposed catch limit is based on the current assessment of Patagonian toothfish in Subarea 48.3, performed using data from an illegitimate toothfish fishery undertaken in the 2021/22 and 2022/23 seasons in the absence of a conservation measure on the fishery for Patagonian toothfish in Subarea 48.3.

1.28 The Working Group also developed a summary of stock status for stocks of other species which are currently not of commercial interest or where commercial fishing is prohibited (Table 2).

1.29 The Working Group recommended that the Scientific Committee consider making the relevant parts of these summary tables available on the Fishery Reports website as they provide useful information on the current status of CCAMLR managed stocks.

1.30 The Working Group recommended that the Scientific Committee consider reporting CCAMLR's management approach and current stock status for CCAMLR fisheries as a beneficial action to show other organisations how CCAMLR manages its fisheries as a contribution to the biennial SOSI report.

1.31 The Working Group recommended that the Scientific Committee consider a process whereby the Secretariat summarises how CCAMLR manages its fisheries (drawing from CCAMLR literature and WG-FSA-IMAF-2024/16) and seek comment via SC-CIRC prior to submission to FAO by the end of 2024.

Krill

2.1 WG-FSA-IMAF-2024/03 presented a summary of advances in the revision of the Krill Fishery Management Approach (KFMA) up to 2023. The document was prepared by WG-EMM and the Secretariat in response to the Scientific Committee's request (SC-CAMLR-42, paragraph 2.42; WG-EMM-2024, paragraph 4.2) and with the intent to publish it as part of the Fishery Reports.

2.2 The Working Group thanked WG-EMM and the Secretariat for the important document, which helped readers understand the revision process of the Krill Fishery Management Approach (KFMA) and increased transparency.

2.3 The Working Group recommended the Scientific Committee task the Secretariat with publishing WG-FSA-IMAF-2024/03 as part of the Fishery Reports documents on the CCAMLR website.

2.4 SC-CAMLR-43/BG/02 Rev. 1 presented the latest implementations of the Spatial Overlap Analysis (SOA) in Subarea 48.1, using an updated set of Management Units (MUs) and a set of seasonal or general protection zones, as proposed by the 2024 Harmonisation Symposium (see Figure 1 in the paper and in CCAMLR-43/29). A range of implementations were produced depending on how krill catches were spread within a year, which scenario was considered (baseline vs fishery desirability), and which temporal window was used to represent fishery desirability. In all implementations the highest proportion of catch was assigned to the Gerlache Strait during winter, and results were particularly sensitive to the method used to spread catches within a year (Z parameter). The authors highlighted some of the caveats associated with the SOA and advocated for detailed scrutiny and enhanced engagement across the CCAMLR community.

2.5 The Working Group thanked the authors for producing the analysis in such a short timeframe and noted that this latest implementation demonstrated the flexibility of the SOA, which was modified to use a monthly time step to accommodate the scenario proposed by HS-2024. It noted that further collaborative consideration was needed to address some of the caveats highlighted in the study, including the paucity of winter data, the concentration of risk in few MUs under the desirability scenarios, and the appropriate calibration of the Z parameter. The Working Group recalled that HS-2024 proposed interim catch limits (CCAMLR-43/29 Recommendations 5 and 6) which will be considered by the Scientific Committee and Commission after the completion of its meeting.

2.6 Dr Kasatkina noted that the D1MPA has not been adopted by the Commission and that the Harmonisation exercise relied on the assumption that the krill fishery has an impact on the ecosystem, which needed to be demonstrated using metrics designed to assess such an impact and approved by the Scientific Committee. Dr Kasatkina noted that to date, there is no scientific evidence of such an ecosystem fishery impact. Dr Kasatkina further noted that the SOA implementation required data collected following agreed protocols during standardised scientific surveys designed to assess the spatiotemporal variability of krill accompanied by a wide range of ecosystem studies on the biology of krill and its habitat, regular observations of distribution and predator demand, such as the one conducted by the *Atlantida*. Dr Kasatkina highlighted the importance of accounting for krill flux from the Bellingshausen and Weddell Seas in SOA implementations. Dr Kasatkina noted that the *Atlantida* data showed that the presence of krill flux casts doubt on the possibility of the ecosystem impact of the fishery at its current level, and that it is necessary to clarify under what conditions the fishery can have an ecosystem impact.

2.7 Some participants recalled that impacts of the krill fishery have been documented both empirically and by models, as well as through by-catch and IMAF analyses. They noted that the difficulty in quantifying impact stemmed from the lack of adequate monitoring which warranted increased data collection efforts. While agreeing that flux is an important driver of krill distribution, some participants noted that localised low biomasses were not necessarily replenished by advection, and that local production was also an important process in this context.

2.8 The Working Group noted that ecosystem complexity and underlying uncertainties in spatial and temporal interactions between krill and its predators highlighted the need for increased efforts toward the development of integrated krill stock assessments.

2.9 WG-FSA-IMAF-2024/08 presented data on the length and biological composition of krill collected in the Commonwealth and Cosmonaut Seas (Division 58.4.2) by Soviet research and fishing vessels between 1972 and 1990, indicating complex spatiotemporal variability in the length and biological composition of krill, which needs to be taken into account when developing krill fishery management schemes in Area 58 (58.4.1 and 58.4.2-East) through the implementation of standardised comprehensive krill surveys. The authors noted that there is a lack of such surveys in Area 58.

2.10 Dr K. Demianenko (Ukraine) expressed concern with the wording used in the paper which presented data as collected by Russian scientific observations for the period 1972-1990. He noted that all mentioned vessels had been operating under the USSR flag. Therefore, Dr K. Demianenko noted that the paper presented data collected during the USSR period, when Ukrainian scientists contributed.

2.11 Dr. Kasatkina emphasised that WG-FSA-IMAF-2024/08 presented Soviet data obtained by Soviet fishing and scientific vessels in Division 58.4.2 for the period 1972-1990, without distinguishing the nationality of Soviet Scientific Observers. She noted that Soviet vessels conducted fishing and research in the CCAMLR zone under the flag of the Soviet Union. The data were submitted to the Secretariat by the Soviet Union. Dr. Kasatkina recalled that the Russian Federation is the successor of the Soviet Union in CCAMLR.

2.12 The Working Group noted that these data were held at the Secretariat and may provide historical context to topics such as spatiotemporal variability, population dynamics, maturity (WG-FSA-2023, paragraph 3.23) and gear standardisation. It recalled that since the CCAMLR-2000 krill surveys, the Japanese/Australian surveys (WG-FSA-2023, paragraph 3.20) used standardised gear and that their analyses and stock assessments were endorsed by the Scientific Committee (SC-CAMLR-42, paragraph 2.98). The Working Group noted that the variability reported in the analysis in WG-FSA-IMAF-2024/08 was likely due to the use of different trawl types. The Working Group noted that given the longevity of krill, recent data were required to assess krill stocks. It further discussed the importance of the spatial coverage of surveys when collecting data for use in stock assessments.

2.13 WG-FSA-IMAF-2024/07 presented an analysis of the Scheme of International Scientific Observation (SISO) krill biological sampling requirements (200 individuals every 3 or 5 days regardless of the catch) and their ability to generate data for estimating key demographic parameters. Using data collected in 2024 on board the vessel FV *Komandor* in Subareas 48.1 and 48.2, the authors indicated significant spatial and temporal variability in the distribution of krill length composition across fishing areas. It was noted that the current observer protocol tends to under-sample krill for different length groups, particularly recruitment groups, by assuming uniform length composition of krill in the catch regardless of catch value and duration of hauling. Further, the authors advocated for an increase in sampling effort as part of SISO protocols to better support the management of the krill fishery and the development of the Krill Stock Hypothesis. The authors advocated for the preparation of unified requirements for the sample size and its design, taking into account the number of hauls per day and the amount of catch per haul.

2.14 The Working Group noted that the analysis only pertained to vessels using traditional trawls and that the question of observer workload was important in this context (WS-KFO-2023). Recognising the importance of data representativeness, the Working Group recalled previous analyses of effective sample sizes (WG-SAM-16/39; SC-CAMLR-XXXVI/21; WS-KFO-2023, paragraphs 3.5–3.7) as well as recent discussions on the subject (WG-SAM-2023, paragraphs 2.10–2.14) which all pertained to the development of a future sampling program and revised sampling protocols. The Working Group encouraged the authors to use these as a guide for future work to explore effective sample size in krill sampling.

2.15 WG-FSA-IMAF-2024/27 presented an integrated krill population dynamics model applied to the western Antarctic Peninsula following feedback from WG-SAM on a previous presentation of this work (WG-SAM-2024/26; WG-SAM-2024, paragraphs 2.2–2.6). The model integrated fishing, environmental and ecological variables, considered the spatial heterogeneity of the krill population structure, and can be used to evaluate the impact of biological and population structure assumptions on stock dynamics.

2.16 The Working Group welcomed the large amount of work conducted by Mr M. Mardones (Chile), a CCAMLR scholarship recipient, and noted that it represented valuable progress towards building an integrated krill stock assessment. It highlighted the value of such work for better understanding krill population dynamics, discussed the importance of the relationship between spawning stock and recruitment, and highlighted the relevance of the Krill Stock Hypothesis in this context.

2.17 The Working Group noted that exploring scenarios without predation would be valuable since the CCAMLR decision rules implicitly account for predator demand. The Working Group endorsed the inclusion of the Long-term Ecological Research (USA) (LTER) survey data into this work and encouraged participants include it in future work. Noting that the authors had addressed some of the comments by WG-SAM (WG-SAM-2024, paragraphs 2.3–2.6), the Working Group encouraged further developments of such models by CCAMLR scientists, particularly length-structured models.

Icefish

Champsocephalus gunnari in Division 58.5.2

3. 1 The fishery for *C. gunnari* in Division 58.5.2 operates under CM 42-02. In 2023/24 the catch limit was 714 tonnes with 22 tonnes taken as of 31 May 2024.

3.2 WG-FSA-IMAF-2024/58 Rev. 1 presented the 2024 random stratified trawl survey results in Division 58.5.2. The survey was carried out following the same design as in previous years and with the completion of 163 valid stations. Five reserve stations were used due to untrawlable ground at some first-choice locations. The survey targeted *Dissostichus eleginoides* and *C. gunnari* and caught 86.3 and 25.6 tonnes, respectively, along with other by-catch species.

3.3 The Working Group thanked the authors for the update, noting the trends in the target and by-catch species. The authors noted that *Macrourus caml* was generally the most abundant species in the macrourid species group. The Working Group suggested that it would be useful to show biomass trends for each macrourid species. Additionally, length and age structures of the target species would be useful to help explain some of the trends, particularly when strong cohorts are present. The Working Group noted that toothfish are tagged during the survey, however very few have been subsequently recaptured in the fishery and these releases are not used in the stock assessment.

3.4 WG-FSA-IMAF-2024/39 presented an update of life history parameters for *C. gunnari* in Division 58.5.2, using data collected between 1997 and 2024 from surveys and the commercial fishery. Additionally, it is the first time since 1998 that size at maturity has been estimated. All life history parameters explored showed some variability over the time series, with a marked acceleration in growth since 2010. Future research work planned includes investigating the drivers of these changes. The authors, consistent with previous Scientific Committee advice, recommend using the most recent estimates of life history parameters in the stock assessment for mackerel icefish, due to the highly plastic nature of this short-lived species and the update being more representative of the recent population.

3.5 The Working Group welcomed the report, and the progress made on exploring the trends in the life history parameters of *C. gunnari*, noting the life history parameters are updated regularly but this is the first time trends over time have been explored. The Working Group noted that separate populations exist on the plateau where commercial fishing is allowed under CM 42-02, and Shell Bank in 58.5.2, and encouraged the authors to conduct research on the Shell Bank population, where possible, to investigate whether different dynamics exist. The Working Group further noted the significant variability in size at 50% sexual maturity occurs between years and encouraged the authors to investigate this with the inclusion of more data.

3.6 WG-FSA-IMAF-2024/36 presented a preliminary assessment of *C. gunnari* in Division 58.5.2 using the generalised yield model in R (Grym) following the results of the trawl survey described in WG-FSA-IMAF-2024/58 and updates to parameter inputs described in WG-FSA-IMAF-2024/39. Bootstrapped biomass estimates had a mean of 16 051 tonnes, with a one-sided lower 95% confidence bound of 9 731 tonnes. The assessment projected forward the proportion of the one-sided lower 95% confidence bound of fish aged 1+ to 3+ (9 363 tonnes) with three different growth models (fitted to data from 2011-2017, 2011-2024 and 2018-2024) and 2024 length weight parameters. Using the growth model for 2018-2024 in the assessment results in yields of 1 824 tonnes for 2024/25 and 1 723 tonnes for 2025/26 that allow for 75% escapement, therefore satisfying the CCAMLR decision rules.

3.7 The Working Group noted the inclusion of the updated growth and length weight parameters, and that the assessment was consistent with the agreed procedure. The Working Group noted that as there are no age 5+ fish in the data to contribute to the estimation of growth parameters for the time period 2018-2024, which may result in a higher estimate of L_∞, the Working Group suggested that a longer time period which includes data on age 5+ fish, could be used for estimating growth parameters. Noting that the current assessment is dominated by 1+ and 2+ cohorts and aims to reflect recent stock productivity, the Working Group recommended using the most recent data and updating regularly.

3.8 The Working Group noted the inclusion of the climate change table in Annex C of the paper and the different format used compared to that presented for toothfish stocks and recognised that as these tables are developed, they are likely to be species-specific due to differences in life history and assessment methods (See Table 7.3b).

Management advice

3.9 The Working Group recommended that the catch limit for *C. gunnari* in Division 58.5.2 should be set at 1 824 tonnes for 2024/25 and 1 723 tonnes for 2025/26.

Research plans submitted under CM 24-01 targeting *Champsocephalus gunnari* in Subarea 48.2

3.10 WG-FSA-IMAF-2024/68, subsequently revised and submitted as WG-FSA-IMAF-2024/68 Rev. 1, presented a proposal by Ukraine to conduct an effort-limited acoustic trawl survey in Subarea 48.2 under CM 24-01 for *C. gunnari*. The research proposal is for three fishing seasons commencing in the 2024/25 season. The main objectives are to determine the distribution, abundance and stock structure of mackerel icefish, provide information on ecosystem change and for improving integrated ecosystem-based approaches to fisheries in Subarea 48.2.

3.11 The revised proposal was submitted during the Working Group meeting to take into consideration comments that arose from the review of the proposal. The Working Group acknowledged the revised plan and noted that it was an improvement on that presented at WG-ASAM-2024 and WG-SAM-2024, also noting that it addressed all the comments made during WG-FSA-2024.

3.12 The Working Group clarified that, for the 15 target trawls, the length of tow should be no more than 60 minutes in duration, timed from when the gear enters the water to when it exits the water, which will allow reaching fishing depths while minimising by-catch which may occur during longer trawls.

3.13 The Working Group suggested extending the survey design beyond the shelf edge to investigate the spatial extent of the population and connectivity between Subareas. The proponents responded that this would be considered in future years of the survey.

3.14 Dr Kasatkina noted that the first step of the research program proposed by Ukraine in Subarea 48.2 was provided in 2022. Dr Kasatkina also noted that elements relating to the acoustic part and plankton data have not been completed (WG-SAM-2023/22; WG-FSA-2023/48), recalling that an external expert did not process the acoustic data and did not provide any information regarding the quality of the acoustic data (WG-FSA-2022, paragraph 5.45). Dr Kasatkina noted that the initial proposal (WG-FSA-IMAF-2024/68) as well as the revised proposal (WG-FSA-IMAF-2024/68 Rev. 1) require clarity on fundamental aspects such as the methodology of the acoustic-trawl survey, acoustic data collection and processing procedures, expected survey results, and an indicator of the survey efficiency. Dr Kasatkina also noted the need to clarify who will collect and process the acoustic data, given that the proponents do not have acousticians to implement the acoustic-trawl survey, and it is still assumed that the collection and processing of data will be carried out by an external expert. Dr Kasatkina noted that the revised proposal includes changes in data collections, using two or three frequency methods, and significant changes in the milestones. Dr Kasatkina noted that the revised proposal requires consideration by WG-SAM-2025 and WG-ASAM-2025 emphasizing that there is still no clarity regarding the methodology for the implementation of the multi-frequency method to distinguish krill and icefish distributions in the water column, clarity regarding the expected results and survey efficiency as well as who will provide data collection and processing of data and noted that the WG-ASAM-2024 approved the document WG-ASAM-2024/08 as a whole, without any recommendations for the implementation of the acoustic trawl survey, since the methodological aspects of the proposed survey for mackerel icefish (*C. gunnari*) were not reflected in the WG-ASAM-2024/08. Dr Kasatkina noted that there is still uncertainty regarding the installation of a 38-kHz transducer on the Ukrainian vessel and the echosounder calibration using a reference sphere, being an essential condition for the implementation of the proposed acoustic trawl survey~~.~~

3.15 Dr Kasatkina noted that there is currently no clarity regarding the acoustic equipment for implementing the acoustic-trawl survey *C. gunnari* in the Statistical Subarea 48.2 proposed by Ukraine, as well as regarding the methodology and effectiveness of this research proposal, possible results and their practical significance. Dr Kasatkina did not support the proposal by Ukraine to conduct an acoustic trawl survey in Subarea 48.2 under CM 24-01 for *C. gunnari* commencing in the 2024/25 season.

3.16 The Working Group recalled that WG-ASAM-2024 had reviewed the proposal with no concerns reported (WG-ASAM-2024, Paragraphs 7.1 – 7.7) and many Members supported the commencement of the survey on the condition that the 38-kHz transceiver is installed, operational and calibrated prior to the survey commencing. The Working Group also recalled this research plan was reviewed at WG-SAM-2024 (Paragraphs 7.16 – 7.24) with no concerns raised.

3.17 The Working Group requested the Scientific Committee provide guidance on this proposal, taking into consideration the views of WG-SAM-2024 and WG-ASAM.

3.18 The Working Group requested the Scientific Committee provide guidance on which parts of research plans each Working Group should evaluate, noting the differences in expertise between WG-ASAM, WG-SAM, WG-EMM and WG-FSA.

Toothfish

General toothfish issues

4.1 WG-FSA-IMAF-2024/35 presented a study estimating post-release survival of Patagonian toothfish caught and released within the New Zealand exclusive economic zone (EEZ) fisheries. Survival estimates were based on information from PSAT studies, historic research, mark-recapture studies (including CCAMLR data) and input from responses to a survey on tagging survivability. The survey was based on the vessel tagging protocol survey that was circulated to vessels participating in CCAMLR exploratory fisheries (WG-FSA-2019, paragraphs 4.21 – 4.23) and from WS-TAG-2023 outcomes. The survey was circulated at a dedicated workshop and was completed by experts, such as fishers, fishery observers, and research scientists.

4.2 The Working Group welcomed the study and noted the wide variety of responses to the survey depending on the level of fishery experience by survey participants. The Working Group further noted that results from PSAT studies had shown varying degrees of success when deploying tags, thus estimating survivability from PSAT tag data should be treated with caution, especially when evaluating post-release survival was not the intended purpose of the tagging activity. The Working Group encouraged those undertaking PSAT studies to develop objectives that could help determine post-release survival. The Working Group noted that post-release survival studies, in general, were lacking and encouraged development of such studies.

4.3 WG-FSA-IMAF-2024/77 presented a review of the issues in relation to the implementation of the multi-vessel research programs in 'data limited toothfish fisheries'. The paper noted that data available to date demonstrated the influence of longline types on the indices of scientific programs and fishing, such as the CPUE of toothfish and Catch-per-unit-effort (CPUE) of by-catch, the length and species composition of catches, tag-recapture data, and VME data. The author noted that standardisation of fishing gear is a critical factor for 'data limited toothfish fisheries' to improve their efficiency and reliability in the context of providing scientific-based data for understanding abundance, population structure, and distribution of toothfish and dependent species according to the objectives and goals of the research program provided in the CCAMLR area. The author further noted that there is no sufficient scientific justification to allow ignoring the inherent requirements of international practice for the implementation of multi-vessels research programs using standardised fishing gear. It was underlined that the use of standardised gear will be consistent with Conservation Measure 21-02, paragraph 6(iii) and will contribute to the achieving the outcomes outlined of Article II of the Convention.

4.4 The Working Group recalled that extensive discussions had taken place on standardisation of gear types in Division 58.4.1 (e.g. SC-CAMLR-42, paragraphs 9.12–9.19; WG-FSA-2022, paragraphs 5.28–5.36; SC-CAMLR-41, paragraphs 3.129–3.135; WG-FSA-2019, paragraphs 4.94–4.114), and that there was no requirement for standardised gear types to be used in any CCAMLR exploratory fishery. The Working Group reflected that many of the references highlighted by Dr Kasatkina in the paper referred to attributed statements made by Dr Kasatkina in Working Group reports and did not constitute agreed advice or practices recommended by the Scientific Committee and its Working Groups.

4.5 At the time of adoption, Dr Kasatkina noted that WG-FSA-IMAF-2024/77 is based on strict citation of paragraphs of the Working Group and Scientific Committee reports, and also provides references to documents submitted by Australia, France, and the United States, strictly citing the relevant paragraphs of the reports. Dr Kasatkina emphasised that the WG-FSA-IMAF-2024/77 paper refers only to one Russian paper that was re-submitted to the Working Group this year. Dr Kasatkina emphasised that it is unfounded that the WG-FSA-IMAF-2024/77 paper is a compilation of the personal statements at CCAMLR meetings.

4.6 The Working Group further noted that the ICES International Bottom Trawl Survey (ICES, 2017) was a survey program based on trawl fishing gear type, using a swept-area based method of determining abundance, whereas the research plan proposed for Division 58.4.1 is designed to determine the population size and structure of Antarctic toothfish (*D. mawsoni*) using a mark-recapture based method. In addition, ICES 2017 allows for the use of different gear types adapted to different ground conditions (see different gear diagrams at p. 41: Northern Irish, p. 47: Spanish, p. 50: French; in ICES, 2017) and provides a statistical package to combine data using different gear selectivities for assessment purposes (https://github.com/casperwberg/surveyIndex). The Working Group noted that this type of multivariate statistical standardisation analysis is what is proposed to be used in the analysis of data from the exploratory fishery in Division 58.4.1.

4.7 At the time of adoption, Dr Kasatkina noted that the practice of ICES surveys is based on the use of standard fishing gear, the parameters of which are strictly controlled on all vessels using special testing procedures before each survey and during the survey, ensuring that the surveys are carried out with a constant trawl swept area and trawl selectivity for each maintained equal on all vessels (anon, 2001; ICES, 2012, 2017). Dr Kasatkina noted that knowledge and control of trawl parameters adapted to different ground conditions will allow to combine data obtained in different areas. At the same time, selectivity and swept area or swept volume for longline gears are unknown and cannot be controlled. because they depend on the odour field.

4.8 Dr Kasatkina noted that the Ross Sea shelf survey has a standardised design, with the survey currently undertaken by one vessel. Dr Kasatkina considered it desirable in Division 58.4.1 to have a standardised program carried out with the participation of several vessels over a number of years.

4.9 WG-SAM-17/23 presented a preliminary analysis of variability in catch rates of target and by-catch species of different longline gear types within selected Small-scale Research Units (SSRUs) in Subareas 88.1 and 88.2. CPUE data (kg/1000 hooks) were used to examine spatial and temporal variability in catch and by-catch rates by looking at residual deviations from the long-term average and cluster analysis on spatial heterogeneity with the Coniss method. The analysis indicated:

(i) spatial–temporal variability in, and mean estimates of, CPUE by SSRU and season

(ii) differences in toothfish length distributions (arising from small and large fish in the catches), as well as in the mean length of toothfish in the catch

(iii) catches are characterised by a wider species composition of by-catch when using the autoline system.

4.10 The Working Group recalled previous discussions at WG-SAM-2017 with regard to this paper (WG-SAM-17, paragraphs 4.56 – 4.60), in particular that there was a range of additional variables that were likely influencing catch rates of target and non-target species. The Working Group further recalled that Dr Kasatkina had indicated that the results of further analysis incorporating additional variables would be presented to WG-FSA-17 (WG-SAM-17, paragraph 4.60), however no additional studies have been presented to any Working Group since the initial presentation of this paper in 2017.

4.11 The Working Group noted that the Secretariat had undertaken a meta-analysis of catch reporting in exploratory fisheries in 2018 (WG-FSA-18/14), which showed little variation in the reporting of target catch and by-catch species between gear type and area, and that differences in reporting were apparent between Members.

Biology and ecology of target species

4.12 WG-FSA-IMAF-2024/15 presented initial findings from a research project evaluating climate change risks to toothfish in Subareas 48.3 and 48.4 mainly focussing on Patagonian toothfish (*D. eleginoides*) in Subarea 48.3, and using groundfish survey data to develop preliminary distribution models. Initial findings indicated strong inter-annual variability in juvenile recruitment at Shag Rocks, with considerably weaker recruitment on the South Georgia shelf, where juvenile abundance was lower and larger fish predominated.

4.13 The Working Group welcomed the study, noting that it aligns with the need to include climate change within the Term of Reference for WG-FSA for stock management purposes. The Working Group noted that the variables used in the model structure for this study are very important when considering the results, and that the study may benefit from some post-hoc Generalised Additive Model (GAM) modelling approaches. For example, feature selection algorithms that address concurvity issues, where multiple smoothed terms in the model are confounded and can equally explain the data, could be compared with values from a full model as a possible alternative.

4.14 The Working Group noted that the study raises interesting questions on the spatial distribution of larval and juvenile fish in Subarea 48.3, especially the distribution of the pelagic larval and juvenile stages and their transition to demersal life history where they then become available to the groundfish trawl survey. The Working Group further noted that the collection of otoliths of larval and juvenile fish is valuable, and otolith chemistry may be used to reflect the environmental history and the transition of life history pattern of fish. The Working Group encouraged additional surveys targeting the distribution of pelagic young of the year and recent recruits to the sea floor to better understand the factors driving their distribution and how climate change may affect their distribution pattern.

4.15 Dr Kasatkina considered that it would be appropriate to conduct a longline survey of toothfish in Subarea 48.3, supplementing the data on juvenile toothfish available from the groundfish trawl survey, which is primarily aimed at assessing the mackerel icefish stock (*C. gunnari*) (see paragraph 4.57).

Age determination for toothfish

4.16 WG-FSA-IMAF-2024/06 presented details for otolith ageing methods of *Dissostichus mawsoni* by the Russian Federation. The Working Group noted that an earlier draft of this paper was presented at WG-FSA-2023 (WG-FSA-2023/12), and that this method used otoliths collected from toothfish catches by the Russian longline vessel FV Sparta in the Ross Sea during the 2018/19 fishing season. Toothfish lengths from these catches ranged from 70 to 178 cm and were aged from 5 to 26 years. The paper further provides methods and recommendations to address health and safety issues for the described age determination methods.

4.17 The Working Group thanked the authors and encouraged the readers and experts from the Russian Federation to attend future CCAMLR workshops on toothfish age determination and become active in the CCAMLR Otolith network through the Discussion Group.

4.18 WG-FSA-IMAF-2024/22 provided details on methods for identifying daily growth increments in toothfish otoliths by Japanese scientists, in response to a request from WS-ADM2. The Working Group noted that an introduction to the method was given at WG-SAM-2024 (paragraph 5.40), and that this paper reports further details along with the methods for collection, selection, preparation, and identification of otolith daily growth increments. The authors note the probable first annulus and that the increment pattern observed seems to indicate daily increments. They concluded that it was possible to estimate the age in days of juvenile fish that were between 6 months to 1 year old, but it was difficult to estimate daily age for adult fish.

4.19 The Working Group congratulated the authors and agreed that this work should be progressed and brought forward to the next otolith ageing workshop. It noted that there was great value in identifying the structure, location and timing of the first annulus. The Working

Group requested that larval and very young toothfish be collected, and that this sort of analysis could greatly assist in understanding early growth and life history of toothfish. It noted that the presence of daily annuli may be influenced by short-term biological and environmental conditions.

4.20 WG-FSA-IMAF-2024/70 (Appendix E of this report) is the report of the co-conveners of the 2nd CCAMLR Ageing Determination Workshop (WS-ADM2) held in, Boulder, Colorado, USA from 22 to 26 April 2024. It noted a preliminary report of WS-ADM2 was presented at WG-SAM-2024 (WG-SAM-2024/14). The report summarised the progress made across toothfish otolith ageing programs and identified future work required to evaluate and improve consistency between Members' otolith ageing programs. The report included requests and recommendations (WG-FSA-IMAF-2024/70, Table 1), as well as ToRs for a proposed 3rd CCAMLR Age Determination Workshop.

4.21 The Working Group noted the considerable amount of progress made during WS-ADM2 and recognised that there remains a substantial amount of further work needed in order to meet the short-, medium-, and long-term goals of the workplan, including developing standard guidelines and establishing a reference set of otoliths.

4.22 The Working Group noted that if growth changed over time, this could impact the interpretation of specimen age. The Working Group further noted that different regions may have dissimilar growth patterns that may be influenced by different life history patterns.

4.23 The Working Group noted that WS-ADM2 had requested that WG-FSA assist in determining whether growth differs by region, for different stocks, or over time, as this information was needed to help determine whether otoliths from different regions, stocks, or over time can be pooled when creating the CCAMLR otolith reference set collection. The Working Group encouraged Members to undertake such analyses and present these to a future meeting of WG-FSA (see Table 7.4).

4.24 The Working Group noted that a UK otolith workshop was held in June 2024, with a focus on learning the process of otolith reading, development of a work program, and to establish a reference otolith set.

4.25 The Working Group recommended that a future CCAMLR workshop on toothfish age determination should identify stocks or samples where growth has changed, and where growth was different but had been prepared using the same methodology. This could assist in determining reasons for any alternative interpretations. The Working Group agreed as the methods became more standardised, fewer reference otolith sets would be required.

4.26 The Working Group noted that there was the need to generate high-quality images of otoliths, which requires appropriate equipment to allow the capture of high-quality images, and hence allow a better interpretation of the images. The Working Group further noted that the Secretariat has developed a database to host otolith images, metadata, and age data. The Working Group recommended that a future Age Determination Workshop could develop datasets that sourced from different labs, as these can now be stored in a consistent format.

4.27 The Working Group recommended that the third workshop on toothfish age determination (WS-ADM3-2025) take place during the 2024/25 intersessional period to progress this work and that intersessional work be progressed through the CCAMLR Otolith Network Discussion group.

4.28 The Working Group recommended the Scientific Committee consider the proposal and Terms of Reference for the third CCAMLR Age Determination Workshop that is provided in Appendix D.

4.29 The Working Group recommended that the Scientific Committee support the same level of funding for the 2024/25 workshop that was requested for WS-ADM2 (AU$15,000) and include Secretariat support at this Workshop.

Toothfish stock assessment workplan

4.30 The Working Group recalled the work program on the effects of spatial bias in tagging data and trends in recruitment, including projected recruitment within the integrated stock assessments, and application of the CCAMLR toothfish decision rules that were recommended by SC-CAMLR-42 (paragraph 2.124).

4.31 The Working Group thanked the authors of all integrated assessments and supplementary analyses, and noted that a large amount of work had been undertaken intersessionally to address the Scientific Committee's workplan. The Working Group noted that this work had been given priority over alternative model developments and was completed within a compressed timeframe to ensure the results could be presented to WG-SAM-2024 and WG-FSA-2024.

4.32 The Working Group recommended that future developments occur over a longer timeframe, allowing for intermediate results to be reviewed by WG-FSA in years when catch advice is not being formulated.

4.33 The Working Group recommended that the Secretariat include updated stock annexes in the fishery reports on the CCAMLR website in the future.

Casal2 verifications

4.34 The Secretariat verified toothfish Casal2 assessments following the WG-SAM guidelines (WG-SAM-2022, Appendix D, Part A; noting the re-wording of step iii for clarity). Part A of the verification process requires that the Secretariat verify that the Casal2 input configuration files can be used to reproduce the key results reported by stock assessment papers and confirm that:

(i) from a simple run (casal2 -r), the software used in the assessment accepts the input configuration files and produces no error messages

(ii) from an estimation run (casal2 -e), the parameter files match the MPD results reported in the assessment papers

(iii) using the proposed yield in Markov Chain Monte Carlo (MCMC) projections, the risks (1 and 2) are consistent with the decision rules

(iv) the accepted base case from the previous accepted assessment passes the above validation using the current version of software and uses the total objective function and B_0 @assert commands in the configuration files; and confirm that the proposed assessment models contain equivalent @asserts for testing in future years.

4.35 All steps were successfully verified (Table 3).

4.36 The Working Group verified toothfish Casal2 assessments following the WG-SAM guidelines (WG-SAM-2022, Appendix D, Part B). Part B of the verification process requires that the Working Group verify that the Casal2 input configuration 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 and 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 (unfished Spawning Stock Biomass (SSB_0), current status (SSB/SSB_0), 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.

4.37 All steps of Part B of the verification process were successfully verified.

4.38 The Working Group recalled the additional diagnostics requested for integrated stock assessments in SC-CAMLR-42 (paragraphs 2.110 – 2.111). The Working Group noted that the requested diagnostics were either presented in papers submitted to WG-FSA-2024 or during the meeting for the toothfish assessments for Subarea 48.3, Divisions 58.5.1 and 58.5.2, and the Ross Sea region. The Working Group recalled the GitHub code repository (WG-SAM-2023, paragraphs 6.33 – 6.35) available for sharing code to produce model outputs and diagnostics, and encouraged Members to contribute to it.

4.39 Kobe plots showing the relationship between stock status and harvest rate (U) were presented for each of the assessments, and are shown in Figure 1. A summary of the evaluation of the CCAMLR decision rules under alternative recruitment assumptions for Subarea 48.3, Division 58.5.1 and the Ross Sea region is presented in Tables 4, 5, 6 and 7.

4.40 The Working Group noted that similar trends in recruitment were estimated by the 48.3, 58.5.1, and 58.5.2 Patagonian toothfish assessments, and recalled that WG-SAM-2024 recommended that, where there is substantive evidence of a decrease in recent recruitment, the recent recruitment rather than the entire estimated recruitment time series should be used in projections to determine the precautionary catch limits for the CCAMLR toothfish decision rules (WG-SAM-2024, paragraphs 5.19 – 5.21).

General workplan

4.41 The Working Group recommended the following work be conducted and presented during future meetings of WG-SAM, with the conclusions presented to WG-FSA- 2026:

(i) investigate sex-disaggregated assessment models for Subarea 48.3 and Divisions 58.5.1 and 58.5.2 that are currently sex-aggregated

(ii) investigate alternative estimators of abundance from tag-recapture data to compare to the estimates from the Chapman estimator

(iii) continue ongoing work to account for spatial changes and other sources of bias in tag-recapture data, and incorporate these into stock assessments.

Focus topic of spatial bias in tag-based assessments

4.42 WG-FSA-IMAF-2024/47 presented a summary of the collaborative work between Members who have developed assessments in Subarea 48.3, Division 58.5.1, Division 58.5.2, and the Ross Sea region since WG-FSA-2023. The paper addressed the impacts of spatial and temporal changes in fishing effort on tag-based abundance estimates. The paper noted that significant progress had been made in understanding the nature of the problem, as well as identifying some of the key drivers of changes in the abundance estimates over time. The paper also recalled that discussions at WG-SAM-2024 (paragraph 5.10) recommended that stock assessment models presented to WG-FSA-2024 should include the following:

(i) a model that was based on the 2023 version updated with new data,

(ii) a model using a biomass time series which is estimated external to the model based on the Chapman estimator and replaces tag-recapture data in the model, and

(iii) a model using 3–5 individual biomass time series, which are estimated external to the model for local regions that have a consistent 'cluster' of effort, and using these regional Chapman estimates to replace tag-recapture data in the model.

4.43 The Working Group thanked the authors and the scientists that had contributed to the work program and welcomed the progress that has been made over the past year to address the priority issues identified by the Scientific Committee.

4.44 The Working Group discussed the assumptions of the Chapman estimator and whether ignoring recaptures that occur after only one year at sea would better align with its random mixing assumption. The Working Group also noted that toothfish movement is complex and may be influenced by factors beyond time at liberty, such as season, year and fish age. The

Working Group noted that bias related to movement patterns might also be explored by examining SSB_0 likelihood profiles from tag recaptures in relation to time at liberty.

Development of management strategy evaluations

4.45 The Working Group recalled a request from the Scientific Committee (SC-CAMLR-42, paragraph 2.121) and the Commission (CCAMLR-42, paragraph 4.62) to investigate the CCAMLR decision rules with MSE.

4.46 The Working Group recalled the advice from Scientific Committee (SC-CAMLR-38, paragraph 3.65) to investigate refinements to increase the robustness of the CCAMLR toothfish decision rules, such as using target and limit harvest rates.

4.47 The Working Group noted that the MSE work should also include evaluation of the 35-year projection period of the decision rule and its requirement to ensure that the target of 50% of SSB_0 would allow the stock to recover to near-virgin levels if there is no fishing.

4.48 The Working Group noted the significant progress that had been made at WG-SAM-2024 (WG-SAM-2024, paragraphs 6.11 – 6.13) in undertaking simulations of potential Harvest Control Rules (HCRs) for toothfish and requested that the Scientific Committee develop a timetable for undertaking full MSEs. The Working Group recommended that the Scientific Committee include the following tasks in this workplan:

(i) identification of the range of uncertainties (related to biology, the environment, the fishery and the management system) to which the management strategy should be robust. These should include:

  (a) the choice of operating model structures and assumptions

  (b) model parameter uncertainty (e.g. growth, natural mortality, depredation, historical IUU catch, stock recruitment steepness, and maturation)

  (c) recruitment trends and uncertainty in these trends

  (d) abundance, age, or other observation data uncertainty and bias (e.g. spatial bias and uncertainty in tag-based abundance estimates).

(ii) identification of the selection of suitable operating models

(iii) identification of suitable performance indicators and metrics

(iv) potential 'breakout' or 'stop' rules

  (a) development of quantitative triggers that would apply if conditions fall outside of the range evaluated by the management strategy

  (b) management options that may apply if a 'breakout' or 'stop' rule was triggered (e.g. a reassessment of the MSE procedure, an updated stock assessment, use of a default harvest rate, rebuild plan, or other appropriate measures).

4.49 The Working Group noted that scientific studies and research have demonstrated that harvest-rate based Harvest Control Rules (i.e. U-based Harvest Control Rules) will generally outperform constant catch Harvest Control Rules (Deroba and Bence 2008).

4.50 The Working Group noted that harvest-rate based Harvest Control Rules could supplement the current CCAMLR toothfish decision rules to provide additional precaution for when stocks were below target levels. The Working Group recommended the Scientific Committee consider supplementing the current CCAMLR decision rules with an interim harvest-rate harvest control rule (WG-SAM-2024, paragraph 6), as suggested in WG-SAM-2024, paragraph 6.13 (iv). The Working Group noted that this could be evaluated as a part of the MSE work to be refined or improved in future.

Dissostichus eleginoides in Subarea 48.3

4.51 WG-FSA-IMAF-2024/28 presented an update of the analysis of spatial changes in the Subarea 48.3 toothfish fishery presented to WG-SAM-2024 and the effects that these changes have on estimates of biomass from Chapman indicators and Casal2 stock assessments. It concluded that the current stock assessment is likely to underestimate the stock size and underestimate the stock status, since the tag recaptures sample a decreasing proportion of the historic footprint, in particular due to changes in depth range of the fishery that excluded an estimated 19% of the vulnerable biomass. It also showed that the contraction of the fishery from management area 48.3A and uncertainty about the magnitude and location of IUU is unlikely to have a large effect on the management of the stock. The authors highlighted that further work is needed to incorporate this analysis into the integrated stock assessment, and proposed a workplan to address this.

4.52 WG-FSA-IMAF-2024/29 and WG-FSA-IMAF-2024/30 presented the updated assessment of the Patagonian toothfish (*D. eleginoides*) in Subarea 48.3 which indicates that the current status of the stock is at 49% of SSB_0 in 2024. Compared to the 2023 assessment, the 2024 assessment included survey compositions at age rather than length, and revised the CPUE standardisation method. From the three recruitment assumptions that were investigated for projections, it proposed the use of recruitment trends derived from comparing the average density of three-year old fish reported in the most recent 20 years of the groundfish survey to that of the average from all surveys. Applying this approach which estimated a 12% drop in recent recruitment compared to longer-term average, stock projections indicate that a constant catch of 2 062 tonnes in the 2025 and 2026 seasons would be consistent with the CCAMLR decision rule after accounting for recent marine mammal depredation rates.

4.53 The Working Group noted that Chapman estimates of vulnerable biomass stratified by depth showed a similar trend to the Chapman estimates of the overall vulnerable biomass, although with a slightly lower decline over time.

4.54 The Working Group noted that, following the recommendation by WG-SAM-2024 (paragraph 4.42), abundance indices based on tag recapture data had been estimated external to the assessment model. The Working Group noted that the inclusion of this abundance indices into the Casal2 model had been explored, but that the resulting dynamics from the models showed implausible trends, and therefore, the work was not pursued further.

4.55 The Working Group requested that future dissimilarity matrices be calculated per depth strata or fishery to assess more clearly the potential sources of spatial bias in tag recapture.

4.56 The Working Group suggested that, as the age composition data appeared to have some evidence of systematic changes over time, the authors investigate ‘areas-as-fleets’ approaches to modelling the fisheries within the model. This may help evaluate the effect of any potential changes in selectivity that may have occurred over time.

4.57 The Working Group noted the proposed method for projecting recruitment based on the survey data in WG-FSA-IMAF-2024/29, which is based on the ratio of the average density of age-3 fish over the most recent 20 years compared to the average density of age-3 fish over the entire 40-year time series. The Working Group also discussed the sensitivity of the method’s outcomes. A test of the influence of weighting abundance to account for uneven intervals between surveys was presented, showing a limited impact.

4.58 The Working Group noted that the trawl survey is multi-disciplinary and samples the shelf in Subarea 48.3, and has proven to be suitable to provide an abundance index of juvenile Patagonian toothfish of 2-, 3- and 4-year-old fish.

4.59 Dr Kasatkina noted that there is still a lack of biological data based on the entire Patagonian toothfish stock distribution in Subarea 48.3, and noted the need for fishery-independent data on the distribution and abundance of the Patagonian toothfish in Subarea 48.3, recalling the recommendations of the Independent Reviews in 2018 and 2023. Dr Kasatkina recalled the position of the Russian side on the need to conduct an international longline survey that would cover the entire population habitats of *D. eleginoides* in Subarea 48.3, supplementing the data on juvenile toothfish available from the groundfish trawl survey.

4.60 The Working Group noted that although fisheries independent longline surveys can provide useful data for stock assessments, they were not a pre-requisite for the development of a suitable stock assessment. The Working Group noted that the Center for Independent Experts (CIE) reviewed toothfish assessments (SC-CAMLR-42/02) that did not include this source of data and endorsed the current approach to provide management advice.

4.61 The Working Group noted the proposed workplan in Table 5 of WG-FSA-IMAF-2024/28 and encouraged the authors to continue to work to address the effects of spatial variability in the stock assessment.

4.62 The Working Group recommended that future stock assessments include a table of tag releases and recaptures and model-derived estimates with MCMC credible intervals for selectivity functions and risk profiles.

4.63 The Working Group recommended investigating the use of empirical resampling for future recruitment and encouraged the authors to run a sensitivity analysis on the chosen recent period for the proposed survey-based approach, as it may capture different phases of past recruitment cycles.

Management advice

4.64 The Working Group recommended that the catch limit for *D. eleginoides* in Subarea 48.3 be set at 2 062 tonnes for 2025 and 2026 seasons.

4.65 At the time of adoption Dr Kasatkina stated that she did not support the Management advice.

4.66 The Working Group noted that Dr Kasatkina had not participated in the assessment subgroup during WG-FSA-IMAF-2024 and encouraged full participation in these discussions in future years so that the scientific concerns can be discussed and addressed.

Dissostichus eleginoides in Division 58.5.1

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

4.68 WG-FSA-IMAF-2024/67 presented an updated integrated assessment model for the Kerguelen Islands D. eleginoides fishery in Division 58.5.1 up to the end of 2022/23. Diagnostics for the assessment were provided in WG-FSA-IMAF-2024/41 and analyses of the spatial bias in mark-recapture data in WG-FSA-IMAF-2024/61. Key additions and updates to the assessment model included the incorporation of catch data up to 2023, new age data from a 4-year otolith reading program, an updated depredation rate (lice (scavenging amphipods) and sperm whales (*Physeter macrocephalus*)), and updated tag recapture data. The paper also included methods to evaluate the effect of spatial bias on the model from tag-recapture data, and an evaluation of the HCRs as recommended by WG-SAM in 2024.

4.69 The updated assessment model was run in Casal2 and estimated SSB_0 at 188 460 tonnes (95% CI: 175 690 – 203 010 tonnes). The estimated SSB status in 2023 was 56.4% (95% CI: 54.2 – 60.2%).

4.70 The Working Group noted that the retrospective and ‘tag peel’ analyses presented in WG-FSA-IMAF-2024/67 did not suggest any evidence of a strong spatial bias from the tagging data. The Working Group noted that the improvement in these diagnostics was likely due to the re-analysis of the tag release and recapture observations by French scientists which significantly improved the quality of the data.

4.71 The Working Group noted that preliminary analyses suggested that when the tag recapture and tag release spatial bias correction factors were applied to the Chapman estimates, the combined effect on the resulting abundance estimates was small and did not result in a trend in bias over time.

4.72 The Working Group noted that the application of the HCRs as recommended by WG-SAM-2024 performed well in achieving the target spawning biomass under the average future recruitment scenario, but with contrasting levels of catch and varying proportions of years spent above or below the target. In scenarios when future recruitment was low, all three HCRs resulted in long-term SSB falling to levels below the 60% target. However, the U-ramp rules proved to be more precautionary, leading to higher average biomass levels than the constant-U rule (WG-SAM-2024 paragraph 6.8).

4.73 The Working Group welcomed the proposed development of a sex-based model for the stock, noting that this would better account for changes in population structure and biological parameters.

4.74 The Working Group noted that the assessment estimated a catch limit of 4 610 tonnes, and that this complied with the French EEZ decision rules, and CCAMLR decision rules under the assumption that the entire historical recruitment time series was representative of future recruitment.

4.75 The Working Group noted that if future recruitment was assumed to be at a level like that estimated for the period from 2007 – 2018, this would result in a lower yield. However, the Working Group also noted that the 2018-year class was estimated to be above average.

4.76 No new information was available on the state of fish stocks in Division 58.5.1 outside areas of national jurisdiction. The Working Group, therefore, recommended that the prohibition of directed fishing for D. eleginoides, described in CM 32-02, remain in force in 2024/25.

Dissostichus eleginoides in Division 58.5.2

4.77 The fishery for *D. eleginoides* in Division 58.5.2 operated in accordance with CM 41-08 and associated measures. In 2023/24, the catch limit for *D. eleginoides* was 2 660 tonnes and 735 t was taken as of 31 May 2024. Details of the fishery and the stock assessment are contained in the Fishery Report (https://fisheryreports.ccamlr.org/).

4.78 WG-FSA-IMAF-2024/69 presented abundance estimates calculated using the Chapman estimator using tagging data collected by the fishery in Division 58.5.2 during the period 2012–2023. The analysis identified a core area ('Core 1') based on review of more frequently fished areas within the fishing footprint as well as fishing depth. A second core area ('Core 2') used a more flexible (and smaller) boundary based on these same factors. These two core areas accounted for 73% and 66% of the total tag recaptures respectively. Additionally, three smaller areas were identified using chemical trace profiles that may have lower mixing between areas. Chapman estimates of the two different core areas as well as the smaller areas were calculated.

4.79 The Working Group noted that the trends estimated from the whole area and the core areas by the Chapman indicator were similar but showed large variability. Associated figures including dissimilarity indices and tag recapture rates were also relatively similar. This suggests that the adjustments made to the boundary did not reduce the spatial variability evident in the full dataset. Abundances estimated for the three smaller areas were also highly variable and inconsistent with possible inter-annual variability in the abundance of the stock. Some abundance values that were estimated were higher than those estimated from the full dataset. Associated dissimilarity matrix figures showed temporal trends in relative dissimilarity that were different for the three smaller areas. The Working Group noted that alternative tag-recapture models may have assumptions more appropriate for estimating abundance of this stock, and should be investigated as part of the workplan for this assessment (paragraph 4.89).

4.80 WG-FSA-IMAF-2024/50 and WG-FSA-IMAF-2024/64 presented an updated assessment for Patagonian toothfish (*D. eleginoides*) at Heard Island and McDonald Islands in Division 58.5.2. Starting with the 2023 assessment model that was used to provide management advice, this paper presents a bridging analysis and sensitivity analyses. The 2024 assessment included updated catch data to 2024 and observations to the end of 2023, recruitment re-parameterised using the simplex parameterisation and estimated for an extra two years compared to the last assessment, and an updated timing of the random stratified trawl survey (RSTS). The base-case model estimated SSB_0 at 64 083 tonnes (95% CI: 60 139–68 635 tonnes) and the current status (B2024) at 37.9% of SSB_0 (95% CIs 37.8–38.0% SSB_0). The authors presented diagnostics including a retrospective analysis and a partial retrospective where years of tag recapture data were successively removed. Additional model sensitivities investigated the impacts on the assessment model of alternative assumptions about natural mortality, the stock-recruit relationship and the range of years over which recruitment is estimated.

4.81 Based on the result of this assessment and the application of the CCAMLR decision rules, the paper noted that a catch limit of 2 640 tonnes would be consistent with the CCAMLR decision rules. The authors considered that this assessment does not provide new advice to inform an updated recommendation on catch limits, and recommended to roll over the advice of 2 660 tonnes for the 2024/25 season. The authors considered that this would have a low level of risk, as the bias caused by spatial patterns in the tag data was likely to lead to an underestimate of SSB_0, and recent stock status and recruitment.

4.82 The Working Group welcomed the large amount of work undertaken by the authors, including analysis of spatial trends in fishing effort, further development of the assessment diagnostics and development of alternative approaches to including tag data within the assessment.

4.83 The Working Group noted that the updated stock assessment attempted to follow the proposed workplan by WG-SAM-2024 (paragraph 5.10) using a sensitivity framework to applying tagging data in different ways in the Casal2 model. Step 1 of this framework was implemented in the 2024 base case model. Biomass time series based on the Chapman estimation were estimated for a core area and for different smaller areas externally from the model for steps 2 and 3, however problems were encountered when these abundance time series were included in the Casal2 model which could not be resolved in the short time available.

4.84 The Working Group noted that the results of evaluations of the alternative Harvest Control rules encouraged by WG-SAM-2024 (paragraph 6.10) had not been presented to the meeting for this stock. The Working Group encouraged that results of such evaluations of the Harvest Control rules be included in future assessments. The Working Group also noted that projections with alternative recruitments had been requested by WG-SAM-2024 (paragraph 5.19) for stocks that showed substantive evidence of decrease in recent recruitment, but noted that there were different views about whether this was the case for this stock.

4.85 The Working Group noted the comparison of estimated recruitment from the assessment with abundances of fish aged 2, 3 and 4 years in the survey. Although the recruitment estimated by the assessment shows a higher period followed by a lower period, the year classes that can be estimated from the survey only covered the period of lower recruitment estimated by the stock assessment, and therefore it is not possible to validate the trend in the estimated recruitment prior to that period from the survey data.

4.86 The Working Group noted that the catch for the 2023/24 season had been lower than the catch limit in CM 41-08 for this season, and noted that this was due to domestic management measures. The Working Group noted that catches from Williams Ridge in the SIOFA area in 2024 were not yet available, and therefore not included in the assessment, but are likely to be negligible.

4.87 The Working Group noted that additional work presented during the meeting showed that the assessment was robust to the assumption of low levels of cryptic biomass (part of the stock assumed by the model, but not observed by the fishery or survey), and that there was no trend in the fits of tagging data related to time at liberty.

4.88 The Working Group noted that the current stock status was estimated as 38% SSB_0 and may be under-estimated by the assessment, but that the information available was insufficient to separate the effects of potential underestimation of the stock, due to negative bias driven by patterns in the tagging data, from stock declines due to low recruitment and impacts of the fishery.

4.89 The Working Group noted the draft workplan outlined in WG-FSA-IMAF-2024/50 which aims to further investigate and account for the effect of spatial patterns in the tag data within the assessment. The Working Group recommended that work to address this was a high priority and should also include reviewing other data sources independent from the assessment and the consistency of other data sources used in the Casal2 assessment. The Working Group recommended that the following work be conducted:

(i) review the use of mark-recapture estimators that underpin tag-based stock assessments

(ii) quantify area-specific impacts of limited adherence to mark-recapture modelling assumptions through simulations

(iii) compare alternative mark-recapture models to derive abundance from HIMI fisheries' tagging data

(iv) develop approaches to identify and mitigate effects of higher than predicted tag-recaptures in some locations and years ('hotspots')

(v) evaluate stock assessment with external indices of tag-based abundance

(vi) analyse the structured longline fishing trial and investigate the integration of its data into the stock assessment

(vii) evaluate sex-based model

(viii) present an updated stock assessment and assessment-independent stock information to WG-FSA-2025

4.90 The Working Group noted that this workplan is ambitious and recommended that progress addressing points (i)–(vii) should be presented to WG-SAM-2025 and incorporated into an updated assessment in order to provide catch advice at WG-FSA-2025.

4.91 Some participants considered that the workplan proposed by WG-SAM-2024 had not been addressed (paragraph 4.89), a new scientific basis for providing advice had not been presented in WG-FSA-IMAF-2024/50, and that the proposed catch limit was not precautionary. The Working Group was therefore unable to recommend a catch limit.

4.92 Dr Ziegler made the following statement:

'*The work presented on D. eleginoides in Division 58.5.2 is consistent with the conclusion by SC-42 (paragraph 2.179) that the current stock status may not be as pessimistic, and the estimated recruitment may not have declined as strongly as that predicted by the stock assessment model in WG-FSA-IMAF-2024/50.*

The stock assessment model is strongly influenced by the tagging data and the assumption of a Chapman estimator to calculate an associated biomass time series in the Casal2 stock assessment model. Tagging data is likely to be mis-represented in the model which has likely led to an overall negative bias in stock biomass estimates, and lower estimates of recent SSB status and recruitment (see also WG-SAM-2024: paragraphs 5.7 and 5.8). A variety of analyses conducted for WG-SAM-2024 and WG-FSA-IMAF-2024 have provided evidence for this:

(i) The interannual variability in spatial distribution of fishing effort and tagging data, combined with low movement rates of toothfish, strongly indicates that the tagging data collected by the fishery violates basic and important assumptions of the Chapman estimator used to estimate stock abundance.

(ii) The tag-peel and retrospective analyses highlighted inconsistency in abundance estimates from the tagging data. The inclusion of more recent tagging data, as opposed to only earlier tagging data, resulted in increasingly lower estimates of B_0*, a more rapid decline in SSB status over the entire fishery period, and as a consequence a lower SSB status in 2024. Current stock status increased with fewer years of tagging data in the model, from 38% to 47% with tagging data up to 2014 releases.*

(iii) Survey catchability q *was estimated by the base case model to be 1.22. This indicates a possible bias in biomass estimates and other parameters derived from tagging data. Survey* q *decreased to more reasonable values* <1 *when recent tagging data were removed.*

(iv) There were inconsistencies between estimates of recruitment from the model and the survey. Stock assessment estimates were reasonably consistent in recent years, while the survey observed strong recruitment in some years, with an increase in survey biomass and young fish recently. When recent tagging data was removed from the model in the tag peel, the model fitted more closely to the survey abundance trend which resulted in elevated model estimates of recent recruitment above average recruitment. Therefore, recent recruitment estimates by the model, particularly from 2008 onwards, are highly uncertain and don't form a reliable basis to be used in stock projections on their own.

Major progress has been made about the spatial and temporal distribution of tagging data with the extensive analyses conducted during 2024. However, further work is *needed and will be undertaken by Australia during the next year to address these issues in the stock assessment (paragraph 4.89).*

With the work in response to the recommendation by SC-42 (paragraph 2.124) still in progress, we recommend to roll over the current catch limit of 2 660 t for one year to the 2024/25 fishing season. This catch limit is almost identical to the catch limit of 2 640 t estimated by the 2024 base case model, and derived by applying the CCAMLR decision rules which the Commission has considered to be precautionary.'

Management advice

4.93 The Working Group was unable to agree a recommended catch limit for *D. eleginoides* in Division 58.5.2 for the 2024/25 season.

4.94 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 2024/25.

Dissostichus mawsoni in Subarea 88.1 and SSRUs 882AB

4.95 The exploratory fishery for *D. mawsoni* in Subarea 88.1 operated in accordance with CM 41-09 and associated measures. In 2023/24, the catch limit for *D. mawsoni* was 3 499 tonnes of which 3255 tonnes were taken. Details of this fishery and the stock assessment are contained in the Fishery Report (https://fisheryreports.ccamlr.org/).

4.96 WG-FSA-IMAF-2024/33 presented a characterisation of the *D. mawsoni* fishery in the Ross Sea region. Scaled length distributions showed no decrease in the size of fish caught through time in any of the management areas. However, there was strong interannual variability in the area south of 70° S that was likely driven by changes in the fine-scale spatial distribution of fishing effort or the influence of strong and weak year classes entering the fishery. There was a small change in the sex ratio of *D. mawsoni*, with a gradual trend of more males caught in all areas until 2015. The number of *D. mawsoni* recaptured over the last five years of the mark-recapture program was higher than the average annual number of recaptures over the past decade, which is expected due to the increased numbers of tagged fish released since 2018 in the S70 area, an increase in recovery effort in that area following the implementation of the RSrMPA, increased survivorship of tagged fish, and increased tag retention and detection.

4.97 WG-FSA-IMAF-2024/71 presented an updated stock annex for the *D. mawsoni* fishery in the Ross Sea region. The annex provided small updates to the previous version, and the inclusion of details about the Ross Sea shelf survey (RSSS).

4.98 The Working Group noted that ageing data in the Ross Sea region have been derived from ageing of otoliths which were collected only by fishing vessels from New Zealand, and recommended that other Members also contribute to fish ageing for the Ross Sea region.

4.99 The Working Group noted that maturity estimates for *D. mawsoni* in the Ross Sea region were last updated in 2012, and the growth and length-weight relationships in 2019. The

Working Group noted that updating maturity required sampling of gonads for histology or weighting gonads to determine the Gonadosomatic Index (GSI), and that neither is part of the current data collection plan for the Ross Sea region. The Working Group recommended that estimates of biological parameters including maturity be updated, and that appropriate collection of maturity samples be included in the next data collection plan for the Ross Sea region.

4.100 WG-FSA-IMAF-2024/32 presented an update of the Bayesian sex- and age-structured integrated stock assessment model for *D. mawsoni* in the Ross Sea region with Casal2. Further model diagnostics were included in WG-FSA-IMAF-2024/34. The model estimated SSB_0 at 77 920 t (95% CIs 72 060–84 690 t) and the current stock status (SSB_{2024}) at 65.2% SSB_0 (95% CIs 62.3–68.1% SSB_0). The authors recommend that the 2024 base case model with recent (10-year) recruitment be used for the provision of management advice, leading to a proposed catch limit of 3 278 t for the 2024/25 and 2025/26 seasons.

4.101 The Working Group noted that, compared to the 2023 stock assessment, this assessment included catch and data on tag-recaptures for 2024, ageing data for the Ross Sea shelf survey and the commercial fishery from 2023, and a range of small changes to some model input parameters that improved model behaviour but had only negligible impact on model outcomes.

4.102 The Working Group noted preliminary investigation in the use of Chapman estimates as abundance indices, rather than the tag-release and recapture data in the Casal2 model. For this step (3) of the sensitivity framework as proposed by WG-SAM-2024 (paragraph 5.10), the Ross Sea region was split into smaller regions, and for each of these Chapman estimates of abundance with one year of liberty were estimated. These estimates were then included in a modified version of the 2024 base case model, together with regions-specific catch history and age composition data. In addition, a constraint, in the form of an additional prior, was added to the model to encourage the relative catchability coefficients of the Chapman estimates time series to have a total summed catchability of one.

4.103 The Working Group noted that the time series of the regional Chapman abundance estimates were highly variable, but the Casal2 assessment did not fit to this variability. The Working Group noted that this variability in estimated regional abundance could have been caused by a lower level of randomness in effort distribution at a smaller spatial scale, e.g. driven by interannual variability in sea ice, as opposed to the scale of the entire Ross Sea fishing region.

4.104 The Working Group recommended to use year class strength estimates from the recent 10-year period (2008 – 2017) in the projections to determine catch limits.

4.105 The Working Group recommended that the catch limit for the Ross Sea region (Subarea 88.1 and SSRUs 882A–B) be set at 3 278 tonnes for the 2024/25 and 2025/26 seasons based on the outcome of the assessment, with 99 tonnes allocated for the Ross Sea shelf survey in 2024/25 (SC-CAMLR-41, Annex 9, paragraph 5.66).

Dissostichus mawsoni in Subarea 48.4

4.106 The fishery for *D. mawsoni* in Subarea 48.4 operated in accordance with CM 41-03 and associated measures. The catch limit for *D. mawsoni* in Subarea 48.4 in 2023/24 was 43 tonnes of which 42 tonnes were taken. Details of the fishery for *D. mawsoni* in Subarea 48.4 and the stock assessment are contained in the Fishery Report (https://fisheryreports.ccamlr.org/).

4.107 WG-FSA-IMAF-2024/31 presented a preliminary tag-recapture based population assessment of *D. mawsoni* in Subarea 48.4. The local biomass of *D. mawsoni* was estimated from tagging returns, giving a five-year average of 968 tonnes since 2020. Applying the CCAMLR agreed precautionary assumption of setting harvest rates based on a 5-year average biomass, and harvest rate of $\gamma = 0.038$, results in a catch limit of 37 tonnes for the 2024/25 season.

4.108 The Working Group noted that there was a latitudinal trend in proportions of the catch of the two toothfish species in Subarea 48.4, with *D. mawsoni* being dominant in the south and *D. eleginoides* dominant in the north. Over time, the dominance of *D. mawsoni* in the catch has moved northwards due to increasing catch rates of *D. mawsoni* and decreasing catch rates of *D. eleginoides.*

4.109 The Working Group noted a plan to age around 1 000 *D. mawsoni* from the region and conduct microchemistry analyses of otoliths to inform about potential stock linkages. The Working Group noted that long-distance tag-recaptures (WG-FSA-2023/71), and existing otolith chemistry and genetic analyses indicate there is one *D. mawsoni* stock across Subareas 48.6 and 48.4, and noted that these findings are consistent with the stock hypotheses proposed by the WS-DmPH.

4.110 The Working Group noted that the harvest rate of 3.8%, which has been applied to determine catch limits in this fishery since 2009, is based on the ratio of catch to the estimated spawning stock biomass in the Ross Sea region in 2007 (Agnew 2009). The Working Group noted that this approach was consistent with the approach taken by the trend analysis for data-poor toothfish fisheries.

4.111 The Working Group recommended that the applied harvest rate to determine catch limits for this fishery could be updated for future assessments, taking into account region-specific biological parameters.

4.112 The Working Group recommended that the catch limit for *D. mawsoni* in Subarea 48.4 be set at 37 tonnes for the 2024/25 season.

Exploratory fisheries with research plans

4.113 WG-FSA-IMAF-2024/12 presented updated estimates of toothfish biomass for Research Blocks in data-limited toothfish fisheries and catch limits for the 2024/25 season determined following the trend analysis decision rules.

4.114 The Working Group thanked the Secretariat for implementing the trend analysis and noted that Table 1 of the paper (WG-FSA-IMAF-2024/12) included research blocks which did not have research plans and had not been fished for many years. It recalled that the calculation and presentation of trends and potential catch limits for all research blocks (WG-FSA-2021, paragraph 4.2(v)) was a helpful way to display which Research Blocks were currently being fished, which were not, and when fishing last occurred.

4.115 The Working Group recommended catch limits for Research Blocks in data-limited toothfish fisheries for the 2024/25 season as given in Table 8 for those research blocks potentially requiring catch advice in Subareas and Divisions for which fisheries notifications were submitted for Exploratory or Research fisheries.

4.116 The Working Group noted the latest vulnerable biomass estimates that will be used for the trend analysis calculations next year. In Division 58.5.2 (WG-FSA-IMAF-2024/64), the 2024 estimate was 23 485 tonnes (CV 0.0435), and in the Ross Sea region (WG-FSA-IMAF-2024/32), the 2024 estimate was 88 594 tonnes (CV 0.057).

4.117 The Working Group reviewed and evaluated research plans for exploratory fisheries against the criteria outlined in WG-FSA-2019/55 (Table 9).

Tag overlap statistics

4.118 The Working Group recalled that the Scientific Committee asked the Secretariat to track the performance of vessels in achieving tag overlap statistics thresholds in exploratory fisheries, noting that 60% was the minimum level specified in CM 41-01, but that vessels should aim to achieve at least 80%. Members whose vessels achieved between 60% and 80% tag overlap in a management area were contacted by the Secretariat and asked to report to WG-FSA to better understand factors causing a low tag overlap statistic (SC-CAMLR-2023, paragraph 2.137).

4.119 The Secretariat reported that during 2023/24 there were 23 instances (11 Members) of vessels that had a tag overlap statistic of between 60% and 80%. The Working Group noted that approximately 65% of vessels achieved or exceeded the 80% target and that approximately 10% were between 60% and 70%.

4.120 The Working Group welcomed the responses from some Members and noted that factors that may result in failure to achieve the 80% target include (i) the size of fish, with larger fish (notably in *D. mawsoni* fisheries) difficult to land in a condition suitable for tagging; (ii) fishing method, with multiple hooking in the trotline system reducing availability of fish in a condition suitable for tagging; (iii) the number of fish tagged, noting that the tag overlap statistic is only considered when 30 or more fish are tagged; and (iv) tagging rate, with the tag overlap statistic harder to achieve when tagging rates are high (5 per tonne compared to 1 per tonne) and (v) operational constraints on fishing activities (bycatch move on) (WG-FSA-11/50).

4.121 The Working Group further noted that it is important to consider the spatial coverage of tagging and the condition of fish being tagged as well as the overlap with the length distribution of captured fish.

4.122 The Working Group noted that there were three instances of the tag overlap statistic being just above 60%, which suggested that some vessels focus on achieving the compliance level rather than the target level.

4.123 The Working Group recommended that the Scientific Committee consider that the review process be adjusted for WG-FSA-2025, such that Members be requested to respond to any instances of tag overlap between 60% and 80% in advance of WG-FSA and that the Secretariat be tasked with collating and summarising the responses for consideration at the WG-FSA meeting.

4.124 The Working Group also recommended the Scientific Committee to request Members whose vessels failed to achieve the 80% target provide information on their tagging protocol or strategy (e.g. every n^{th} fish).

4.125 The Working Group recalled WG-FSA-2012/49 which compared condition of fish caught with Spanish and Trotline gear and indicated that there were enough fish in good condition across all size categories to achieve a high tag overlap statistic (WG-FSA-12/49).

Dissostichus mawsoni in Subarea 48.6

4.126 WG-FSA-IMAF-2024/24 summarised fishing operations and data collection in the exploratory longline fishery in Subarea 48.6 targeting Antarctic toothfish (*D. mawsoni*) between 2012/13 and 2023/24 conducted by Japan, Spain, and South Africa. During 2023/24, two vessels (Spain and Japan) participated in the fishery, but sea-ice limited fishing in Research Block 486_4. Catches to date in 2023/24 are 435.87 tonnes, against a catch limit of 518 tonnes, but one vessel returned to 486_2 in September to continue fishing.

4.127 WG-FSA-IMAF/20 summarised information from Pop-up Satellite Archival Tags (PSATs) deployed in Subarea 48.6 as part of the research program in support of the exploratory fishery. To date 12 out of 27 PSATs deployed by the Japanese vessel have transmitted data, whilst 8 out of 10 of the PSATs deployed by the Spanish have transmitted data. Most of the fish tagged in the southern Research Blocks moved north or north-west, although one moved east to Division 58.4.2. Further detailed analysis is required to examine movement patterns.

4.128 WG-FSA-IMAF-2024/17 reviewed the stock hypothesis for *D. mawsoni* in Subarea 48.6 as part of the research plan for the exploratory fishery in Subarea 48.6. Updated data and analysis suggest that adult migration is infrequent, and the stock structure of *D. mawsoni* in the Weddell Sea is primarily determined by the migration of juveniles.

4.129 WG-FSA-IMAF-2024/19 reviewed the by-catch of macrourids in research fisheries in Subarea 48.6 since 2012 with a view to developing species-specific models as proposed by WG-FSA-2023. Macrourids are the main by-catch in the fishery, and although by-catch includes four species (*Macrourus holotrachys*, *M. carinatus*, *M. caml* and *M. whitsoni*), previous analyses have grouped them as *Macrourus* spp. Given the different life history characteristics, it is desirable to consider the impacts of the fishery on each species. Whilst many are recorded as *Macrourus* spp., an analysis of fish identified to species level indicated that catches in the southern Research Blocks (486_4 and 486_5) were mostly *M. caml* and *M. whitsoni*, whilst *M. holoytachys* and *M. carinatus* were also caught in the northern research blocks. The authors noted that whilst the observer data contains useful information, it was not considered suitable to apply the modelling approach taken in the Ross Sea in WG-SAM-2023/14, which was designed to only distinguish between two species.

4.130 WG-FSA-IMAF-2024/21 updated the biological parameters of Antarctic toothfish in Subarea 48.6, including an experimental correction of age data. The Japanese age data was thought to overestimate age by approximately 10 years, when compared with age data from Spanish readings from the same Subarea and *D. mawsoni* in the Ross Sea. Over-estimated age data was identified by comparison with the Ross Sea or the Spanish von Bertalanffy growth curves and corrected using a linear relationship. Age-length keys and maturity ogives were updated using the corrected age data. The authors recommend the development of a consistent method to determine age of Antarctic toothfish at the next CCAMLR Age Determination Workshop and the development of criteria to identify false rings in the otoliths.

4.131 WG-FSA-IMAF-2024/18 reported on the development of a stock assessment model for *D. mawsoni* in Subarea 48.6, including moving from CASAL to Casal2 and testing sensitivity to changes in the age data. The study used 'corrected' Japanese estimates of age reported in WG-FSA-IMAF-2024/21. The maximum posterior density (MPD) results showed that the correction of age data caused an increase in the estimated biomass in all models (ranging from 39 334 to 55 726 tons) compared to the earlier model (Model 2021). The authors noted that some issues remain, such as fits of tag returns after 2017 and standardised CPUE fits.

4.132 The Working Group recognised the substantial body of work that had been undertaken in support of the research plan for the exploratory fishery in 48.6 and thanked the scientists for their efforts.

4.133 The Working Group welcomed the development of the Casal2 assessment model and noted the significant impact that the corrected age data had on estimates of biomass. The Working Group noted that re-reading of otoliths will be preferrable to correcting erroneous readings and that using a thicker section of the second otolith may improve the reliability of age estimates.

4.134 The Working Group noted the importance of age data in assessments and supported the recommendation that consistent methods be developed to train and calibrate readers when determining the age of Antarctic toothfish at the next ageing workshop. The Working Group further noted the importance of maturity data and the maturity ogive produced with these data in the assessment model, and suggest that Members improve the maturity ogive with the inclusion of more data that do not rely solely on macroscopic staging.

4.135 The Working Group welcomed the review of macrourid data and recognised the importance of identification to the species level. The Working Group noted some anomalies in the historical data but recognised that recent improvements in identification guides had enabled observers to better distinguish between the species.

4.136 WG-FSA-IMAF-2024/23 presented a revised new 4-year research plan for the exploratory fishery for Antarctic toothfish in Subarea 48.6 (under CM 21-02, paragraph 6(iii)), taking account of comments from WG-SAM-2024 (paragraph 7.4). The spatial design of the plan is unchanged from the previous version, with four research blocks. South Africa will contribute to laboratory and analytical work only, whilst the Republic of Korea will join Spain and Japan in the exploratory fishery. Revisions to the plan include increased sampling of by-catch, inclusion of particle tracking modelling under Objective 2 and clarifications in respect of the design and analysis of the research fishing.

4.137 Dr Kasatkina noted that multiple gear types should not be used for research proposals submitted under CM 21-02 paragraph 6(iii), as research plans should be reported in accordance with the format of Conservation Measure 24-01, Annex 24-01/A, format 2 which refers to standardised gear.

4.138 The other participants of the Working Group noted that the use of standardised gear types is not a requirement for research proposals submitted under CM 21-02 paragraph 6(iii).

4.139 The Working Group noted there remain uncertainties in relation to the connectivity between Subarea 48.6 and Subarea 48.4, which may warrant further investigation. The Working Group further noted that combining particle tracking modelling with otolith chemistry and genetics could enhance Objective 2 of the research plan.

4.140 The Working Group reviewed and evaluated the revised research plan outlined in WG-FSA-IMAF-2024/23 against the agreed criteria outlined in WG-FSA-2019/55 (see Table 9).

Management advice

4.141 The Working Group recommended continuing the research fishing in Subarea 48.6 according to the research proposal in WG-FSA-IMAF-2024/23.

4.142 The Working Group recommended that the catch limits for Subarea 48.6 be based on the trend analysis as shown in Table 8.

Dissostichus mawsoni in Divisions 58.4.1 and 58.4.2

4.143 WG-FSA-2024/26 presented a report on exploratory fishing activities undertaken by Australia, France, Japan, the Republic of Korea, and Spain in Divisions 58.4.1 and 58.4.2 between the 2011/12 and 2022/24 fishing seasons, noting the achievement of the milestones detailed in the research objectives.

4.144 The Working Group welcomed the report and congratulated the Members involved for the large body of work presented. The Working Group noted that it is important to resume data collection in Division 58.4.1 and to continue with it in Division 58.4.2.

4.145 WG-FSA-IMAF-2024/55 presented an update of the integrated stock assessment for *D. mawsoni* in Divisions 58.4.1 and 58.4.2. Compared to the previous assessment (WG-FSA-2022/34), this model included more tag-recapture data from Division 58.4.2, new ageing data from the 2022 and 2023 fishing seasons, and an updated estimation of region-specific growth parameters. The assessment model indicated that *D. mawsoni* stock in Divisions 58.4.1 and 58.4.2 is unlikely to be depleted by the current low level of fishing mortality. The model also highlighted the impact of no fishing in Division 58.4.1 since 2018. The authors strongly recommend that exploratory fishing under the new research plan resume in Division 58.4.1 such that tagging and data collection can occur beyond the currently limited areas in Division 58.4.2 to improve data availability for the stock assessment model and allow it to be used for management advice on catch limits in the future.

4.146 The Working Group noted the high uncertainty in the estimation of historical IUU catch and recommended that this model should be developed into a sex-based model in the future. The Working Group also noted that ageing of tagged toothfish that have shown long distance movements would help understand such movements better.

4.147 WG-FSA-IMAF-2024/25 Rev. 1 presented a multi-Member proposal for continuing research in the *D. mawsoni* exploratory fishery in East Antarctica (Divisions 58.4.1 and 58.4.2) from 2022/23 to 2025/26, including the research objectives, methods, and milestones in accordance with CM 21-02 requirements.

4.148 The Working Group welcomed the paper and commended the clarity of the information presented. It noted the research plan in WG-SAM-2022/04 for Division 58.4.2 was agreed in 2022 and therefore needs to be evaluated again by WG-FSA-IMAF-2024.

4.149 Dr Kasatkina noted that multiple gear types should not be used for research proposals submitted under CM 21-02, paragraph 6(iii), as research plans should be reported in accordance with Conservation Measure 24-01, Annex 24-01/A, format 2, which refers to standardised gear. She pointed out that there are no provisions in the rules of procedure of the Scientific Committee and the Commission for partial implementation of CCAMLR Conservation Measures.

4.150 The other participants of the Working Group noted that the use of standardised gear types is not a requirement for research proposals submitted under CM 21-02 paragraph 6(iii).

Management advice

4.151 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 8.

4.152 The Working Group recommended that the research proposal as detailed in WG-FSA-IMAF-2024/25 Rev. 1 proceed for Division 58.4.2 and that a comparison of gear types using a depth-stratified, random sampling design, using two gear types in each research block be conducted in Division 58.4.1.

Dissostichus mawsoni in Subarea 88.2

4.153 CCAMLR-43/18 presented an issue involving conflicting text within CM 41-01, Annex B, CM 41-09 and CM 41-10 by the inclusion of a cross reference to a requirement within CM 41-10 and CM 41-01, Annex B. A revision to CM 41-01, Annex B and CM 41-10 was suggested as a solution.

4.154 The Working Group thanked the Secretariat for proposing this revision and noted that the proposed revision should be discussed by the Commission.

4.155 WG-FSA-IMAF-2024/P03 presented the results of the analysis of otolith chemistry of Antarctic toothfish from three areas along the ice shelf of the Dotson–Getz Trough (Subarea 88.2) using both hydrological and fishery survey data in the Amundsen Sea polynya to better understand fish movement in this polynya. This study first revealed the westward ontogenetic movement of toothfish along the ice shelf in the Amundsen Sea polynya, which was consistent with the hypothesis proposed in Parker et al. (2019) and SC-CAMLR-39/BG/33. This study highlighted the importance of local hydrography to life history processes of *D. mawsoni,* therefore influencing the stock structure in the Southern Ocean. The authors recommended that regional or circumpolar studies should consider the effect of local or regional hydrography on the connectivity of marine species in the CAMLR Convention Area. The authors encouraged

Members to collect hydrographical data such as through calibrated CTD deployments during fishing operations.

4.156 The Working Group welcomed this work and encouraged authors to conduct further analysis by identifying the ages of the sampled otoliths. The Working Group noted this work was consistent with the stock hypothesis in this region and suggested the authors continue to test the stock connectivity between regions or Subareas through this approach. The Working Group further noted the value of collecting hydrographical data during fishing operations.

4.157 The Working Group suggested participants collaborate in collecting data and conducting analyses by pooling metadata that includes fish size, collected otolith, chemistry data, and spatial distributions. This would help enhance the studies of toothfish biology and ecology among Members and improve the understanding of toothfish in the Convention Area. The Working Group noted Members could request the metadata related to catch and otolith collection through the Secretariat.

4.158 WG-FSA-IMAF-2024/73 presented the preliminary analysis of two years of structured fishing in the Amundsen Sea region (SSRUs 882C-H) to 2023/24. The analysis showed that the uneven distribution of fishing effort on the seamounts in the north of this region (included within SSRU882H) has impacted the tagging program and limited tag recaptures. Two years of structured fishing has increased the number of seamounts where tagged fish were released, with an increase of one seamount in 2023 and three more in 2024. Additionally, the number of seamounts with available tags increased by one in 2024.

4.159 The Working Group recommended that the structured fishing along with the delayed start of the season in 882H continue, as is currently required by CM 41-10 (2022).

4.160 The Working Group noted that the proposed Age Determination Workshop (Appendix D) would be an opportunity for Members to proceed with age reading of historical otoliths from this Subarea, as these data are needed should an integrated stock assessment be developed for the region. Dr Chung (Republic of Korea) noted Korea's plan to start age reading for *D. mawsoni* collected in the Amundsen Sea.

Research plans targeting toothfish notified under CM 24-01

Dissostichus mawsoni in Subarea 88.1

4.161 WG-FSA-IMAF-2024/65 presented the results of the Ross Sea shelf survey, which contributes to the toothfish stock assessment. The survey encountered challenges during its thirteenth iteration in 2024. Due to an extended commercial fishing season, requiring the vessel to return to port to refuel, only 12 stations in the core strata, and all 10 stations in the special stratum, could be completed before the area froze over. To avoid this in future, the survey team recommends prioritising core areas, where logistically feasible, to ensure vital data collection. Additionally, a Vulnerable Marine Ecosystem (VME) trigger as per CM 22-07 occurred at McMurdo Sound. Further investigation of the VME is recommended, with suggestions for using underwater cameras to study species composition.

4.162 The Working Group welcomed the results, noting the importance of the Ross Sea shelf survey for the Ross Sea toothfish stock assessment. It noted that the model used to investigate

CPUE variations with seasons may benefit from the inclusion of more variables, such as sea ice coverage, coupled with day of season, and longitude. It noted that work was presented to WG-EMM regarding the VME trigger on three of five line segments in McMurdo Sound and the advice of WG-EMM-2024 regarding VME for research surveys (WG-EMM-2024 paragraphs 7.7 – 7.11). The Working Group also recalled that priority should be given to completing the core strata first in future years (WG-EMM-2024, paragraph 7.9).

4.163 WG-FSA-IMAF-2024/72 presented a notification for the continuation of the Ross Sea shelf survey (RSSS). The RSSS, conducted annually since 2012, follows a revised three-year proposal (2023 – 2025).

4.164 The Working Group noted that the RSSS has a catch limit as agreed in SC-CAMLR-41 (SC-CAMLR-41, paragraph 3.138) for 2024/25 of 99 tonnes (including the core strata and the Terra Nova Bay stratum). The research plan was assessed as per the criteria outlined in the table provided in WG-FSA-2019/55.

4.165 The Working Group noted that Dr C. Jones (USA) participated in the 2024 survey and that Dr M. Mori (Japan) would be participating in the 2025 survey and highlighted the long history of collaboration with international scientists in the RSSS.

Management advice

4.166 The Working Group recommended the research outlined in WG-FSA-IMAF-2024/72 for the 2024/25 season proceed, with a catch limit set at 99 tonnes.

4.167 WG-FSA-IMAF-2024/38 presented an analysis of the diet of Antarctic toothfish (*Dissostichus mawsoni*) in the Ross Sea during the 2022/2023 austral summer. Based on 70 stomach samples from the 2022/23 RSSS, all individuals on the continental shelf had prey in their stomachs, while over half of those on the slope had empty stomachs. Fish, particularly Nototheniidae (dominated by *Trematomus* spp.), were the main prey on the shelf. On the slope, *M. caml* was the predominant prey. These findings suggest spatial variability in the diet of *D. mawsoni*, linked to prey availability in different areas.

4.168 The Working Group welcomed this report that contributes to knowledge on diet of Antarctic toothfish. It noted that genetic analysis could help better identify prey composition, even if stomach contents are digested. The level of digestion was noted as a useful indicator of how long the prey has been in the stomach. The Working Group also highlighted that diet composition can inform biodiversity in the region.

Dissostichus mawsoni in Subarea 88.3

4.169 WG-FSA-IMAF-2024/42 presented a study on diet composition and feeding strategy of Antarctic toothfish in Area 88 from the exploratory longline fishery in 2024 by the Republic of Korea. The authors studied the diet of *D. mawsoni* in CCAMLR Subarea 88.1, SSRUs 882A and 882B, and Subarea 88.3. Based on stomach content analysis of 561 specimens, *D. mawsoni* is a piscivorous predator. In Subareas 88.1 and 88.2, *Macrourus* species dominated the diet, while in Subarea 88.3, *Channichthyidae* species were the primary prey. Molluscs were the second major prey group, with small amounts of crustaceans and stones also consumed. *D. mawsoni* is an opportunistic predator with a narrow niche and a trophic level of around 4.25.

4.170 WG-FSA-IMAF-2024/43 presented a study on the difference in diet of Antarctic toothfish between Area 88 and Subarea 58.4 using metabarcoding analysis. It examined geographical variations in diet between areas based on 2 192 stomach samples collected from 2017 – 2023. *D. mawsoni* mainly preys on fish, with regional differences in prey composition with Macrourus species dominated, though molluscs were more common in Subareas 88.1 and 88.3. Depth significantly influenced prey composition, with more uniform diets in slope areas and greater variability on shelves. These findings highlight the ecological importance of geographical factors and suggest future research should focus on the effects of climate change and fishing on this species and the Antarctic food web.

4.171 The Working Group welcomed these studies and noted their contribution to knowledge of *D. mawsoni* diet and biodiversity of the region. It noted that such studies may benefit from the inclusion of year effect to assess temporal variations and investigate the potential effects of environmental conditions (e.g., climate change) on prey distribution. The Working Group suggested that it may be valuable to investigate a potential diet shift between small and larger fish in relation to depth.

4.172 The Working Group noted that diet studies provide an opportunity to identify shifts in prey composition over time, which would be beneficial in highlighting potential shifts due to climate change. The Working Group further noted that recent work has been published on effective sample size estimation for diet studies to detect changes and recommended Members explore this for future studies. The Working Group encouraged the authors of WG-FSA-IMAF-2024/42, WG-FSA-IMAF-2024/43 and WG-FSA-IMAF-2024/38 to contribute their data to the Scientific Committee on Antarctic Research (SCAR) Southern Ocean diet and energetics database (SO-Diet) to enhance collaboration.

4.173 WG-FSA-IMAF-2024/54 presented a study on population genetic structure of Antarctic toothfish, *D mawsoni* from Areas 58 and 88 using microsatellites and Single Nucleotide Polymorphisms (SNPs). Results showed higher genetic diversity in populations from the Ross Sea (Subarea 88.1) compared to the Amundsen-Bellingshausen Sea (Subareas 88.2 and 88.3) and East Antarctica (Area 58). While population structure analysis suggests a shared gene pool due to high gene flow during the larval phase, weak but significant differentiation was detected between some population pairs.

4.174 The Working Group noted this work aligns with the results of previous studies in these regions. It noted that the dynamics of sea ice and local hydrography may play an important role on the early stages of toothfish in these regions and existing studies in national programs are underway.

4.175 WG-FSA-IMAF-2024/62 presented analyses of spatial distribution, stock structure, and biological characteristics of Antarctic toothfish, *D. mawsoni*, in Subarea 88.3. Antarctic toothfish were caught at depths of 550 to 2000 m in Subarea 88.3, with size distributions and catch rates varying by depth and location. Bimodal size distributions indicate the presence of both juveniles and adults. Females grow larger than males, and maturity is reached at around 125 – 135 cm and 12 – 18 years of age. The central slope is identified as a critical habitat. Further research is needed on stock structure, environmental influences, and by-catch species like grenadiers to support sustainable management and stock assessments.

4.176 The Working Group welcomed the paper. It suggested that the authors look at length frequencies by year and areas to investigate potential progressions of cohorts, as well as Research Block tagging rates. It also suggested to analyse the variations of the biological parameters among the years. The Working Group also noted that the low tag recaptures may be due to the low captures of intermediate length fish, which are poorly represented in catches.

4.177 WG-FSA-IMAF-2024/59 evaluated the use of Scientific Electronic Monitoring (SEM) systems on toothfish longline vessels in the CAMLR Convention Area. SEM systems aim to improve data collection and reduce the burden on Scientific Observers working in challenging conditions. Trials on the FV Greenstar and FV Marigolds showed that SEM effectively automated data collection and provided valuable insights, but there were challenges in species identification and data accuracy due to technological and environmental limitations. While SEM systems support human observers, further technological improvements, such as machine learning and optimised camera placement, are needed.

4.178 The Working Group noted that a number of trials have taken place in CCAMLR and outside of the Convention Area on toothfish vessels. It further noted that discussions about criteria for SEM trials would be beneficial and encouraged further work on e-monitoring. The Working Group noted that SEM presents many opportunities for enhanced data collection, including detailed by-catch information.

4.179 The Working Group recommended the development of an electronic monitoring workplan as part of the Scientific Committee workplan.

4.180 WG-FSA-IMAF-2024/52 presented a new research plan for Antarctic toothfish (*Dissostichus mawsoni*) under CM 24-01, paragraph 3 in Subarea 88.3 by the Republic of Korea and Ukraine from 2024/25 to 2026/27. Compared to the previous research plan, the new research plan proposed the removal of Research Blocks 5, 7, 8, 9, and 10 and the addition of two new Research Blocks (11 and 12, Table 10) with 30 research hauls planned in each (Table 11 and Figure1).

4.181 The Working Group noted this research plan had been reviewed by WG-SAM (WG-SAM-2024, paragraphs 7.7 – 7.11). The Working Group recommended that the proponents include the Research Blocks on the sea ice repeatability map in future iterations of the research plan. The research plan was evaluated against the criteria outlined in Table 9.

Management advice

4.182 The Working Group recommended the research outlined in WG-FSA-IMAF-2024/52 for the 2024/25 season proceed.

4.183 The Working Group recommended that the catch limits for Subarea 88.3 be based on the trend analysis as shown in Table 8. With the addition of two new effort limited Research Blocks being conducted with 30 sets in each and a catch limit of 23 tonnes in each of Research Block 11, and 12.

Other areas outside of national jurisdiction in area 58

4.184 No new information was available on the state of fish stocks in Divisions 58.4.3a. 58.4.3b, 58.4.4a, 58.5.1 and 58.5.2, or Subareas 58.6 and 58.7 outside areas of national jurisdiction. The Working Group, therefore, recommended that the prohibition of directed fishing for *D. eleginoides*, described in CM 32-02, CM 41-06 and CM 41-07 remain in force in 2024/25.

Non-target catch and incidental mortality associated with fishing

5.1 WG-FSA-IMAF-2024/74 presented the SCAR Action Group on Southern Ocean fish (SCARFISH), which among other objectives, will facilitate communication between CCAMLR and the wider SCAR Southern Ocean fish research community. The paper indicated that SCARFISH would be tasked to identify knowledge gaps to improve CCAMLR ecosystem-based fisheries management, to synthesise CCAMLR fish-related research needs to solicit answers from the wider Southern Ocean fish research community, and to broaden the diversity of researchers in Southern Ocean fish research. The paper identified climate change impacts, omics, non-exploited and by-caught species, trophic inter-relationships and species essential habitats as knowledge gaps that would benefit from SCARFISH action. The paper also presented Terms of Reference and a list of the SCARFISH group members.

5.2 The Working Group welcomed the initiative and highlighted the wide range of topics requiring attention. It noted SCARFISH would benefit from conducting an assessment of research priorities to pursue (e.g. a centralisation of toothfish diet data to examine distribution of prey, and the impact of microplastics on Southern Ocean fishes) in order to identify key areas for action. The Working Group further noted that not all continents were represented among the executive committee and consultative members, and encouraged the Working Group participants to step forward and join SCARFISH.

5.3 The Working Group identified seven overarching research themes to which SCARFISH could contribute and progress to help with CCAMLR Scientific Committee work (Table 12). It also identified priority elements to help organise a future work plan that will be discussed within SCARFISH. The drivers behind these themes and elements included the need to understand the impacts of climate change on Southern Ocean fish communities, enhance knowledge of by-catch species life histories, support the advancement of fisheries stock assessments in the face of climate change, and improve communication beyond CCAMLR to a broader audience. In addition, the Working Group recognised that some of the overarching themes are potentially already considered by SCAR action or expert groups and that SCARFISH could help liaise with these groups to assist CCAMLR with its priorities.

Fish by-catch (macrourids, skates, other)

5.4 WG-FSA-IMAF-2024/37 presented an analysis of by-catch species length and weight data, spatial distribution and CPUE collected from Subarea 58.7 (Prince Edward and Marion Islands), and Area 51 from 1996 to 2023. It indicated that by-catch represented less than 20% of the catch by weight, and that length frequency remained consistent during the whole period examined. The paper also indicated that this study is the first conducted in Subarea 58.7 and that it will contribute towards formulating an updated data collection plan for the fishery.

5.5 The Working Group welcomed this preliminary work, noting that it also represented the first report on by-catch in Subarea 58.7. It further noted that in 2023, macrourid by-catch data collection had improved to include the sex determination of fish, revealing that *M. holytrachys* females predominated. The Working Group noted the potential impact this could have on the stock status of this species and encouraged the continuation of this work.

5.6 WG-FSA-IMAF-2024/P02 presented an analysis of trophic relationship of two ectoparasites of *C. gunnari* from the South Orkney Islands, the copepod *Eubrachiella antarctica* and the leech *Trulliobdella capitis*, using stable isotopes. The paper showed *E. antarctica* infestation site on hosts occurred on the fin. Both *E. antarctica* and *T. capitis* were shown to have a higher prevalence in the South Orkneys than in other locations in the Southern Ocean, and therefore could potentially be used as a biomarker of Southern Ocean populations. It further showed that *E. antarctica* predominantly feeds on its host, and therefore can be considered a parasite, whereas *T. capitis* is more likely a symbiont of *C. gunnari*. The paper considered stable isotopes as useful tools for better understanding the parasite mediated nutrient flow in the ecosystem and food-webs complexity and stability.

5.7 The Working Group welcomed the paper and noted the importance of parasites in informing food web dynamics in the Convention Area. The Working Group further noted parasites could be considered as biotags to be used in conjunction with otolith chemistry to analyse *C. gunnari* stock structure.

5.8 WG-FSA-IMAF-2024/P04 presented a method to distinguish otoliths bearing anomalies so as to avoid introducing bias in further otolith-based analyses such as microchemistry. The paper described a knowledge distillation (KD) anomaly detection model where a pre-trained extensive teacher neural network supervises a smaller student network. The dataset used comprised 852 *Electrona carlsbergi* otolith images collected from the Chinese krill fishery in the Scotia Sea. Two KD models were compared, showing similar results of 99% correct classification of normal images, and 96% correct classification of abnormal images. The paper further indicated that the KD was performing well with most anomaly types but was unable to identify colour anomalies with sufficient accuracy. The authors recommend Members collect and study otoliths from by-catch species to improve anomaly detection and reduce biases in otolith-based studies.

5.9 The Working Group welcomed the paper and noted the otolith database used in the study could be made available to CCAMLR. It also noted that the KD model applicability could be extended to species other than *Electrona carlsbergi* and to other image types such as colour patterns of fish, and could be used to facilitate electronic monitoring image data analyses.

By-catch management in krill fisheries

5.10 WG-FSA-IMAF-2024/05 presented an updated summary of fish by-catch in the krill fishery based on recommendations by WG-FSA-2023 (paragraph 5.10) reporting on fish by-catch data collected by SISO observers and vessel crew in the krill fishery. The paper presented a draft extrapolation method — consistent with that conducted for IMAF events

(WG-IMAF-2023/03 Rev. 1) and including estimates of uncertainty generated by bootstrapping records (see also WG-SAM-2024/11). Noting the accumulation of analyses in this annual report, the Secretariat requested feedback regarding its contents for future iterations, as well as the contents of the Fishery Report (https://fishdocs.ccamlr.org/FishRep_48_KRI_2023.pdf).

5.11 The Working Group welcomed the analysis and noted the sporadic and localised nature of large by-catch events and the importance of increased observation effort, where diverse factors including lower effort contribute to higher uncertainty in extrapolated values.

5.12 The Working Group noted that the method used for upscaling SISO by-catch weights uses the total catch, which is the sum of krill catch and crew-reported by-catch. Recalling the crew's limited ability to detect small organisms (WG-FSA-2022, paragraph 6.7), the Working Group agreed on the importance of using an alternative scaling method that is independent of crew-reported by-catch. The Working Group tasked the Secretariat with conducting an analysis of total by-catch, utilising only observer by-catch data and vessel-reported krill catch data, and with presenting results at WG-FSA-2025.

5.13 The Working Group considered whether any of the contents that have become redundant could be removed from future reports and discussed whether any of the current contents could be made public in the Fishery Report. The Working Group noted the benefit of making some of the contents available in the Fishery Report because it is of public interest and useful to Members.

5.14 The Working Group noted that the scaling method followed standard methodology, as applied in other analyses requiring scaling to account for total catch (e.g., upscaled length frequency distributions), but could not agree on which results of the extrapolation method could be made public as part of the Fishery Report. While some participants requested that the table of per-taxon extrapolated weights be made public, others argued that issues pertaining to uncertainty in both weights and species identification precluded publication.

5.15 The Working Group recommended that the Scientific Committee consider WG-FSA-IMAF-2024/05. Particularly the methods of extrapolation used (see paragraphs 5.11 – 5.12) and the uncertainties in subsequent estimates of total extrapolated fish by-catch in Table 4 of WG-FSA-IMAF-2024/05.

5.16 The Working Group noted that modelling approaches such as GAMs will allow formal evaluation of by-catch while accounting for factors such as location, month, or vessels. It further noted that future analyses would benefit from power analyses to help better understand appropriate sampling efforts. The Working Group noted that such an approach will be used to analyse IMAF data (WG-SAM-2024, paragraph 9.6), and looked forward to these results.

5.17 The Working Group noted that whilst the vessel crew inspects the entire catch for fish bycatch, small fish (< 10 cm in length) would be difficult to detect. The Working Group also noted the lack of information on how by-catch sampling is conducted by the vessel crew and how that relates to observers by-catch sampling, and this limits the utility of the data. The Working Group therefore developed a questionnaire (Appendix 5.2.1) to be sent to vessel operators to better understand the current by-catch sampling process and to improve by-catch sampling instructions for vessel crews.

5.18 The Working Group recommended the Scientific Committee task the Secretariat with circulating the questionnaire (Appendix 5.2.1) and reporting the results back to WG-FSA-2025.

5.19 WG-FSA-IMAF-2024/13 presented preliminary results of a project investigating taxonomic uncertainties of fish by-catch reported between 2022 and 2024 and utilising the extensive biological archive at British Antarctic Survey (BAS). This was further coupled with a systematic search of the literature on timings of larval and juvenile fish in the water column to bring together molecular and ecological information to develop an enhanced species identification guide to help observers identify fish by-catch.

5.20 The Working Group welcomed the work and noted its importance to improving the accuracy of the identification of early life history stages of fish species. The Working Group also noted the benefit of working as a community to advance the work and encouraged participants to exchange information and samples as appropriate.

5.21 WG-FSA-IMAF-2024/P01 presented an analysis of by-catch data collected by SISO observers during the 2010-2020 fishing seasons in the Antarctic krill fishery. Except in 2010 (2.2%), the by-catch ratio was stable and ranged from 0.1% to 0.3% of the catch. Fish dominated the by-catch, followed by tunicates and crustaceans. The paper reported that the observer coverage was high, and by-catch levels were generally low across gear types. The paper stated that maintaining high observer coverage will be important for detecting impacts of a warming climate.

5.22 The Working Group noted that while by-catch rate may be lower compared to other pelagic trawl fisheries, considering the size and the expanding nature of the fishery, the actual amount of fish by-catch was substantial. Given that the status of a number of fish populations are low in the region, and considering the potential impacts of climate change, even the current level of fish by-catch warranted caution. The Working Group also noted that further analysis of seasonal aspects would help understand the spatial and temporal patterns and the nature of by-catch.

5.23 The Working Group noted that the estimated by-catch in WG-FSA-IMAF-2024/P01 was lower when compared to by-catch reported in WG-FSA-IMAF-2024/05. The Secretariat clarified that the reason for this discrepancy was likely that the data analysis in this paper was undertaken before the Secretariat undertook data corrections as outlined in WG-FSA-2023/73 and now routinely performed (Annex 1 in WG-FSA-IMAF-2024/05).

VME management and habitants of particular concern

5.24 WG-FSA-IMAF-2024/45 presented the spatial and temporal distribution of VME by-catch within the Prince Edward and Marion Island region (Subarea 58.7) using data from 2009 to 2023. The analysis focussed on identifying trends in VME taxa that may require further investigation. The authors suggest modelling different thresholds related to the sensitivity of longline catch while taking account of the specific life histories of the taxa, which ensures that smaller VME taxa receive appropriate consideration as the next step. Additionally, data capture workflows will also be refined to ensure species identifications are cross-validated by taxonomists.

5.25 The Working Group welcomed this important first report of the analysis of the VME species in Prince Edward and Marion Islands region. The Working Group noted spatial shift in by-catch locations and considered this shift could be one of the reasons for the decline in VME taxa by-catch weight since 2015. The Working Group looked forward to the progress of further analysis and future VME monitoring in the region into the future.

Incidental mortality associated with fishing (IMAF)

5.26 WG-FSA-IMAF-2024/10 presented a summary of incidental mortalities of seabirds and marine mammals associated with fishing during the 2024 fishing season, based on data reported by the vessels and SISO observers. In longline fisheries, 43 white-chinned petrel (*Procellaria aequinoctialis*) mortalities were recorded, along with six southern elephant seals (*Mirounga leonina*) and one minke whale (*Balaenoptera acutorostrata*), the first recorded mortality for this species in CCAMLR fisheries. In trawl fisheries, the cape petrel (*Daption capense*) was the most common seabird mortality, with three recorded incidents. In the krill fishery, two humpback whale (*Megaptera novaeangliae*) mortalities occurred, and one injured individual was reported as released alive. However, following CCAMLR-XXIII (paragraphs 10.30 and 10.31) the released whale was considered as a mortality event, as it was released with injuries likely to compromise its long-term survival.

5.27 The paper also presented per-cruise extrapolations of warp strikes in trawl and mortality in longline fisheries. In the longline fishery a total of 92 seabird mortalities was estimated. The per-cruise extrapolated warp strike estimates for traditional krill trawlers were 336 light strikes and zero heavy strikes, while continuous krill trawlers recorded 457 light strikes and 2 189 heavy strikes, up to 11 September 2024. The paper also presented total extrapolated IMAF events based on methods described in WG-SAM-2024/11.

5.28 The Working Group welcomed the information presented by the Secretariat and noted that significant work remains to understand the scale and spatial patterns of seabird and marine mammal interactions with fisheries, which is critical for informing effective mitigation strategies.

5.29 The Working Group discussed the high variability in the number of seabird warp strikes among vessels and the lack of standardised mitigation measures. It suggested that investigating the operational practices of vessels with various levels of strikes could provide valuable insights for informing future mitigation strategies.

5.30 Following WG-SAM discussions, the Working Group also considered the potential use of alternative extrapolation approaches (e.g. GAMs fitted under the assumption of zero-inflated data, see WG-SAM-2024 paragraphs 9.5 – 9.7) that could incorporate additional explanatory variables, such as weather conditions, activity category and time of day, to improve the estimates of total seabird warp strikes.

5.31 The Working Group further noted that there is a need for increased data collection to support the modelling of warp strikes and to improve understanding of incidental mortality events. It recalled that the purpose of conducting warp strike observations is two-fold: to assess total impacts on dependent species and assist to develop effective mitigation measures.

5.32 The Working Group acknowledged the workload and diverse tasks undertaken by observers on krill vessels and noted that either having two observers on board or other approaches would enhance data collection. The Working Group also noted the increase in the number of observers may not be an ideal solution for the warp strike observations. The Working Group further noted recent advances in machine learning methods for analysing electronic monitoring data, which could also enhance coverage of warp strike observations and data collection. Furthermore, the Working Group identified the need to determine which vessels in the krill fishery currently operate electronic monitoring systems (paragraph 4.142).

5.33 The Working Group noted that the failure to record the observer's warp strike observation period on one vessel prevented the extrapolation of seabird warp strike data for that vessel, highlighting the importance of documenting the duration of the observation period.

5.34 The Working Group noted that incidental mortality of elephant seals in longline fisheries has been a recurring issue in recent years. It suggested that a task be added to the Working Group workplan to summarise relevant information regarding this issue during the intersessional period, including a review of historical interaction and mortality data, along with additional information on abundance trends and foraging behaviour for populations affected.

Review of current and emerging incidental mortality issues in CCAMLR fisheries

5.35 WG-FSA-IMAF-2024/02 reported on the incidental capture of an adult male humpback whale (*Megaptera novaeangliae*) by the Chilean krill trawler *Antarctic Endeavour* in Subarea 48.2 on 1 February 2024. The whale, measuring approximately 15 m in length, was released alive from the net which took the crew about 40 minutes. Notably, the individual was oriented in the net with its head facing the opening. Although the whale had visible injuries and exhibited signs of lethargy after release, it was observed swimming and breathing. Two days earlier, on 30 January 2024, the observer noted a humpback whale interacting with the mouth of the net and pieces of epibionts from whale skin were found during by-catch sampling.

5.36 The Working Group thanked the authors for the transparency of the report and noted that this event marked the first recorded incidental capture of a whale in the krill fishery from a vessel using traditional trawl gear. The Working Group emphasised the need for more detailed pre- and post- incident observations to better understand how such incidents occur, noting that in this case, the whale must have breached the seal excluder device (SED). Additionally, the Working Group suggested that photos of identifying features, such as the underside of the humpback whale fluke, could be submitted to public identification databases, such as 'Happywhale.com', to potentially track post-release outcomes.

5.37 The Working Group noted the importance of understanding the design and implementation of SEDs and cetacean excluder devices (CEDs) outlined in fisheries notifications (SC-CAMLR-42, paragraph 3.28). The Working Group also discussed the potential benefits of developing a single marine mammal excluder device (MMED) to prevent both seals and cetaceans from being caught, thereby avoiding issues associated with having separate devices that may interfere with each other.

5.38 The Working Group noted the importance of the detection of whale epibionts and the observed interaction with the mouth of the net, leading up to the event as early indicators of whale interactions with trawl nets, which may result in incidental mortality.

5.39 The Working Group noted the health and safety risks to the crew when handling and releasing large marine mammals caught in trawl and nets. It suggested that the development of guidelines and informational materials on responding to incidental capture of marine mammals would enable a safer and more effective handling and release on board vessels, as well as improved data collection. The Working Group identified resources available from other fisheries and recommended that Members engage with the 'IWC Collaboration' Discussion group to request support in the development of these materials. The Discussion group can be joined by request to the Secretariat.

5.40 WG-FSA-IMAF-2024/46 presented a report on the incidental capture of a minke whale (*Balaenoptera acutorostrata*) by a Korean toothfish longliner, *FV Blue Ocean*, in Subarea 88.1 on 8 January 2024. The deceased whale, measuring approximately 15 m in length, was discovered with its tail entangled in the buoy line when the vessel began hauling the trotline gear. The crew released the carcass by cutting the buoy line. In response to this incident, the authors proposed several measures for consideration to prevent or respond to similar events including:

(i) the development of procedures for handling unexpected interactions with marine mammals, along with regular training and drills for crew

(ii) improved observer training to ensure faster documentation and reporting of similar events

(iii) pre-operational planning to include analysis of whale migration routes to avoid high-risk areas

(iv) future improvements in gear design and the introduction of tools to safely disentangle marine mammals.

5.41 The Working Group noted that this event marked the first recorded incidental mortality of a minke whale in any CCAMLR fishery and sought clarification on the species identification. It noted that the whale was most likely an Antarctic minke whale (*Balaenoptera bonaerensis*), rather than a dwarf minke whale (*B. acutorostrata*), due to the overlap of Antarctic minke whale distribution in the location of the incident and the absence of white banding on the flipper, which is a characteristic of the dwarf minke whale.

5.42 The Working Group noted that although training and drills for quick response to whale entanglement could be beneficial, it required specialist equipment and training, as it is considered a high-risk activity. The Working Group recommended that the 'IWC Collaboration' Discussion Group be utilised to provide advice on this issue.

5.43 WG-FSA-IMAF-2024/66 presented an update on incidents and modifications to cetacean mitigation measures during the 2023/24 fishing season. The paper reports on the incidental capture of a juvenile humpback whale (*Megaptera novaeangliae*) by the Norwegian continuous krill trawler FV Antarctic Endurance in Subarea 48.2 on 27 January 2024. The deceased whale was discovered in the trawl net opening, in the gap between the CED and the bottom of the net while it was being hauled for maintenance. The crew released the carcass from the net, allowing it to drift away.

5.44 The paper also reports an incidental capture of a juvenile humpback whale by the continuous krill trawler FV Antarctic Sea in Subarea 48.2 on 17 May 2024. The deceased whale was discovered in front of the CED while the fishing gear was being hauled for inspection of the hose system. The carcass came free during the hauling process. Two days earlier, on 15 May, the vessel experienced irregular manoeuvrability, with unexplained tension on the port-side warps during turns. During this period the fishing depth ranged between 25 and 70 metres. Furthermore, whale blubber was recovered from the factory conveyor belt on the same day. The echosounder did not indicate the presence of any animals in the area. The two whale carcasses could not be recovered, so the collection of biological data was limited to visual observations.

5.45 The paper reports that adjustments to the design of the CED, outlined in SC-CAMLR-41, Appendix D, were modified to cover a small opening between the new CED position and the bottom of the net lining. The modified CED was fitted to the trawl nets onboard FV Saga Sea in December 2023 and the FV Antarctic Sea in January 2024. The modified CED was also installed on the trawl net of the FV Antarctic Endurance in January, immediately following the incident of whale mortality. All vessels continued to use the acoustic pinger deterrents from previous fishing seasons, as detailed in WG-IMAF-2022/01.

5.46 As with paper WG-FSA-IMAF-24/02, the Working Group further noted the importance of documenting early indicators of whale interactions such as the blubber found in the by-catch sampling, the unexplained tension on the warps and unusual behaviour of the net presented in the paper. The Working Group noted that attention given to recording these events could drive a directive of actions to reduce incidental mortalities. Furthermore, the authors noted that skin, blubber and whale parasites are found in the by-catch sampling infrequently and are documented in the observer reports, but these are not included in a database.

Reporting on net monitoring cable trial on continuous trawlers

5.47 WG-FSA-IMAF-2024/51 presented the report from 2023/24 trial of the net monitoring cable (NMC) mitigation measures. Three Norwegian flagged vessels were permitted a derogation from CM 25-03 along with other continuous trawl vessels provided they developed mitigation measures and underwent a series of trials to test their effectiveness in preventing or reducing their impact on bird populations (SC-CAMLR-38/18). Between June 2023 and March 2024, 8% of total trawling time was monitored across the three Norwegian vessels (FVs Antarctic Endurance, Antarctic Sea and Saga Sea) through a combination of deck and video observations. 120 strikes against the NMC were observed across the three vessels from June 2023 to March 2024, the majority involving cape petrels (*Daption capense*). 117 of these were on the Saga Sea, with 110 of which were recorded over a two-month period between 23 November 2023 and 24 January 2024. The authors noted that < 3% of the 13 183 observation periods (representing over 4 000 observer hours) showed any contact with seabirds and the stern trawler (Saga Sea) showed a higher incidence of strikes than the side beam trawlers (Antarctic Sea and Antarctic Endurance).

5.48 The Working Group thanked the authors for submitting a detailed paper and noted the importance of understanding the different in gear configurations and procedures used between the continuous trawlers. The Working Group further noted a contribution from authors of the paper that the Saga Sea had an increased number of seabirds strikes during a three-day period that the 'sock' was not deployed in 2021.

5.49 The Working Group reviewed Table 13 (presented during the meeting) which detailed the location of bird strikes on particular gear locations, as well as providing an estimate of strikes per unit effort. The Working Group noted that the Antarctic Sea and the Antarctic Endurance had low levels of birds strikes, however the Saga Sea had the most strikes, with most being recorded against the NMC between December 2023 and January 2024 in Subarea 48.2.

5.50 The Working Group reflected that the trial could not be considered completely successful as interaction rates in the Saga Sea, a stern trawler, were considerably higher than for the two side-beam trawl vessels.

5.51 The Working Group further noted that most of the strikes recorded on the NMC for the Saga Sea, and encouraged Norway to continue working to resolve implementation issues with the sock, and investigate alternative mitigation measures to prevent access by seabirds into the area surrounding the NMC.

5.52 WG-FSA-IMAF-2024/44 presented an update on Agreement on the Conservation of Albatrosses and Petrels (ACAP) activities and advice. In presenting the paper, Dr Favero noted that a working document presented to the ACAP Seabird Bycatch Working Group (SBWG) on Norwegian continuous trawl was well received and helped the SBWG to better understand the operational procedures of this fishery. The paper noted that insufficient evidence was provided to the SBWG to fully assess whether any of the proposed mitigation measures used on Norwegian trawl vessels could be adopted as ACAP best practice, but the SBWG noted that the approaches should be considered as 'under development', and that further work was encouraged.

5.53 The Working Group thanked ACAP for providing the update and noted the long history of collaboration between ACAP and CCAMLR for developing and refining seabird mitigation measures. The Working Group encouraged information on the mitigation measures used in NMC trials to be submitted to ACAP SBWG to support further advice.

5.54 WG-FSA-IMAF-2024/75 presented the report of the trials of mitigation measures undertaken by the Chinese vessel FV Shen Lan in 2022/2023. The continuous trawl method was using during the first period and traditional trawl method thereafter. The NMC was used during the continuous trawling period and a set of mitigation devices were deployed to minimize cable strikes. A total of 65.5 hours on-vessel bird-strike observations (video + deck), amounting to 7.8% of the overall fishing hours were carried out. No seabird strikes were observed either on the net monitoring cables (NMC), the trawl warps or mitigation devices. During the traditional trawling period, observation on seabird warp-strikes was conducted at least once daily following the standard warp strike observation protocols outlined in the SISO krill logbook instruction and no warp strikes were observed. An additional 50 hours of onshore observation by video footage replay was conducted and ten bird-strikes, five of which were on the NMC, four on the trawl warp and one on the mitigation device, were observed.

5.55 WG-FSA-IMAF-2024/57 presented the report of the second trial of mitigation measures in use on the FV Shen Lan during the 2023/24 fishing season. The continuous trawling system was used from 7 February to 17 May 2024 in Subareas 48.2 and 48.1, and the traditional trawl method was used from 11 July until the end of fishing operations. The NMC was used during continuous trawling, with 249.6 hours of on-vessel bird-strike observations being conducted, accounting for 11.8% of the total fishing hours, with 15 seabird strikes observed. During the traditional trawling period, observations on seabird warp strikes were conducted following the current standard warp strike observation protocols outlined in the SISO krill logbook instruction and eight seabird strikes were observed during this period.

5.56 The Working Group thanked the authors and noted the paper provided clear details on the operational procedures and the mitigation measures in place. The Working Group noted that both sides of the vessel were monitored simultaneously, due to the presence of two observers on board. No bird strikes were observed on deck during these observations, only after reviewing the video as reported in paper WG-FSA-IMAF-2024/75. The Working Group noted that observations both on deck and from video can provide valuable data, although some details may be visible from deck observations only.

5.57 WG-FSA-IMAF-2024/56 presented the report of the first trial of mitigation measures used on the Chinese krill fishing vessel F/V Fu Xing Hai during the 2023/24 fishing season. The NMC was deployed from the stern of the vessel, and a snatch block was used to keep the NMC close to the hull thus reducing its aerial extent. The trawl warp was deployed using a derrick at midship on each side of the vessel. Mitigation measures including a 'Netting sock' and coloured streamer lines were used, and coloured pennants were attached to additional ropes or wires used for securing the pumping hoses, trawl warps and derricks. Fishing were conducted in Subareas 48.2, 48.1 and 48.3 from 4 February to 20 August 2024. During the trial, a total of 356.7 hours on-vessel seabird strike observation were conducted, amounting to 12.1% of the 2945.9 hours total fishing time. From May to June, a total of 127.8 hours on-vessel observation were conducted, amounting to 17.5% of the 730.7 hours total active fishing time. A total of 47 seabird strikes, including 27 heavy strikes were observed with no obvious seabird mortalities resulting from the strikes. Most strikes occurred on the trawl warp with none on the net monitoring cable. The result suggests that the snatch block was highly effective for mitigating seabird strike on the NMC, and while other mitigation devices were also effective. The occurrence of seabird strikes was influenced by seabird abundance around the vessel and the natural light conditions, and the wind direction relative to the vessel. The authors suggested that the severity definition or classification of bird strike be reviewed to reflect the underlying cause of the seabird contact with the water.

5.58 The Working Group thanked the authors for the report noting the utility of the collection of information on environmental conditions, bird abundance around the vessel and details on the mitigation measures and the modification of some gear to minimise seabird interactions.

5.59 The Working Group reviewed Table 14 (presented during the meeting) to compare warp strike rates between all vessels that have participated in NMC mitigation trials, and noted that according to the table, slightly higher interaction rates are recorded from deck observations than from video observations, and in general a high level of strikes were observed on trawl warps, except for on the Saga Sea which had a higher level of NMC strikes. The Working Group noted concern about the level of bird strike on NMC and warps on the Saga Sea (Table 2 and WG-FSA-IMAF-2024/10 Table 3) and urged the vessel operators to enhance the effectiveness of the mitigation around the NMC and warps on the Saga Sea.

5.60 The Working Group noted the benefit of augmenting deck observations with video data in order to support the observers' workload, but also that it is important to keep gathering information via deck observations. The Working Group discussed the observer coverage and recalled a minimum of 5% coverage was endorsed by Commission 2023 (CCAMLR-43 paragraph 4.111 & 4.112) for all CCAMLR trawlers, not only the ones with the NMC trial under CM 25-03 derogation, noting this coverage can be achieved with a combination of on deck and video observations, and that multiple observers on a vessel may be able to better manage this task.

5.61 The Working Group discussed the mitigation trial process and noted that there were no defined metrics for an acceptable number of strikes, or a strike rate, but there was general agreement that the vessels should show that mitigation measures in place are effective in demonstrating a low level of seabird interactions before any trial period ceases.

5.62 The Working Group reflected that the development of mitigation measures in CCAMLR longline fisheries resulted in detailed specifications of mitigation devices that could be implemented on vessels, and that it was desirable to develop similar specifications of suitable mitigation measures which account for different gear configurations and vessel designs in trawl fisheries. Until such specification were developed the Working Group considered that any vessel using a NMC was required to undergo a trial specified in CM 25-03 Annex A.

5.63 The Working Group requested the Scientific Committee consider developing specific text for inclusion in CM 25-03 to differentiate the requirement for the Antarctic Endurance and Antarctic Sea vs other vessels participating in the NMC seabird mitigation trial, as the Working Group considered that these vessels had demonstrated a low level of strike activity. However as warp strike observations onboard trawling vessels are required to increase to 5% of total fishing time from the 2024/2025 season to improve the precision of warp strike rate estimates (CCAMLR-42 paragraph 4.111), it is not appropriate to reduce the observation rate below that agreed by Commission.

5.64 The Working Group noted that observations of warp strikes via video cameras systems are an integral part of the observations undertaken to meet the bird strike observation requirements of the NMC seabird mitigation trial, but currently data from video observations of warp strikes are not submitted to the Secretariat, and therefore it is necessary that vessels participating in the trial provide reports on the trial to WG-IMAF. The Working Group tasked the Secretariat with adapting the warp strike data collection worksheet to allow for inclusion of these data, and instructions to ensure that video observations cover the entire aerial extent of the warp and NMC cable. This approach may enable the derogation in CM25-03 to not require trial reporting to WG-IMAF for vessels that have been part of the trial for several years and have demonstrated low rates of bird strikes (i.e., Antarctic Sea and Antarctic Endurance).

Warp strike classification

5.65 The Working Group discussed the definition of 'light' and 'heavy' strikes and noted that determining what constitutes a heavy strike can be challenging in some circumstances. The Working Group noted that the heavy strike definition is consistent with that provided by ACAP (WG-IMAF-2023/04). These areused as a proxy for the risk of mortality and not included in the mortality figures provided in WG-FSA-IMAF-2024/10 by the Secretariat, which only count the incidental mortalities with the fishing gear brought onboard the vessel.

5.66 The Working Group noted that the current IMAF data worksheet does not allow for the inclusion of mortalities observed during warp strike observations from interactions with warp or NMCs and tasked the Secretariat with developing modifications to the IMAF worksheet to enable these data to be collected in the 2026 season onwards.

Mitigation methods for marine mammals

5.67 WG-FSA-IMAF-2024/04 presented a research project aiming to determine potential causal factors that may have contributed to the whale mortalities observed since 2020 in CCAMLR krill fisheries. The study aims to:

(i) Quantify the rate and behavioural nature of interactions between baleen whales and CEDs, including the mouth of the trawl) across gear types

(ii) Characterise species and size (age) classes of individuals interacting with the CED relative to individuals in close proximity to trawlers using different trawling methods

(iii) Determine the degree and significance of any causal or correlative relationships between CED interaction rates with trawling method, season, baleen whale abundances in proximity to trawlers, acoustically-derived estimates of krill biomass and fishing effort.

5.68 The Working Group thanked the authors for sharing the research proposal and recognised the value of the information to be collected. The Working Group also noted the earlier conversations about this project between the authors and experts from the International Whaling Commission '(IWC) Collaboration' Discussion group. The IWC Collaboration extended an offer for future advice in the design, data collection and analysis to maximise the usability of the outcomes of this project and encouraged interested parties to join this group by contacting the Secretariat, to provide feedback through this forum.

Specification of marine mammal mitigation devices

5.69 The Working Group considered the specification of marine mammal mitigation devices, and noted that whilst it was a requirement to use MMEDs in Conservation Measures 51-01, 51-02, 51-03 and 51-04, limited information was collected on the configuration of these devices.

5.70 The Working Group noted that the information submitted in krill-fishery notifications is generally insufficient to assess whether the design of MMEDs successfully mitigates incidental mortality or needs improvement.

5.71 The Working Group considered that it was desirable to collect information on the design and construction of MMEDs to enable better specification of these devices, and developed

Table 15 to provide an example of how these data could be collected during the vessel notification procedure.

5.72 The Working Group tasked the Secretariat to develop and circulate a survey during the 2025 season using the information provided in 15 as a template, and requested that the Secretariat present the results of this survey at WG-IMAF-2025, with the intent to refine MMED information required in Conservation Measure 21-03.

5.73 The Working Group recommended that the requirements for use of MMED be clarified and requested the Scientific Committee consider the following text be substituted for operative paragraph 7 of CMs 51-01 and 51-02 as well as operative paragraph 8 of CMs 51-03 and 51-04: "The use of one or more marine mammal exclusion devices on trawls is mandatory. Exclusion devices shall minimize incidental capture of cetaceans (whales) and pinnipeds (seals and fur seals)."

Mitigation methods for seabirds

5.74 WG-FSA-IMAF-2024/01 presented a review of the scientific literature on the potential for stick water to attract seabirds in krill fishing operations. The paper examined the olfactory abilities of procellariform seabirds (albatrosses, petrels and shearwaters) which are sensitive to scent compounds such as pyrazine and trimethylamine (released from macerated krill) and dimethyl sulfide (DMS) (associated with phytoplankton). It highlighted that stick water, a by-product of krill processing, contains compounds that could attract seabirds to krill fishing operations from large distances. The review explored how this could increase seabird attendance around vessels and lead to a higher risk of warp strikes during fishing operations. The author recommended the Working Group should consider this when considering the merit of any amendments to CM 25-02 (2023), specifically the discharge of stick water.

5.75 The Working Group noted that although the literature outlined how certain seabirds were attracted to stick water, there was no indication of their behaviour when they arrived at the source, and anecdotal information from observers has suggested they lose interest if there is no food source present.

5.76 The Working Group further noted that the composition of stick water may vary among vessels according to the processing methods employed onboard which may affect how attractive it is to different species. Combined with the way the vessel is configured to discharge stick water (e.g., above or below the water surface), this may have an influence on the rate of bird strikes.

5.77 Dr Kawaguchi (Australia) recalled a study on krill processing (Yoshitomi et al. 2007) where stick water had been defined as 'water remaining from the processing of krill'. The study estimated that 20,000 tonnes of krill would produce 3,000 tonnes of meal and 1,500 tonnes of stick water.

5.78 The Working Group recommended that the Scientific Committee task the Secretariat to develop a survey and circulate it to Members to determine the types of products that are produced by vessels in CCAMLR fisheries, the location of stick water discharged from vessels, and to inform how by-products from krill processing methods on individual vessels contribute to the composition of stick water, as this may assist in determining if stick water contains potential food sources for birds.

5.79 WG-FSA-IMAF-2024/09 presented an updated set of gear diagrams intended for inclusion in Conservation Measure 25-02 Annex C. The paper considered the inconsistencies between the gear specifications outlined in paragraphs 3 and 4 of CM 25-02 and the diagrams provided in the Annex C for Spanish and trotline longline gear configurations. The need for alignment between the gear details specified in the text and the diagrams was highlighted during discussions in WG-IMAF-2023 (SC-CAMLR-42, paragraph 3.49) and clarifications requested by the Scientific Committee.

5.80. The Working Group welcomed the proposal set out in WG-FSA-IMAF-2024/09, and requested the Scientific Committee endorse the revised diagrams for CM 25-02 and refer them to the Commission.

5.81 WG-FSA-IMAF-2024/44 presented an update on ACAP activities and advice since October 2023. It highlighted three new assessments that had been undertaken for ACAP species that forage in the CCAMLR area: the Southern Royal Albatross *Diomedea epomophora*, the Campbell Albatross *Thalassarche impavida* and the White-capped albatross *T. steadi*, all of which had been re-classified as being in decline. In addition, seven of the nine populations, listed by ACAP as high priority, occur in the Convention Area. Advice from ACAP's most recent Seabird Bycatch Working Group (SBWG12) was mainly related to mitigation devices for krill trawlers and in particular, assessed the mitigation measures developed for net monitoring cables.

5.82 The Working Group expressed concern over the decline of the three assessed species and encouraged Members to collect and submit any information they could get on them and other ACAP species. ACAP will provide the Working Group with updated information after its next meeting in 2026.

5.83 The Working Group suggested ACAP consider some of the small petrel species (e.g., cape petrel, snow petrel (*Pagodroma nivea*)) which interact mostly with krill vessels, to be included as ACAP species. Although they are considered species of Least Concern on the International Union for the Conservation of Nature and Natural Resources – the World Conservation Union (IUCN) list, there are local populations facing conservation issues. The Working Group acknowledged that although ACAP resources are limited, and its best practice advice also applies to ACAP non-listed species, the listing of additional species may be considered in the future.

5.84 The Working Group noted that while there was no formal agreement between the IUCN and ACAP, there is some interaction, and the IUCN is responsible for red-listing species.

Data collection needs from seabird and marine mammal interactions

5.85 WG-FSA-IMAF-2024/53 Rev. 1 outlined a seabird warp strike observation protocol, developed by ACAP, for trawl fisheries intended to be incorporated into the SISO tasking, highlighting the importance of estimating the abundance of seabirds in the vicinity of fishing operations. This arose following recommendations presented in WG-IMAF-2023/05, which acknowledged that understanding seabird abundance can help assess the risk of heavy warp strikes. It examined the need for observers to conduct species-specific counts, acknowledging the potential impact on their time for other tasks and the necessity for additional training. ACAP offered to provide the additional materials. In addition, the paper proposed changing the current finfish trawl bird abundance observation protocols to bring them into line with those proposed for the krill fishery.

5.86 The Working Group noted that the 25-m semicircle proposed in the protocol was a relatively small area compared to the previous abundance estimate protocol used in the finfish fishery. However, it was acknowledged that this was an easier area to assess for observers and would cover the area around the warp.

5.87 The Working Group noted that for consistency, the time taken for the initial 'snapshot' to estimate species type and numbers should be standardised. The Working Group recommended that the snapshot should be instantaneous, limited to a few seconds rather than minutes, when undertaking the seabird abundance observations.

5.88 As the protocol represented a change of methodology within the finfish fishery, the Working Group noted that this may affect any future analyses of bird abundance.

5.89 WG-FSA-IMAF-2024-76 presented an updated pinniped identification guide, following comments received from WG-IMAF-2023. The paper considered the need for more detailed data collection on the sex and total body length of incidental seal mortalities with the aim of assessing the potential impacts of incidental mortalities in CCAMLR fisheries on sex or maturity cohorts within affected seal populations. In addition, the paper provides updated information for identifying the most common pinnipeds in the CCAMLR area and standard protocols for measuring carcasses and collecting biological data from by-caught species. It provided a number of recommendations including adding fields for length and sex data to the current data collection forms and encouraging observers to take specific photographs of carcasses onboard vessels. Additionally, the authors proposed creating a dedicated location on the CCAMLR website for storing pinniped images, which would assist in species identification and the documentation of incidental mortality events.

5.90 The Working Group provided some suggestions for improvement for future versions. These included adding the sub-Antarctic fur seal and changing the silhouettes by species used to explain measurements, among others.

5.91 The Working Group thanked the authors their work on the guide and endorsed its use by observers and the recommendations provided.

Review of WG-IMAF work programme and future work

5.92 The Working Group reviewed the progress made with the IMAF work programme (Table 16) and the additional work added as a result of discussions during WG-FSA-IMAF-2024. This included a review on elephant seal incidental mortality and the effects of stick water on warp strikes and review of general bird behaviour around fishing vessels

Scheme of International Scientific Observation

6.1 WG-FSA-IMAF-2024/11 Rev. 1 presented details on the CCAMLR Scheme of Internation Scientific Observation deployments during the 2024 season, of which there were 31 longline and 13 trawl trips observed. The authors outlined the changes to the observer forms, manuals and supplemental information for the 2025 season, a transparent process for tracking changes implemented across all CCAMLR forms and manuals, the introduction of an online forms archive, and options for the allocation of prizes to recognise the efforts of krill fishery observers.

6.2 The Working Group thanked the Secretariat for this work, noting that tracking changes of documents through the e-Groups is time consuming for participants, and agreed that providing summary metadata of form changes in the online forms archive will improve the transparency of past changes. The Working Group endorsed the process outlined in WG-FSA-IMAF-2024/11 Rev. 1 for communicating and documenting changes to forms and instructions.

6.3 The Working Group thanked the Secretariat for translating the toothfish and skate tagging instructions into the official languages of the Commission, noting that they will be included with CCAMLR tag orders for all vessels fishing in the CCAMLR fisheries. The Working Group also thanked COLTO for providing translation of the tagging protocol into additional common languages in use on vessels.

6.4 The Working Group recommended that the Scientific Committee endorse a change to the reference in Conservation Measure 41-01, Annex C, linking the CCAMLR tagging protocol to the Commercial Data Manual – Longline Fisheries.

6.5 The Working Group welcomed the offer from the Association of Responsible Krill Operators (ARK) to fund several prizes acknowledging the contributions of krill observers and recommended that allocation of the prizes should be based on an effort-weighted lottery system, as this would remove any influence on the data collection.

6.6 WG-FSA-IMAF-2024/40 presented a newly developed CCAMLR Tagging Manual for use by vessels and observers in CCAMLR fisheries.

6.7 The Working Group thanked the authors for their hard work and for having agreed to take on this large task. The Working Group welcomed the offer by the Secretariat to have the manual translated into the official languages of CCAMLR, and requested the Secretariat liaise with interested parties to investigate whether the manual could be translated into common languages used by crews on longline vessels.

6.8 The Working Group noted that the waterproof tagging protocol posters produced by the Secretariat may be useful outside of the CCAMLR area. The Working Group requested that the Secretariat make the templates of these posters available online, so that Members from both CCAMLR and adjoining Regional Fishery Management Organisations (RFMOs) could print them as needed given the importance of tagging and collection of these data.

6.9 The Working Group recommended that the Scientific Committee endorse the tagging manual and task the Secretariat with making it available along with other vessel and observer guides (SC-CAMLR-43/BG/38).

Future work

Electronic tagging

7.1 WG-FSA-IMAF-2024/60 presented the Southern Ocean Fish Electronic Tagging and Data Sharing Initiative (SOFETAG), which was established to encourage collaboration among Members to develop and implement data sharing protocols and templates for the distribution of electronic tagging data. The paper provided an overview of various benefits that CCAMLR and its Members could achieve through participation with the initiative, such as enhanced data discoverability and accessibility, improved data quality and reliability and facilitated collaboration and reproducibility.

7.2 The Working Group welcomed the initiative and the invitation to collaborate on this work. The Working Group highlighted the value of data interoperability for integrating datasets and achieving a comprehensive understanding of species ecology, and noted the widespread application of the initiative across many different studies (e.g., habitat use, spatial distribution, spawning dynamics).

7.3 The Working Group recalled the importance of communicating lessons learned from these experiences, noting that it is important to not only share the methodology and data used, but also to share any analyses performed to help inform future studies (e.g., survey design planning).

7.4 The Working Group recalled that the SOFETAG was established to initially focus on PSATs, but consideration of other methods of telemetry (including conventional tagging) would be important in further developing any information-sharing mechanisms.

7.5 The Working Group recalled the 'Spatial Data Viewer' developed by the Secretariat as a visualisation tool for the different spatial management activities occurring (or in development) in the Convention Area (WG-EMM-2024 paragraphs 1.11 – 1.12), and suggested that adding a layer of PSATs data may be a useful technique to visualise information on releases and recoveries.

7.6 The Working Group requested the Secretariat engage with relevant Members to compare PSAT data held within the CCAMLR database with that of the Member, update CCAMLR data if PSAT deployments are not recorded and create valid linkages with fishery data for deployment and recovery metadata, and then explore options to make the metadata available to the research community.

7.7 The Working Group noted that PSATs are being used commonly in the Convention Area and it would be an opportune time to hold a focus topic or workshop on the use of PSAT technologies for studies of e.g. tagging mortality, movement, habitat association, spawning behaviour.

7.8 The Working Group recommended the promotion of biologging research collaborations among CCAMLR Members and encouraged engagement of other scientists through the new SCAR Action Group, SCARFISH.

Climate Change

7.9 WG-FSA-IMAF-2024/14 presented an update on the progress of recommendations from the CCAMLR Workshop on Climate Change (WS-CC-2023). The Working Group welcomed the paper and recalled that these recommendations were endorsed at SC-CAMLR-42.

7.10 The Working Group reviewed the tables presented which summarised the outcomes of the Workshop (Tables 17 and 18) and updated the summary of tasks, timescale, priority level and progress of work (not started, in-progress, ongoing or complete). The Working Group recalled the purpose of their review was to provide a progress update to the Scientific Committee.

7.11 The Working Group further noted that additional details on specific tasks for each recommendation will be detailed in the workplan and sought clarification from the Scientific Committee regarding the definitions for some tasks (e.g., risk assessments), which will be critical to ensuring the work meets its objectives.

7.12 The Working Group recalled the tables summarising evidence for changes in stock assessment and population parameters or processes that could be due to the effects of environmental variability or climate change (Tables 19 to 23).

7.13 The Working Group recommended the Scientific Committee consider these tables while progressing its work on monitoring and formulating management responses to the effects of climate change and make them available as part of the relevant Fishery Reports.

7.14 The Working Group recommended the Scientific Committee consider incorporating the tasks from Tables 17 and 19 into the workplans for the relevant Working Groups.

Workplan

7.15 The Working Group reviewed its workplan (SC-CCAMLR-42, Table 1) and adjusted the priority status, timing and contributors associated with the current tasks (Table 20). It also added several new tasks generated from discussions during the meeting such as those pertaining to stock assessments.

Other business

8.1 WG-FSA-IMAF-2024/48 presented improvements that Ukraine has developed to mark their longline fishing gears to aid in identification if the gear was to be lost during fishing operations. The marking scheme would be applied to Spanish and Trotline gear configurations and comprise vessel-specific markings using different materials, dimensions, and branding on each component of the fishing gear, including ropes, hooks, weights, anchors in addition to buoys. Each specific component would also be photographed to allow matching of any found gear components.

8.2 The Working Group thanked the authors for the paper and the efforts to support identification of fishing gear found in the Convention Area. The Working Group noted that the industry as a whole is engaged in efforts to improve gear marking as well as in reducing the likelihood of gear loss through improved construction, as discussed at a recent COLTO gear Workshop (CCAMLR-43/BG/02 Rev.1). This work is also being progressed through the Intersessional Correspondence eGroup on 'Unidentified fishing gear in the Convention Area', reported in CCAMLR-43/BG/17.

8.3 The Working Group noted it would be useful to receive information on how other Members were improving identification of their fishing gears and recommended that the Scientific Committee strengthen CM 10-01 to require marking more than just the line buoys.

8.4 WG-FSA-IMAF/49 presented an analysis of data from six PSATs deployed on Patagonian toothfish in the South Atlantic, which revealed periods of diel changes in depth that were then used to estimate the longitude of the fish during its period at liberty. The additional information on longitude suggested that four of the individuals may have made a return migration spanning a period of approximately one year. The authors suggested that toothfish may not be as sedentary as conventional tagging data imply, and that combining additional data from otolith microchemistry with PSAT tags may allow an additional mechanism to infer geographic position of tagged individuals during the period they are tagged.

8.5 The Working Group welcomed this novel approach to analysing PSAT data and noted that the results raise questions about the potential movements patterns of toothfish between Burdwood Bank, and banks to the east. The Working Group noted that previous genetic studies suggested strong separation between the populations in the two areas, which would be in contrast with the random mixing along the series of banks, unless return migrations occurred.

8.6 The Working Group noted that these movement patterns and home site fidelity were relevant to the Agent-Based Modelling (ABM) workplan (WG-SAM-2023 (paragraph 7.3(v))).

8.7 The Working Group noted that variation in the diel timing of vertical movements translates to significant uncertainty in longitude estimation, but that the observations seem consistent with the likely positions of the tagged fish at the time. The Working Group further noted that if toothfish spend significant periods in mid-water, then acoustic surveys may include observations of toothfish targets that would better inform life history and stock structure. The Working Group considered that microchemistry from historical otolith collections may be biased if the environment had changed but that otolith microchemistry from recaptures of PSAT tagged fish could be linked to periods when they inhabited mid-water.

8.8 Dr F. Massiot-Granier (France) informed the Working Group that a 20-day survey, POKER V, began in mid-September 2024 onboard the FV Atlas Cove with 7 scientists. The survey is being conducted in the French EEZ on the Northern Kerguelen Plateau, focusing on depths shallower than 500 meters. A total of 150 trawl stations will be deployed fitted with a CTD. The primary objective is to initiate a time series of Patagonian toothfish recruitment independent of the commercial fishery, while maintaining comparability with previous POKER surveys conducted in 2006, 2010, 2013, and 2017.

8.9 The campaign's goals are to:

(i) Assess the biomass and abundance of juvenile toothfish on the Kerguelen Plateau

(ii) Gain insights into the life history traits and ecology of juvenile toothfish

(iii) Characterise the marine habitats where juvenile toothfish are found

(iv) Evaluate the biomass of other fish species.

8.10 These findings are expected to significantly improve stock assessment models for the Patagonian toothfish population in the Kerguelen EEZ, which are crucial for setting catch limit recommendations. Additionally, they will provide a better understanding of the mechanisms driving recruitment variability on the Kerguelen Plateau.

8.11 Dr M. Collins (UK) notified intention to conduct a demersal trawl survey in Subarea 48.3 during January – February 2025. The planned core survey will be consistent with previous surveys conducted by the UK in Subarea 48.3 (1990-2023). The main objectives will include:

(i) estimating the biomass and population structure of mackerel icefish (*C. gunnari*);

(ii) estimating the biomass and population structure of juvenile Patagonian toothfish (*D. eleginoides*);

(iii) estimating the biomass and population structure of other demersal species, including previously exploited species.

8.12 In addition, deeper trawls (350 – 600 m) will be undertaken to collect additional information on the distribution and population structure of Patagonian toothfish and species that are by-catch in the longline fishery. Samples will be collected from a range of species to support ecological studies, including the diet of icefish and Patagonian toothfish. The survey will also include deployments of a CTD to collect oceanographic data and a neuston net to sample larval fish. Further details of the survey, including details of the vessel and survey dates, will be provided in an SC Circular later in the year.

8.13 Dr Ziegler informed the Working Group that Australia would be conducting the annual Random Stratified Trawl Survey at Heard and MacDonald Islands in 2025.

8.14 Dr Walker informed the Working Group that New Zealand will conduct an expedition by the Research Vessel Tangaroa to the Ross Sea region in 2025, and that further details are provided in WG-EMM-2024 paragraph 8.5.

8.15 Dr Collins informed the Working Group that the IUCN had recently listed *Pseudochaenichthys georgianus* as ‘endangered’ and *C. aceratus* as ‘vulnerable’ but that the IUCN had not consulted with CCAMLR or with the UK in making these determinations.

8.16 The Working Group noted that both of these species were common in surveys and in bycatch observations and that work to assemble data on the distribution and abundance to provide to the IUCN may be useful in their re-assessment of these status designations. Dr Collins offered to collaborate with other interested participants to develop this work.

8.17 The Working Group recommended that the Scientific Committee ask the IUCN for more information about their process for species status designations and request that CCAMLR be consulted prior to any future listings of Antarctic Marine Living Resources.

Advice to the Scientific Committee

9.1 The Working Group's advice to the Scientific Committee is summarised below according to the agenda structure of the Scientific Committee meeting (Scientific Committee agenda number). These advice paragraphs should be considered along with the body of the report leading to the advice.

(i) Harvested species: General (2)

- (a) FAO stock status reporting (paragraphs 1.29, 1.30, 1.31)

(ii) Krill: Progress towards a spatial overlap assessment (2.1.3)

- (a) Krill management summary paper to fishery reports (paragraph 2.3)

(iii) Finfish: General (3)

- (a) Toothfish age determination workshop (paragraphs 4.27, 4.28, 4.29)
- (b) Toothfish stock assessment workplan and MSEs (paragraphs 4.41, 4.48, 4.50)
- (c) Toothfish tagging
  - i. Tagging overlap statistics (paragraphs 4.123 and 4.124)
  - ii. CM 41-01 reference to tagging protocol (paragraph 6.4)
  - iii. Revised tagging manual (paragraph 6.9)

(iv) Icefish in Area 48 (3.1.1)

- (a) Icefish survey under CM 24-01 (paragraphs 3.17 and 3.18)

(v) Toothfish in Area 48 (3.1.2)

- (a) Catch limit advice for *D. eleginoides* in Subarea 48.3 (paragraphs 4.64 and 4.65)
- (b) Catch limit advice for *D. mawsoni* in Subarea 48.4 (paragraph 4.112)
- (c) Catch limits in exploratory fisheries with Research plans: Subarea 48.6 (paragraphs 4.141 and 4.142)

(vi) Icefish in Area 58 (3.2.1)

(a) Icefish catch limits in 58.5.2 (paragraph 3.9)

(vii) Toothfish in Area 58 (3.2.2)

(a) Catch limit advice for *D. eleginoides* in Division 58.5.2 (paragraphs 4.93 and 4.94)

(b) 58.4.1 and 58.4.2 (paragraphs 4.151 and 4.152)

(c) Prohibition of directed fishing for *D. eleginoides* in Division 58.5.1 outside areas of national jurisdiction (paragraph 4.76)

(d) Catch limits in areas outside national jurisdiction (paragraph 4.184)

(viii) Toothfish in Area 88 (3.3.1)

(a) Catch limit advice for *D. mawsoni* in the Ross Sea (paragraph 4.105)

(b) Subarea 88.2 Research Blocks (paragraph 4.115)

(c) Catch limits in research fishing under CM 24-01

i. Ross Sea Shelf Survey (paragraph 4.166)

ii. Subarea 88.3 (paragraphs 4.182 and 4.183)

(ix) Fish and invertebrate by-catch (4.1)

(a) Fish bycatch in the krill fishery (paragraphs 5.15 and 5.18)

(x) Incidental mortality associated with fishing (IMAF) (4.2)

(a) Net monitoring cable (paragraph 5.63)

(b) Marine mammal exclusion devices (paragraph 5.73)

(c) Stickwater (paragraph 5.78)

(d) Gear diagrams in CM 25-02 (paragraph 5.80)

(xi) Ecosystem monitoring and management (5)

(a) IUCN species status (paragraph 8.17)

(xii) Climate change (7)

(a) Climate change workshop recommendations (paragraphs 7.13 and 7.14)

(xiii) IUU fishing (8)

(a) Gear identification and CM 10-01 (paragraph 8.3)

(xiv) SISO (9)

(a) Electronic monitoring workplan (paragraph 4.179)

Adoption of the report and close of meeting

10.1 The report of the meeting was adopted requiring 6.5 hours of discussion.

10.2 The plenary sessions of the meeting were streamed via zoom and were attended by 1 – 10 Member participants each day.

10.3 At the close of the meeting, The Mr Somhlaba thanked all participants of the Working Group for the hard work and positive contributions. He also thanked the Secretariat for their support, snacks, diligence processing the report, and coordination in progressing the work of the group.

10.3 On behalf of the Working Group, Dr Collins thanked the Co-conveners for their leadership, skill, and humour in steering the group through intense discussions of the complex issues before the Working Group

10.4 Mr Walker, and on behalf of Dr Favero, also thanked the participants for their hard work and for the progress made on IMAF topics through this joint meeting. He also thanked the Secretariat team for their work, responsiveness, and high-quality work in support of the meeting.

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Tables

Table 1: Status of commercial fisheries in the Convention Area as of 1 October 2024. Current research fisheries and fisheries that operated before the CAMLR Convention entered into force are not included. 'Near target' indicates stocks with biomass (CCAMLR Assessment Categories 1 and 2) or harvest rates (CCAMLR Assessment Category 3) currently or projected to be within ± 5% of established CCAMLR targets. 'Above target' and 'below target' indicate stocks with biomass or harvest rates outside of this range. Target biomass is 50% (60% in Division 58.5.1) of unfished spawning biomass for *Dissostichus* spp. and 75% of unfished spawning biomass for *Euphausia superba* and *Champsocephalus gunnari*. Category 1 assessments are integrated stock assessments (*Dissostichus* spp.) or 2-yr projections based on the results of recent trawl surveys (*C. gunnari*). Category 2 assessments (*E. superba*) are 20-yr projections based on the results of hydroacoustic surveys conducted > 5 years in the past. Category 3 assessments (*Dissostichus* spp.) are trend analyses of catch per unit effort or mark-recapture estimates of vulnerable biomass, with target harvest rates of 4% for toothfish in Category 3. FAO Status determined on the basis of indicated FAO Characteristic from FAO (2011). Blank indicates no information available.

Species	CCAMLR Subarea or Division	Last calendar year of reported catch	CCAMLR assessment category	CCAMLR status as of 1 October 2024	FAO status (FAO characteristic) as of 1 October 2024
Euphausia superba	48.1, 48.2, 48.3, and 48.4	2024	2	Above target	Underfished (3)
	48.5	1991		Not assessed	
	48.6	1993		Not assessed	
	58.4.1	2017	2	Above target	Underfished (3)
	58.4.2	2018	2	Above target	Underfished (3)
	58.4.3	1979		Not assessed	
	58.4.4	1979		Not assessed	
	88.1	1990		Not assessed	
	88.2	1980		Not assessed	
	88.3	1991		Not assessed	
Champsocephalus gunnari	48.2	1990		Commercial fishing prohibited	
	48.3	2018	1	Above target	Underfished (2)
	58.5.1	2015		Not assessed	
	58.5.2	2024	1	Near target	Underfished (2)
Dissostichus eleginoides	48.1	Never commercially fished		Commercial fishing prohibited	
	48.2	Never commercially fished		Commercial fishing prohibited	
	48.3	2024	1	Near target	Underfished (2)
	48.4	2024	1	Above target	Underfished (2)
	58.4.3a outside areas of national jurisdiction	2018		Closed fishery with catch limit of zero tonnes	
	58.4.3b	2009		Not assessed	
	58.4.4a	2000		Not assessed	
	58.4.4b	2020		Not assessed	
	58.5.1[1]	2024	1	Near target	Underfished (2)
	58.5.2 within areas of	2024	1	Below target	Maximally Sustainably Fished (2)

	national jurisdiction				
	58.5.2 outside areas of national jurisdiction	Never commercially fished		Commercial fishing prohibited	
	58.6[1]	2024		Above target	Underfished (2)
	58.7[1]	2024		Not assessed	
Dissostichus mawsoni	48.1	Never commercially fished		Commercial fishing prohibited	
	48.2	Never commercially fished		Commercial fishing prohibited	
	48.4	2024	3	Near target	Underfished (1)
	48.5	Never commercially fished		Commercial fishing prohibited	
	48.6	2024	3	Near target	Maximally Sustainably Fished (3)
	58.4.1	2018		Commercial fishing prohibited	
	58.4.2	2024	3	Near target	Underfished (3)
	58.4.3b outside areas of national jurisdiction	2009		Closed fishery with catch limit of zero tonnes	
	88.1 and 88.2AB	2024	1	Above target	Underfished (2)
	88.2C-G and H	2024	3	Near target	Maximally Sustainably Fished (3)
	88.3[2]	Never commercially fished		Commercial fishing prohibited	

1 This stock is managed by national authorities.
2 Annual research fishing occurs, with catches reported through 2024.

Table 2: Status of fisheries in the Convention Area for species that are not commercially harvested as of 1 October 2024. Research fisheries are not included.

Species or Family	CCAMLR Subarea or Division	Last year of reported catch	CCAMLR Assessment category	CCAMLR status as of 1 October 2024	FAO status (FAO characteristic) as of 1 October 2024
Lithodidae	48.2	2010		Not assessed	
	48.3	2010		Not assessed	
Martialia hyadesi	48.3	2001		Not assessed	
Macrouridae	58.4.3a	2004		Not assessed	
	58.4.3b	2004		Not assessed	
Channichthyidae	48.3	1986		Not assessed	
Chaenocephalus aceratus	48.1	Never commercially fished		Commercial fishing prohibited	
	48.2	Never commercially fished		Commercial fishing prohibited	
	48.3	Never commercially fished		Commercial fishing prohibited	
Chaenodraco wilsoni	58.4.2	2004		Not assessed	
Pseudochaenichthys georgianus	48.1	Never commercially fished		Commercial fishing prohibited	
	48.2	Never commercially fished		Commercial fishing prohibited	
	48.3	Never commercially fished		Commercial fishing prohibited	
Nototheniidae	48.3	1980		Not assessed	
	58.4.4	1979		Not assessed	
	58.5	1978		Not assessed	
	58.6	1983		Not assessed	
Lepidonotothen kempi	58.4.2	2004		Not assessed	
Trematomus eulepidotus	58.4.2	2004		Not assessed	
Pleuragramma antarcticum	58.4.2	2004		Not assessed	
Gobionotothen gibberifrons	48.1	Never commercially fished		Commercial fishing prohibited	
	48.2	1988		Commercial fishing prohibited	
	48.3	Never commercially fished		Commercial fishing prohibited	
Lepidonotothen squamifrons	48.1	Never commercially fished		Commercial fishing prohibited	

	48.2	Never commercially fished	Commercial fishing prohibited
	48.3	Never commercially fished	Commercial fishing prohibited
	58.4.4a except for waters adjacent to the Prince Edward Islands	Never commercially fished	Commercial fishing prohibited
	58.4.4b	Never commercially fished	Commercial fishing prohibited
Notothenia rossii	48.1	Never commercially fished	Commercial fishing prohibited
	48.2	Never commercially fished	Commercial fishing prohibited
	48.3	1985	Commercial fishing prohibited
Patagonotothen guntheri	48.1	Never commercially fished	Commercial fishing prohibited
	48.2	Never commercially fished	Commercial fishing prohibited
	48.3	1988	Commercial fishing prohibited
Myctophidae	88.3	1988	Not assessed
Electrona carlsbergi	48.1	Never commercially fished	Commercial fishing prohibited
	48.2	Never commercially fished	Commercial fishing prohibited
	48.3	1991	Commercial fishing prohibited
Sharks	all	Never commercially fished	Commercial fishing prohibited
All other finfishes	48.1	Never commercially fished	Commercial fishing prohibited
	48.2	Never commercially fished	Commercial fishing prohibited

Table 3: Secretariat verification of Casal2 assessments submitted to WG-FSA-IMAF-2024. P(*SSB*<20%SSB_0) and P(*SSB*<50%SSB_0) are the probabilities (P) that the spawning biomass (*SSB*) falls below set proportions of the unfished level (SSB_0), as specified in the CCAMLR toothfish decision rules 1 and 2 respectively.

Assessment/Model Run	Variable	Reported value	Secretariat value	WG-FSA-IMAF-2024 paper No.
Subarea 48.3	SSB_0	93 850	93 850	29
Casal2 final	Objective function	771.7	771.7	
	P(SSB <20% SSB_0)	<0.01	<0.01	
	P(SSB <50% SSB_0)	0.50	0.50	
Division 58.5.1	SSB_0	188 230	188 230	67
M2	Objective function	684.8	684.8	
	P(SSB <20% SSB_0)	<0.01	<0.01	
	P(SSB <50% SSB_0)	0.24	0.24	
Division 58.5.2	SSB_0	64 609	64 609	50, 64
3	Objective function	2 564.17	2 564.17	
	P(SSB <20% SSB_0)	<0.01	<0.01	
	P(SSB <50% SSB_0)	0.50	0.50	
Ross Sea region	SSB_0	78 438	78 438	32
R2.0	Objective function	3 022.74	3 022.74	
	P(SSB <20% SSB_0)	<0.01	<0.01	
	P(SSB <50% SSB_0)	0.50	0.50	

Table 4: Outcomes from 2024 stock assessments for *Dissostichus* spp. in Subarea 48.3, Division 58.5.1, and Subarea 88.1 plus SSRUs 882AB. $U_{50/60}$ is the long term constant exploitation rate (U) that leads to SSB being 50% or 60% of SSB_0.

	Subarea 48.3	Division 58.5.1[1]	Subarea 88.1 + SSRUs 882AB
Species	*D. eleginoides*	*D. eleginoides*	*D. mawsoni*
Target SSB/ SSB_0 (%)	50% SSB_0	60% SSB_0[2]	50% SSB_0
SSB_0 (t)[3]	94 064	188 460	77 920
Current status from assessment (% SSB_0)[3]	49.6	56.4	65.2
Current biomass, $SSB_{current}$, from assessment (t)[3]	46 873	106 230	50 860
Catch limit proposed by assessment authors (t)	2 062	4 610[4]	3 298
Implied harvest rate (proposed catch limit/$SSB_{current}$)	0.044	0.043[4]	0.065
Cohorts for which year class strength (YCS) is estimated	1985–2016	2001–2018	2003–2017
	Candidate catch limits given a scenario in which future productivity is characterised by long-term mean recruitment (project recruitment using all estimates of YCS)		
Catch limit using CCAMLR Gamma 1 (depletion)	3 765	6 950	4 689
Catch limit using CCAMLR Gamma 2 (escapement)	2 733	4 610	3 460
Catch limit determined using the minimum of Gamma 1 and Gamma 2	2 733	4 610	3 460
Catch limit using new gamma based on $U_{50/60}$[5]	2 966	4 359	4 324
Catch limit recommended by WG-FSA	2 062		3 298

[1] CCAMLR does not provide catch advice for this fishery.
[2] Target set by the French Authorities.
[3] Median of the MCMC posterior estimate.
[4] Catch limit and implied harvest rate in force for the 2024/2025 fishing season.
[5] Methods differ between stock assessments.

Table 5: Candidate catch limits from the integrated stock assessment for *D. eleginoides* in Subarea 48.3 given a scenario in which future productivity is characterized by contemporary recruitment (see WG-SAM-2024, paragraph 6.10). U_{50} is the long term constant exploitation rate (U) that leads to SSB being 50% of SSB_0.

Approach used to characterize contemporary recruitment	Scale projected recruitment using data from research surveys, with scalar equal to average numbers of age 3 fish captured during 2005-2024 divided by average numbers of age 3 fish captured during 1987-2024
Mean YCS used for projection	0.88
Catch limit using CCAMLR Gamma 1 (depletion)	3 247
Catch limit using CCAMLR Gamma 2 (escapement)	2 062
Catch limit using the minimum of Gamma 1 and Gamma 2	2 062
Catch limit using new gamma based on U_{50}	2 211
Catch limit recommended by WG-FSA	2 062

Table 6: Candidate catch limits from the integrated stock assessment for *D. eleginoides* in Division 58.5.1 given a scenario in which future productivity is characterised by contemporary recruitment (see WG-SAM-2024, paragraph 6.10). U_{60} is the long-term constant exploitation rate (U) that leads to SSB being 60% of SSB_0.

Approach used to characterize contemporary recruitment	Project recruitment using estimates of year class strength from 2007-2018 (most recent 12 years)
Mean YCS used for projection	0.72
Catch limit using CCAMLR Gamma 1 (depletion)	4 610
Catch limit using CCAMLR Gamma 2 (escapement)	1 160
Catch limit using the minimum of Gamma 1 and Gamma 2	1 160
Catch limit using new gamma based on U_{60}	1 165

Table 7: Candidate catch limits from the integrated stock assessment for *D. mawsoni* in Subarea 88.1 and SSRUs 882AB given a scenario in which future productivity is characterised by contemporary recruitment (see WG-SAM-2024, paragraph 6.10). U_{50} is the long term constant exploitation rate (U) that leads to SSB being 50% of SSB_0.

Approach used to characterise contemporary recruitment	Project recruitment using estimates of year class strength from 2008-2017 (most recent 10 years)
Mean YCS used for projection	0.97
Catch limit using CCAMLR Gamma 1 (depletion)	4 490
Catch limit using CCAMLR Gamma 2 (escapement)	3 298
Catch limit determined using the minimum of Gamma 1 and Gamma 2	3 298
Catch limit using new gamma based on U_{50}	4 070
Catch limit recommended by WG-FSA	3 298

Table 8: Research Blocks biomasses (B, tonnes) and catch limits (CL, tonnes) estimated using the trend analysis. PCL: previous catch limit; ISU: increasing, stable or unclear; D: declining; Y: yes; N: no; -: no fishing in the last Season; x: no fishing in the last 5 Seasons. Recommended catch limits are subject to approval by the Commission.

Area	Subarea or Division	Research Block	Species	PCL	Trend decision	Adequate recaptures	CPUE Trend Decline	B	B×0.04	PCL×0.8	PCL×1.2	Recommended CL for 2025
48	48.6	486_2	*D. mawsoni*	148	ISU	Y	N	3 789	152	118	178	152
		486_3	*D. mawsoni*	42	ISU	N	N	2 162	86	34	50	50
		486_4	*D. mawsoni*	126	ISU	Y	N	8 580	343	101	151	151
		486_5	*D. mawsoni*	202	ISU	Y	Y	86 299	3452	162	242	242
58	58.4.1	5841_1	*D. mawsoni*	112	x	x	x	x	x	x	x	112*
		5841_2	*D. mawsoni*	80	x	x	x	x	x	x	x	80*
		5841_3	*D. mawsoni*	79	x	x	x	x	x	x	x	79*
		5841_4	*D. mawsoni*	46	x	x	x	x	x	x	x	46*
		5841_5	*D. mawsoni*	116	x	x	x	x	x	x	x	116*
		5841_6	*D. mawsoni*	50	x	x	x	x	x	x	x	50*
	58.4.2	5842_1	*D. mawsoni*	103	ISU	Y	N	11 588	464	82	124	124
		5842_2	*D. mawsoni*	206	ISU	N	Y	8 601	344	165	247	165
88	88.2	882_1	*D. mawsoni*	184	-	-	-	-	-	-	-	184
		882_2	*D. mawsoni*	322	ISU	Y	N	9 450	378	258	386	378
		882_3	*D. mawsoni*	242	ISU	N	N	8 850	354	194	290	290
		882_4	*D. mawsoni*	222	ISU	Y	N	17 726	709	178	266	266
		882H	*D. mawsoni*	146	ISU	Y	N	4 155	166	117	175	166
	88.3	883_1	*D. mawsoni*	13	ISU	N	Y	2 173	87	10	16	10
		883_2	*D. mawsoni*	20	x	x	x	x	x	x	x	20
		883_3	*D. mawsoni*	38	ISU	N	Y	6 471	259	30	46	30
		883_4	*D. mawsoni*	38	ISU	N	Y	2 378	95	30	46	30
		883_6	*D. mawsoni*	43	ISU	N	N	3 485	139	34	52	52
		883_11	*D. mawsoni*	-	-	-	-	-	-	-	-	23 +
		883_12	*D. mawsoni*	-	-	-	-	-	-	-	-	23 +

*Proposed maximum catch is based on the 75th percentile of catch rates and longlines with 5000 hooks (see Table 8 in WG-FSA-IMAF-2024/25).

+ Proposed maximum catch is based on the 75th percentile of catch rates and longlines with 7000 metres (see paragraph 4.146)

Table 9: Review of research plans for exploratory fisheries under CM 22-02 and research fisheries under CM 24-01.

Subarea/division:	48.6	58.4.1 and 58.4.2	48.2	88.1	88.3
Proposal:	WG-SAM-2024/04 WG-FSA-IMAF-2024/23	WG-SAM-2024/02 WG-FSA-IMAF-2024/25 Rev. 1 ** The research activity at Division 58.4.2 has been conducted in 2022/23–2023/24 fishing season. This is the third year of an ongoing four-year plan with no significant change proposed for Division 58.4.2.	WG-SAM-2024/06 WG-FSA-IMAF-2024/68	WG-SAM-2022/01 Rev. 1 WG-FSA-2022/41 Rev. 1 WG-SAM-2023/02 WG-SAM-2024/05 WG-FSA-IMAF-2024/72	WG-SAM-2024/03 WG-FSA-IMAF-2024/52 Rev. 1
Members:	JPN, KOR, ESP, ZAF	AUS, FRA, JPN, KOR, ESP	UKR	NZL	KOR, UKR
Conservation measure under which the proposal is submitted:	CM 21-02	CM 21-02	CM 24-01	CM 24-01	CM 24-01
Time period:	2024/25–2027/28	2022/23–2025/26	2024/25–2026/27	2022/23–2024/25	2024/25–2026/27
Main species of interest:	*Dissostichus mawsoni*	*Dissostichus mawsoni*	*Champsocephalus gunnari*	*Dissostichus mawsoni*	*Dissostichus mawsoni*
Main purpose of the research (e.g. abundance, population structure, movement, …)	Abundance	Abundance	Distribution and abundance of *Champsocephalus gunnari* in Subarea 48.2; developing method to estimate biomass for mackerel icefish;	Population structure and distribution, monitoring of recruitment, research and monitoring inside the MPA.	Abundance, Stock structure, connectivity.

Is the purpose of the research linked to Commission or Scientific Committee priorities?	Y: The objectives are linked to a priority for CCAMLR (section 1a).	Y: Section 1a	Y	Y: sections 1a, 1b Research designed to be used in the RSR assessment and research links directly to 17 or 22 topics under the RSrMPA research and monitoring plan.	Y: 1. Objective of the research plan (a).
1. Quality of the proposal					
1.1 Is there enough information to evaluate the likelihood of success of the research objectives?	Y: This proposal, especially sections 3a, 3b, and 3c provide enough information.	Y: Sections 3a, 3b & 3c	Y	Y: sections 3a–3d Proponents have successfully implemented the survey and data collection for most years of the series.	Y: Detailed description on how the research will meet each objective (1. Objective of the research plan (b)).
2. Research design					
2.1 Is the proposed catch limit in accordance with research objectives?	Y: The catch limit determined by Trend Analysis and its rationale are explained in sections 4a and 4b.	Y: Sections 4a & 4b	Y: Effort limited survey; total area covered by research catches (trawl towing area by the station grid and target trawling, in total) is less than 0.1% of the total research area; there is a flexibility to complete a hydroacoustic survey even in case of use of the whole catch limit.	Y: sections 4a, 4b Catch limits for most recent research plan were based on the 95th percentile of catch from the full time series for the core strata, plus catch based on the 90th percentile for the special strata, and should not restrict the survey data collection.	Y: The catch limit determined by Trend Analysis and its rationale are explained in sections 4a and 4b. The catch limit at new research blocks (RB 11 and 12) is calculated by using the mean CPUE of previous fishing operations at surrounding area (section 4a).
2.2 Is the sampling design appropriate to achieve research objectives?	Y: Sampling design and data collection plan are described in sections 3a and 3b.	Y: Section 3b e.g. WG-SAM-2019, paragraphs 6.6–6.7 and 6.11–6.13, and Table 1.	Y: Krill measurement using survey guidelines in WG-EMM-18/23 (see WG-ASAM-2024, paragraphs 7.1–7.8).	Y: section 3a Stratified random design, power analysis to determine number of stations needed for CV 10%; data collection for all organisms.	Y: The sampling design for each RB is in line with the research plan flowchart (WG-SAM-16/18 Rev.1). 3. Survey design, data collection and analysis. The repeatability of

					new research blocks is shown in Figure 2.
2.3 Have the environmental conditions been thoroughly accounted for?	Y: Bottom topography and repeated accessibility estimated by sea ice condition are considered into sampling design (sections 1c and 3a).	Y: Appendix 2, Section b.	Y: Survey design, use of mid-water trawl to avoid a negative impact to the bottom organisms.	Y: section 3a Timing is before autumn freeze-up but could be delayed if commercial fishery season protracted.	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: The experience of notified vessels are explained in section 5.	Y	Y: Experience in krill acoustic biomass estimation.	Y: WG-SAM-11/16, WG-FSA-12/41, WG-SAM-13/32, WG-SAM-14/25, WG-FSA-14/51, WG-SAM-15/44, WG-SAM-16/14, WG-SAM-17/39, WG-FSA-17/57, WG-SAM-17/01, WG-SAM-18/10, WG-FSA-17/41, WG-SAM-19/03, SC-CAMLR-39/BG/28, WG-FSA-21/23, WG-FSA-2022/40, WG-FSA-2023/09, WG-SAM-2024/21, WG-FSA-IMAF-2024/65.	Research fishing by the *Greenstar* has occurred annually since 2016. *Marigold* joined in this research from 2020.

3.1.2 Collecting scientific data?	Y: The experience and research capability of notified vessels are explained in section 5. The number of biological sampling including otolith collection is increased to address the comments from WG-SAM-2024 (section 3b).	Y: Section 5	Y: Revised research proposal add information for data collection.	Y: section 5, reference in Appendix 1, section 3.1.1. Wide range of biological, acoustic, and environmental data collected over survey time series.	Y: Data will be collected consistent with CM 41-01, Annex A. Specifies observer sampling requirements. (3. Survey design, data collection and analysis (b))
3.2 Do the research platforms have acceptable tag detection and survival rates?	Y: In Ross Sea, tag detection and survival rate of *Shinsei-maru No.8* are 0.3 and 0.76, respectively. Tag overlap statistics range from 64–78% in 2023/24. In JPN vessel, tagging was biased on smaller fish since large fish tend to be in bad condition for release (hooks stuck in the throat deeply or in their eyes). WG-FSA-12/49 indicates no clear difference between Trotline and Spanish in fish suitability for tagging and an adequate number of suitable fish for tagging were available.	The vessels *Antarctic Discovery* and *Tronio* have good tagging performance with a detection index of 1 and 0.87, and survival index of 0.67 and 1 (NZL 2024). The vessel *Kingstar* had a tag detection of 0.88 and survival of 0.94 (NZL, 2024). The vessel *Antarctic Aurora* had a survival index of 1 and a detection index of 0.89, and the *Shinsei-Maru No. 8* a survival index of 0.76 and a detection index of **0.30**. The vessel *Southern Ocean* has a survival index of 0.52 and a detection index of 0.41. The vessels *Cap Kersaint* and *Sainte Rose* have tagging experience from fishing in Division 58.5.1 and did not have	NA	Y: *Janas* and *San Aotea II* have been active in the Ross Sea fishery since 1999 and the *San Aspiring* since 2005. Survival detection from 2024 assessment: *San Aotea II*: survival = 0.99, detection = 1.0; *Janas*: survival = 0.94, detection = 1.0; *San Aspiring*: survival = 1.0, detection = 1.0	Y: *Greenstar* has a survival index of 0.57 and a detection index of 1 from the Ross Sea region.

		the tagging performances calculated.			
3.3 Have the research teams sufficient resources and capacity for:					
3.3.1 Sample processing?	Y: Previous achievements of research milestones are described in sections 1b and 1c. Ageing works for the otolith of by-catch fishes will be conducted.	Y: Section 3b	Y: Revised research proposal add information for sample processing.	Y: section 3b Data collected on survey were part of a review WG-SAM-2022/13 and are reported upon annually (see paper list in table section 3.3.2).	Y: Two vessels have previous research experience and presented the results (3. Survey design, data collection and analysis).
3.3.2 Data analyses?	Y: Previous achievements of research milestones (sections 1b and 1c) and research capability (section 5) are represented in the proposal.	Y: Table 5	Y: Research cooperation to undertake complete analysis of obtained data	Y: Sections 3c, 3d WG-SAM-11/16, WG-FSA-12/41, WG-SAM-13/32, WG-SAM-14/25, WG-FSA-14/51, WG-SAM-15/44, WG-SAM-16/14, WG-SAM-17/39, WG-FSA-17/57, WG-SAM-17/01, WG-SAM-18/10, WG-FSA-17/41, WG-SAM-19/03, SC-CAMLR-39/BG/28, WG-SAM-2021/23, WG-FSA-2022/40, WG-FSA-2023/09.	Y: Presented the analyses results described in the Milestones table (3. Survey design, data collection and analysis).
4. Data analyses to address the research questions					
4.1 Are the proposed methods appropriate?	Y: Research objection and analytical method are represented in sections 1a and 3c.	Y: Section 3c	Y: Revised research proposal add information for analytical method.	Y: section 3c	Y
5. Impact on ecosystem and harvest species					

5.1 Is the catch limit proposed consistent with Article II of the Convention?	Y: The catch limit determined by Trend Analysis and its rationale are explained in sections 4a and 4b.	Y: Sections 4a & 4b	Y	Y: sections 4a, 4b Catch will be deducted from the Subarea 88.1 catch limit.	Y: The catch limit determined by Trend Analysis and its rationale are explained in sections 4a and 4b. The catch limit at new research blocks (RB 11 and 12) is calculated by using the mean CPUE of previous fishing operations at surrounding area (section 4a).
5.2 Are the impacts on dependent and related species accounted for and consistent with Article II of the Convention?	Y: Information about fish and VME by-catch are described in section 4c.	Y: Figure 1, Section 4c	Y	Y: Sections 4b, 4c, Appendix 3 SC-CAMLR-39/BG/03, SC-CAMLR-39/BG/28.	Y: Catch limits for key by-catch species (CM 33-03).
6. Progress towards objectives for ongoing proposals					
6.1 Have the past and current milestones been completed?	Y: Section 1c and WG-FSA-IMAF-2024/24 indicated the achievement of milestones listed in previous research proposals.	Y: Table 5, Section 1c	Previous acoustic data analysis is in process.	Y: WG-SAM-11/16, WG-FSA-12/41, WG-SAM-13/32, WG-SAM-14/25, WG-FSA-14/51, WG-SAM-15/44, WG-SAM-16/14, WG-SAM-17/39, WG-FSA-17/57, WG-SAM-17/01, WG-SAM-18/10, WG-FSA-17/41, WG-SAM-2019/03, SC-CAMLR-39/BG/28, WG-FSA-2021/23, WG-SAM-2022/13, WG-FSA-2022/40, see Appendix 2, WG-FSA-2023/09, see Appendix 3.	Y: Appendix 1

6.2 Has previous advice from the Scientific Committee and its working groups been addressed?	Y: Responses to previous advice are listed in SC-CAMLR-38, para. 3.98. Specific comments from WG-SAM-2024 are addressed in the revised proposal as shown in WG-FSA-IMAF-2024/24.	Y: Report WG-FSA-2019, para. 4.91; WG-SAM-2024, para. 8.15; WG-SAM-2024, para. 8.11.	Y	Y: see papers in table section 3.3.2	Y: WG-SAM-2024, paragraphs 7.7–7.12
6.3 Are all the objectives likely to be completed by the end of the research plan?	Y: Table 1 shows the milestones timeline.	Completion of research objectives is conditional on the continuation of the exploratory fishing activities in Division 58.4.1.	Y	Y: see papers in table section 3.3.2	Y
6.4 Are there any other concerns?	Y: By-catch milestones will be updated to include processing otolith, estimating biological parameters of by-catch species, improving Macrourus and icefish identification for next term.	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 exploratory fishery.	Y: Conditional that the 38-kHz transceiver is installed, operational and calibrated prior to the survey commencing	N	N

Table 10: Location of vertices for the new Research Blocks proposed in 88.3 (see WG-FSA-IMAF-2024/52 Rev. 1 for details).

Research Block	Latitude	Longitude
883_11	-70	-100
	-70	-95
	-71.5	-95
	-71.5	-100
883_12	-70	-95
	-70	-90
	-71.5	-90
	-71.5	-95

Table 11: Station locations in new Research Blocks 88.3_11 and 88.3_12 in Subarea 88.3 for the research plan outlined in WG-FSA-IMAF-2024/52.

Research Block	Station	Lat	Long	Research Block	Station	Lat	Long
883_11	1	-70.6069	-97.2976	883_12	1	-70.4611	-94.4316
883_11	2	-70.6964	-98.1399	883_12	2	-70.3292	-94.9019
883_11	3	-70.7733	-99.3119	883_12	3	-70.5263	-93.6234
883_11	4	-70.4389	-95.7494	883_12	4	-70.4267	-94.6882
883_11	5	-70.4729	-96.0779	883_12	5	-70.4924	-90.3899
883_11	6	-70.8388	-99.7802	883_12	6	-70.5421	-92.1934
883_11	7	-70.705	-98.5216	883_12	7	-70.4837	-90.0991
883_11	8	-70.8152	-99.5501	883_12	8	-70.5337	-91.2385
883_11	9	-70.5559	-96.7709	883_12	9	-70.5098	-90.6548
883_11	10	-70.4605	-95.9149	883_12	10	-70.4679	-94.1684
883_11	11	-70.6046	-96.9217	883_12	11	-70.5711	-92.7014
883_11	12	-70.5744	-96.5368	883_12	12	-70.5745	-90.2323
883_11	13	-70.5444	-96.3667	883_12	13	-70.5902	-90.9498
883_11	14	-70.4382	-95.2195	883_12	14	-70.5657	-93.8966
883_11	15	-70.8286	-99.3114	883_12	15	-70.583	-90.5245
883_11	16	-70.3583	-95.1457	883_12	16	-70.5188	-94.657
883_11	17	-70.7424	-98.8631	883_12	17	-70.6246	-91.2442
883_11	18	-70.5004	-95.8205	883_12	18	-70.558	-94.2141
883_11	19	-70.9	-99.8389	883_12	19	-70.5908	-91.9331
883_11	20	-70.4279	-95.5344	883_12	20	-70.5676	-93.3918
883_11	21	-70.7597	-98.7084	883_12	21	-70.6661	-91.7004
883_11	22	-70.9537	-99.8667	883_12	22	-70.673	-90.767
883_11	23	-70.6544	-97.0468	883_12	23	-70.6837	-90.1802
883_11	24	-70.484	-95.4971	883_12	24	-70.5112	-94.9208
883_11	25	-70.99	-99.5554	883_12	25	-70.7374	-90.5822
883_11	26	-70.6985	-97.7093	883_12	26	-70.6338	-94.097
883_11	27	-70.8478	-99.1298	883_12	27	-70.5938	-92.9705
883_11	28	-70.7553	-98.4355	883_12	28	-70.6897	-91.0347
883_11	29	-70.55	-95.9685	883_12	29	-70.6255	-93.6685
883_11	30	-70.6747	-97.2155	883_12	30	-70.6102	-94.6521

Table 12 Rationale for overarching themes to be developed in coordination between SCARFISH and CCAMLR Working Groups.

Overarching themes	Areas of research	Other relevant SCAR groups
Life history traits	• Biological parameters of by-catch species, including for assessment in the krill and finfish fisheries • Larval fish by-catch species identification and distribution, including range shifts • Reproductive strategies • Ageing.	
Community ecology	• Diet, especially in relation to krill in finfish diet and overall consumption • Isoscapes (stable isotope analysis).	
Connectivity	• Larval fish transport/egg retention in relation to oceanography • Otolith chemistry.	Ant-ICON
Climate Change	• Impacts on early life history, egg and larval distribution • Species range shifts • Predictive species distribution modelling.	SORP AntClim^{now}
Core Habitats	• Species distribution models • Nesting habitats.	EG-ABI
Plastics	• Microplastics in fish diet • Plastics impacting the Antarctic ecosystem.	Plastic-AG
Communication	• Research and Monitoring Plan guidance • Communication with adjacent RFMOs to better understand species range distribution • Help with IUCN review of Southern Ocean species conservation status; • Communicate with SOOS to suggest standardised fish collection protocols • Reference guides, e.g. the next edition of Fishes of the Southern Ocean, and fish larvae guides.	

Table 13: Comparison of strikes observed by video and on deck from vessels that have been taking part in the trial. Norwegian vessels represent four seasons, Shen Lan two seasons and Fu Xing Hai one season.

	Effort			Strikes		BPUE*		
Vessel	Video	Deck	Item	Video	Deck	Video	Deck	Max. BPUE
Antarctic Endurance	877.9	587.0	Warp	32	34	0.036	0.058	Deck
			Cable	15	16	0.017	0.027	Deck
			Warp/Cable	2	1	0.002	0.001	Video
			Mitigation	6	0	0.007	0.000	Video
			Other	6	1	0.007	0.002	Video
Antarctic Sea	573.4	620.4	Warp	8	16	0.013	0.026	Deck
			Cable	3	8	0.005	0.013	Deck
			Warp/Cable	1	2	0.001	0.003	Deck
			Mitigation	0	0	0.000	0.000	NA
			Other	1	1	0.002	0.002	Video
Saga Sea	722.6	587.7	Warp	117	50	0.162	0.085	Video
			Cable	186	233	0.257	0.396	Deck
			Warp/Cable	2	2	0.003	0.003	Deck
			Mitigation	18	3	0.025	0.005	Video
			Other	6	5	0.008	0.009	Deck
Shen Lan	265.3	90.8	Warp	13	2	0.049	0.022	Video
			Cable	5	2	0.019	0.022	Deck
			Warp/Cable	2	0	0.008	0.000	Video
			Mitigation	1	0	0.004	0.000	Video
Fu Xing Hai	233.8	122.9	Warp	21	21	0.090	0.171	Deck
			Cable	0	0	0.000	0.000	NA
			Mitigation	0	1	0.000	0.008	Deck
			other	0	4	0.000	0.033	Deck

* Birds Per Unit Effort – Strikes observed per hour

Table 14: Comparison of strikes observed by video and on deck from Norwegian vessels that have been participating in the trial, season 5 (01/06/2023 – 18/03/2024). Includes extrapolated total estimated strikes, based on a simple approach of hours of trawl effort x observed strikes rates.

	Fishing Effort		**Obs. Effort**			**Strikes**		**BPUE***			**Total**
	Trawl	**Hrs**	**Video**	**Deck**	**Item**	**Video**	**Deck**	**Video**	**Deck**	**BPUE Both**	**Extrapolated Strikes**
AE	3 439	6 878	106.4	165.5	Warp	0	0	0.000	0.000	0.000	0
					Cable	0	0	0.000	0.000	0.000	0
					Both	2	0	0.019	0.000	0.007	101
					Mitigation	0	0	0.000	0.000	0.000	0
					Other	0	0	0.000	0.000	0.000	0
AS	2 896	5 792	87.7	145.0	Warp	0	0	0.000	0.000	0.000	0
					Cable	1	0	0.011	0.000	0.004	50
					Both	0	0	0.000	0.000	0.000	0
					Mitigation	0	0	0.000	0.000	0.000	0
					Other	0	0	0.000	0.000	0.000	0
SS	3 343	6 686	69.8	196.1	Warp	2	13	0.029	0.066	0.056	754
					Cable	17	100	0.244	0.510	0.440	5 884
					Both	0	0	0.000	0.000	0.000	0
					Mitigation	0	0	0.000	0.000	0.000	0
					Other	0	2	0.000	0.010	0.008	101

* Birds Per Unit Effort. AE – Antarctic Endurance. AS – Antarctic Sea. SS – Saga Sea

Table 15: Details on design and specification of MMEDs

	Characteristics of mammal exclusion device(s)	Device 1	Device 2	Other devices used to mitigate incidental capture (e.g., acoustic pingers)
1	Purpose (whale and/or seal exclusion)			
2	Basic design (large mesh panel, escape window, and/or other)			
3	Material(s) from which the device is constructed (synthetic, metal and/or other)			
4	Location in net (mouth, top panel, side panel, belly, and/or codend)			
5	Orientation relative to head rope or beam of the net (vertical, horizontal, and/or oblique)			
6	Maximum dimensions (m) of device (e.g., length, width, depth)			
7	If applicable, mesh size of the excluder device panel (mm, see CM 22-01) or distance (mm) between vertical and/or horizontal elements comprising excluding grid			
8	Diameter or width (mm) of elements comprising excluding grid			
9	If applicable, sensors used to indicate incidental capture of marine mammals (cameras, strain gauges, and/or other)			

Table 16: Annotated table of **WG-IMAF** workplan updated for 2024. Timeframe periods are short = 1–2 years, medium = 3–5 years and long = 5+ years. AI = artificial intelligence, EM = electronic monitoring, MMED = marine mammal exclusion device.

Theme	Task	Timeframe	Contributors	Secretariat participation
1. Review of incidental mortality	1.1 Summary of incidental mortality and interactions at a fine scale (spatial and temporal)	Ongoing	Dr Favero, Mr Walker and Prof. Phillips	Yes
	1.2 Development of a web-based tool to allow examination of interactions and incidental mortality data across CCAMLR fisheries	Medium	Dr Favero, Mr Walker and Prof. Phillips	Yes
2. Marine mammals – incidental mortality	2.1 Refine design of additional data to be collected by observers and crew when whale entanglements occur (see list developed under paragraph 4.17)	Completed	Dr Kelly (IWC Collaboration) and Mr Pardo	Yes
	2.2 Investigate the use of underwater sensor/cameras attached to the net (and AI) to provide information on the occurrence of whale interactions and any subsequent entanglements/capture (continuous)	Short	Dr Kelly (IWC Collaboration), Dr Lowther and Dr Lindstrøm	-
	2.3 Development of data collection protocols for pinniped mortalities and training materials	Completed	Mr Pardo	Yes
	2.4 Review of Elephant seal incidental mortality (including additional information on abundance trends and foraging behaviour for populations affected)	Short	Dr Kelly	Yes
3. Seabirds and Marine mammals – risk assessment	3.1 Consider developing risk assessment and/or overlap analysis for seabirds and marine mammals	Medium	Dr Lindstrøm, Dr Kelly and Prof. Phillips	-
4. Marine mammals – mitigation	4.1 Review designs of marine mammal exclusion devices and develop specifications for those in use in CCAMLR trawl fisheries (including consideration towards a convex shape to the exclusion mesh to deflect whales (and seals) away from the net mouth)	Ongoing	Dr Kelly (IWC Collaboration), Dr Lowther, Mr Pardo and Dr Lindstrøm	-

Theme	Task	Timeframe	Contributors	Secretariat participation
	4.2 Undertake experiments into effectiveness of different MMED designs (for various species) (including performance trials in flume tanks)	Medium	Dr Kelly (IWC Collaboration), Dr Lowther, Dr Lindstrøm and Dr Ying	-
5. Seabirds – incidental mortality	5.1 Power analysis of required observer sampling required for warp strikes	Update if required	Dr Kelly, Dr Hinke and Mr Walker	-
	5.2 Redesign the warp strike observation protocols	Completed	Dr Debski	Yes
	5.3 Exploration of approaches to undertake warp strike extrapolations (Note GAM approach recommended by WG-SAM)	Short	Dr Favero, Dr Hinke and Mr Walker	Yes
	5.4 Review required levels of observer sampling for seabird incidental mortality with longline fishery	Short	Mr Zhu, Dr Kawaguchi	Yes
	5.5 Determine composition of stick water resulting from different processing methods from krill trawlers	Short	Dr Favero	Yes
	5.6 Investigate the effect of stick water as an attractor in the immediate vicinity of the vessel	Medium	Dr Kruger	
	5.7 Develop trawl vessel classification based on deployment configurations of fishing gear, processing states and discharge positions to better understand bird strike variability	Short	Dr Kruger	Yes
6. Seabirds – mitigation	6.1 Consider performance of trawl warp/cable strike mitigation approaches utilised by continuous trawl vessels (including environmental conditions and other factors) including the improvement and specification development for the 'sock' design.	Short	Dr Debski and Dr Arata	-
	6.2 Review existing use of and consider mitigation requirements in conventional trawl vessels and develop specifications for suitable mitigation	Short	Dr Debski and Dr Arata	-
	6.3 Review developments in demersal longline mitigation	Update if required	Ms Livesey, Dr Debski and Mr Arangio/ Mr McNeill	-

Theme	Task	Timeframe	Contributors	Secretariat participation
7. Observer reports and data collection	7.1 Consider IMAF-related tasks for observers in the various CCAMLR fisheries	Ongoing	Mr Clark	Yes
	7.2 Consider use of EM and AI to improve the efficiency of data collection to aid observers	Medium/ Long	Mr Clark	-
8. Marine debris effects on seabird and marine mammals	8.1 Review information on the effect of marine debris on marine mammals and seabirds in the Convention Area	Short	Ms Livesey	Yes
9. Light pollution effect on seabirds	9.1 Consider options for the management of light pollution for vessels fishing in the Convention Area	Update if required	Ms Livesey	-

Table 17: This table provides a summary of tasks recommended by the CCAMLR Climate Change Workshop (WS-CC-2023) for the Scientific Committee to consider while progressing its work on monitoring and formulating management responses to the effects of climate change, to ensure that CCAMLR can continue to meet its objective in Article II of the Convention in a changing climate. Timescale indicates the time needed to complete the task, with "Short" indicating within the next 1-2 years, "Medium" indicating 3-5 years, "Long" indicating 5+ years, and "C" indicating continuous TBD indicates no discussion due to the lack of time available during WS-CC-2023. The original table from WS-CC-2023 (SC-CAMLR-42, Annex 11, Table 1) has been expanded to include updates from WG-FSA-2023, SC-CAMLR-42, WG-EMM-2024 and WG-FSA-2024. Recommendations to WG-FSA are shown in bold (based on information in columns 3, 7 and SC-CAMLR-42).

No.	Task	Suggested WG/fora	Timescale	Priority (H/M/L)	Paragraph (WS-CC-2023)	Progress/plans from WG-EMM-2024	Progress/plans from WG-FSA, to be reviewed and updated at WG-FSA-2024
1	**Work with adjacent RFMOs and RMBs to identify potential for range shifts due to climate change of exploited species/species of interest, and produce a list of species/stocks straddling or likely to straddle CAMLR Convention Area, as well as identifying data sharing needs.**	Secretariat WG-FSA	Short	H	2.24		WG-FSA-2023, paragraph 4.43 WG-FSA-IMAF-2024/31 SIOFA MOU (tagging, etc.) (diet analysis paper – WG-FSA-IMAF-2024/42)
2	Work with relevant RFMOs/RMBs to exchange knowledge of ecosystem impacts of climate change, and lessons learned in incorporating climate change into their activities.	Secretariat	Short (C)	M	2.24	WG-EMM-24, paragraph 9 (workplan table)	
3	Provide public-facing information explaining how climate change variability is included in stock assessments and management of harvested stocks, through a dedicated CCAMLR webpage, and inclusion of information in	Secretariat	Short	H	3.40		

	Fishery Reports (See No. 18 below).						
4	**Identify any non-target species within the CAMLR Convention Area likely to increase in commercial importance.**	WG-EMM	Short	H	2.24	To WG-FSA	Not progress
5	**Review data collection programmes related to the fisheries to ensure they are adequate to detect significant changes in species life history parameters and distribution that affect management.**	WG-FSA (SISO) WG-ASAM WG-EMM	Short	H	2.24 See 3.32	SKEG WG-EMM-2024, paragraphs 5.70; 6.1 (WG-EMM-2024/08), 6.54	WG-FSA-2023, paragraphs 4.42-4.45 WG-FSA-IMAF-2024/39 Fisheries report climate change section. SCARFISH – [CCAMLR managed areas in ecosystem context] Ongoing task
6	**Develop methods to incorporate the effects of projected climate change on assumed recruitment patterns or uncertainty for toothfish recruitment into assessment projections.**	WG-SAM WG-FSA	Medium	M	2.16 2.24 See 3.29	To WG-FSA	WG-FSA-2023, paragraphs 4.42-4.45 WG-FSA-IMAF-2024/63 WG-SAM-2024/25
7	**Develop appropriate parameters for all harvested species (e.g., WS-CC-2023/20, Table 1) to monitor the effects of climate variability/change on parameters and processes relevant to stock assessments.**	WG-FSA WG-SAM	Medium	H	3.35 See 3.30		WG-FSA-2023, paragraphs 4.42–4.45 and Table 5 (see also SC-CAMLR-2.149) In progress
8	**Develop a workflow to incorporate information on the effects of climate change in management advice and alternative management approaches, including long-term change in spatial**	WG-SAM WG-FSA	Medium	M	2.24		WG-FSA-2023, paragraph 4.46 New climate change agenda item in WG-FSA Climate change section in fisheries report Ongoing

	distributions and inclusion of climate change projections.						
9	**Use a risk assessment framework to obtain an initial prioritisation of the likely impacts of climate change on harvested species with focus on regional scale.**	WG-EMM WG-FSA	Short	H	2.11 See 2.10	Unallocated – no progress	WG-FSA-2023, paragraphs 4.41–4.42 (WG-FSA-2023/63) Update on Patagonian toothfish and climate change project (Subarea 48.3) to WG-FSA-2024 No progress
10	**Use a risk assessment framework to obtain an initial evaluation of the likely effects of climate change on dependent and by-catch species.**	WG-EMM WG-FSA	Medium	M	2.11	WG-EMM-2024, paragraphs 3.15 (WG-EMM-2024/36); 6.38 (WG-EMM-2024/35); 6.56 (WG-EMM-2024/P03)	WG-FSA-2023, paragraphs 4.41–4.42 (WG-FSA-2023/63) No progress
11	The Workshop encouraged Members to supply relevant data to SOOS noting that SOOSmap is a data discovery tool, comprising circumpolar standardised, curated data. The Workshop recommended that the Scientific Committee tasks the Secretariat with liaising with SOOS to develop information for use by CCAMLR.	WG-EMM	TBD	TBD	1.15	Ongoing CEMP / environmental data	
12	**The Workshop recommended that the Scientific Committee request advice from SCAR to help develop a framework for using climate models to drive ecological projections for AMLR and dependent and related species.**	WG-EMM WG-FSA	TBD	TBD	1.48	Ongoing, informal SCAR+ groups, created outside CCAMLR Potential reporting into SC. Ant-ICON. Future SCAR groups WG-EMM-2024, paragraph 5.60, CEMP data analysis to engage with the group WG-EMM-2024, paragraphs 6.1 (WG-EMM-2024/08), 6.12, 6.26, 7.16 (WG-EMM-2024/40)	Priority element for SCARFISH

13	The Workshop recommended that the Scientific Committee develop a catalogue of the different types of extreme events, their time scales and the species and life stages that they are likely to affect (building for example on information in WS-CC-2023/12) which would be a useful aid to communicating data needs to climate modellers.	WG-EMM	TBD	TBD	1.52	CEMP Environmental parameters group task. WG-EMM-2024, paragraph 3.85
14	The Workshop recommended that the Scientific Committee consider the development of a risk assessment for management responses to extreme events.	SC WG-EMM	Long	M	3.25	CEMP review discussions, parameters to detect, measure and monitor extreme events. [links to No. 12 above/WS-CC-2023, paragraph 1.48] Ongoing discussion with SCAR groups
15	The Workshop recommended that Scientific Committee collate a list of important variables to be monitored following an extreme event to facilitate a coordinated and timely response to such events and their physical/biological effects both on marine components and land-based predators.	WG-EMM	Medium	H	1.28	CEMP environmental parameters task. SCAR discussion group (WG-EMM-2024, paragraph 6.26) WG-EMM-2024, paragraph 6.38 (WG-EMM-2024/35): crabeater seals WG-EMM-2024, paragraph 3.67 (WG-EMM-2024/18) snow events in 2008/2010 affecting penguin populations
16	The Workshop recommended that the Scientific Committee consider forwarding the report from this Workshop to the CEP in order to assist with planning for the proposed joint CEP/SC-CAMLR workshop.	TBD SC	TBD	TBD	3.18	Done

17	The Workshop recommended that the Scientific Committee include further detail on tasks relevant to climate change in its workplan, with the objective of identifying and progressing the work necessary to ensure that CCAMLR can continue to meet its objectives as stated in Article II of the CAMLR Convention in a changing climate. This work is likely to include research and modelling as well as testing and possible refinement of management approaches.	TBD SC	TBD	TBD	3.39	WG-EMM-2024, paragraphs 5.29, 5.60	
18	The Workshop further recommended that the Scientific Committee identify ways to address the following immediate priorities. Update the fishery reports to include more information on the potential effects of climate change on harvested species and stocks, and management response to these effects; (related to no. 23 below) Develop a web page to explain CCAMLR's response to climate change to the public.	Secretariat	Short	H	3.40		In progress. Provided for assessed stocks at WG-FSA-IMAF-2024
19	Identify specific information requirements and develop requests for information from	SC WG-EMM	Short	M	1.32		Update on SCARFISH (SCAR Action Group on fish) to WG-FSA-2024

	other organisations, such as SCAR or SOOS.						
20	The Workshop welcomed the paper and recognised the importance of collaboration between IWC and CCAMLR, noting that Dr N Kelly (AUS) is the SC-IWC observer to SC-CAMLR and vice versa, and recommended that the collaboration continues, especially noting the importance of considering marine mammals in the current enhancement of the CCAMLR Ecosystem Monitoring Program (CEMP).	WG-EMM	TBD	TBD	1.39	WG-EMM-2024, paragraph 6.35. Ongoing through the CEMP review WG-EMM-2024/34, CCAMLR-IWC collaborations WG-EMM-2024 paragraph 2.12 (WG-EMM-2024/21), encounters of Antarctic krill fishing vessels and air-breathing krill predators	
21	**The Workshop recommended that the Scientific Committee consider how often stock assessment parameters should be updated and noted that reference points may be non-stationary under the effects of climate change.**	TBD WG-FSA	TBD	TBD	2.26		WG-FSA-2023, paragraphs 4.42–4.45 Completed WG-FSA normal procedures when new parameters are presented (they will likely include the effects of climate change)
22	**Consider how information on projected short-term (interannual, multi-year) and long-term (decadal) changes to the recruitment of toothfish should be taken into account in the context of CCAMLR's principles of conservation and decision rules.**	SC WG-SAM WG-FSA	Medium	H	3.29		WG-FSA-2023, paragraphs 4.57–4.58 Short-term Long-term Ongoing

23	**Develop a template for reporting on monitoring of the potential effects of environmental variability and climate change for stock assessments (potentially based on the parameters described in WS-CC-2023/20), for inclusion in the annual CCAMLR Fishery Reports.**	SC WG-FSA	Short	H	3.35		WG-FSA-2023, paragraphs 4.42–4.45 and Table 5 (see also SC-CAMLR-2.149) Further clarification to be developed.
24	**Identify specific climate variables and metrics for which data are already, or could be, collected, that would be useful in communicating the status of AMLR through time.**	WG-EMM WG-SAM WG-FSA	Medium	H	3.15	WG-EMM-2024, paragraph 5.60, 6.1 (WG-EMM-2024/08), 6.14, 6.31, 6.38 (WG-EMM-2024/35), 6.42, 6.65, 6.73 (WG-EMM-2024/38). CEMP review – data analysis e-group, environmental parameters SCAR groups (WG-EMM-2024, paragraph 6.26) WG-EMM-2024 paragraph 6.47 (WG-EMM-2024/30), information for AMLR status reports WG-EMM-2024, paragraphs 3.4 (WG-EMM-2024/05), 5.3, 6.52, 6.71, 7.16 (WG-EMM-2024/40)	WG-FSA-2023, paragraphs 4.42–4.45, 4.181–4.182 SST, sea-ice extent, ecosystem anomalies
25	Develop a glossary of climate related terms and definitions, as well as best practices and standards to aid in the selection and communication of essential variables, climate models and emission scenarios.	SC	Medium	L	3.22	Ongoing via Climate Glossary E-group	

Table 18. Additional work highlighted by the CCAMLR Climate Change Workshop (WS-CC-2023, (SC-CAMLR-42, Annex 11, Table 2)) for consideration within the Scientific Committee's workplan. Timescale indicates the time needed to complete the task, with "Short" indicating within the next 1-2 years, "Medium" indicating 3-5 years, "Long" indicating 5+ years, and "C" indicating continuous. TBD indicates no discussion due to the lack of time available during WS-CC-2023. The original table from WS-CC-2023 (SC-CAMLR-42, Annex 11, Table 2) has been expanded to include updates from WG-EMM-2024 and WG-FSA-IMAF-2024. Tasks most relevant to WG-FSA are shown in bold (based on information in column 3).

No.	Task	Suggested WG/fora	Timescale	Priority (H/M/L)	Paragraph (WS-CC-2023)	Progress/plans from WG-EMM-2024	Progress/plans from WG-FSA-2024
1	Understand causes of extreme weather and climate events, and how particular characteristics of extreme events (intensity, duration etc.) translate into positive or negative impacts on biological processes, including tipping points and cascading effects. Use this understanding to develop monitoring programmes suitable for detecting and monitoring the ecological impact of extreme events.	WG-EMM	Long	M	1.54 See also 1.28, 1.52, 3.25	See Table 1 above	
2	Develop mechanisms, potentially analogous to CM 24-04, to respond to the effects of high impact and/extreme events.	SC	Long	M	1.26		
3	Develop a gap analysis to identify CCAMLR environmental monitoring needs and the potential to source these data or derived metrics from relevant organisations.	WG-SAM WG-EMM	Short	H	1.13	WG-EMM-2024, paragraph 6.53. CEMP, Status of the Environment discussion / data analyses	
4	**Consider approaches used in Arctic fisheries which could be applicable to Antarctic fisheries.**	SC WG-FSA	Short	M	2.2		No progress
5	Continue IWC-CCAMLR information sharing to help inform krill management, for example on food webs and krill consumption rates, whale recovery, abundance and distribution.	SC WG-EMM	Long (C)	M	1.40	See Table 1 above	

6	Understand the physiological effects of climate change on marine species including by-catch in the Convention Area (e.g., skates).	WG-EMM	Long	L	1.36		
7	Establish coordination between ANTOS and CEMP for long-term monitoring programmes (e.g., in the establishment of sentinel monitoring sites).	WG-EMM	Long	M	1.42	WG-EMM-2024, paragraph 6.67	
8	**Monitor benthic communities in tandem with key environmental parameters, in order to understand natural variability and detect and attribute climate change and/or fishing impacts.**	WG-EMM WG-FSA	Medium (C)	L	1.43		No progress Environmental parameters not defined (planned, e.g. fish nest) WG-FSA-IMAF-2024/42 and WG-FSA-IMAF-2024/43
9	Obtain and disseminate expert advice (with SCAR support) on best practices for selecting, using and communicating earth system models, regional climate models and emission scenarios when undertaking ecological projections.	WG-EMM	Short	H	3.8, 3.9, 3.10	See Table 1 above	
10	Investigate impact of uncertainty in trophic effects and climate change on early life stages on uncertainty in CCAMLR Decision Rules.	WG-SAM	Medium	L	1.11		
11	Integrate the likely effects of climate change into the Krill Stock Hypothesis.	WG-EMM	Long	M	1.29	WG-EMM-2024, paragraph 3.28, SKEG	
12	Evaluate, and consider output/results from genomic techniques to detect climate change adaptations, as well as finer stock boundaries for Patagonian or Antarctic toothfish.	WG-EMM	Long	L	1.27		WG-FSA-IMAF-2024/43
13	Identify and protect areas of essential habitat such as fish nest areas and skate egg case nurseries.	SC	Short (C)	H	1.36, 1.37		
14	Use CM 22-06 to examine climate change impacts on VMEs and use	WG-EMM	Medium	L	1.43	Ongoing with CEMP indicators discussion	

	VMEs to monitor changes in ecosystems.						
15	Identify bioregions with faster/slower warming to consider for climate refugia, including the development of definitions associated with refugia.	WG-EMM	Medium	L	2.32	WG-EMM-2024, paragraph 7.19 (WG-EMM-2024/46)	
16	Develop approaches to better communicate uncertainties from complex climate and ecological models and their future projections to managers.	SC	Medium (C)	H	2.5, 3.10, 3.19		
17	Develop a dashboard of standardised "Essential Climate Variables" to monitor for trends or changes in key physical variables which can be linked to species distributions and population level processes. This could be conducted at a regional scale to capture spatial differences.	WG-EMM WG-SAM	Medium (C)	H	3.13	WG-EMM-2024, paragraph 3.15 and Table 1 above. To be considered by CEMP discussions and communication	
18	Engage with SCAR on the further development of guidance on use of climate models, e.g., CMIP models, for the Convention Area.	WG-EMM	Medium	M	3.9	See Table 1 above	
19	**Further develop methods to use existing data to test for trends in key productivity parameters for all stocks with adequate data. New sample collection, approaches and analyses (e.g., new genomic and bioinformatic methods) should also be considered.**	WG-SAM WG-FSA	Medium	H	3.32		WG-FSA-IMAF-2024/43 eDNA
20	Develop models to test for long-term change in the spatial distribution of Southern Ocean fish that are linked to environmental drivers, for example by using spatiotemporal analyses, and based on genomic methods. These models could then be coupled with	WG-SAM	Long	L	3.33		

	future projections of environmental state, e.g., from ESMs, to anticipate change in species distributions.				
21	The Workshop noted that it would be useful to provide information on relevant and prioritised essential variables to the CEP and ATCM, and to national Antarctic programmes.	SC	Short	M	3.17
22	Engage with the ‘Antarctica InSync’ programme to provide input on climate, ocean and ecosystem variables relevant to CCAMLR objectives, and to investigate the potential involvement of fishing vessels.	SC	Short	M	3.38
23	The Workshop noted that the Scientific Committee and its working groups could consider using seasonal climate forecasts on a year-to-year basis to understand the ecological implications of extreme climate conditions occurring in a particular year, and how proactive measures could be taken in advance of extreme events. The workshop noted that this approach is used in other fisheries worldwide, including in the Arctic.	TBD	TBD	TBD	3.26

Table 19: Table summarising evidence for changes in stock assessment and population parameters or processes that could be due to the effects of environmental variability or climate change in the Patagonian toothfish fishery in Subarea 48.3 (WG-FSA-IMAF-2024/29).

Parameter or process			Evidence for trends and potential drivers
1a	Recruitment	Mean recruitment	Results from the groundfish surveys indicate a negative relationship between juvenile toothfish density and summer maximum SST prior to spawning (Belchier and Collins, 2008). Survey data (e.g. Hollyman et al. 2023) suggest that a lower period of recruitment observed during the 2006–2019 surveys may now be coming to an end. Proportion of small (< 90 cm TL) individuals has remained relatively constant from 1997–2021 (Abreu et al. 2024).
1b		Recruitment variability	No information at present, however, the depletion rule (risk of falling below 20% of B_0) is not a constraint in this assessment. Earl et al. (2024) explored estimating autocorrelation in recruitment estimates.
2	Age at maturity		Evidence of increased age at maturity with time from 2009–2021 in females, but not in males (Marsh et al. 2022). Changes cannot be attributed to climate change or environmental variability at present. Size at maturity has remained stable over the last 25 years (Abreu et al. 2024).
3	Stock-recruit relationship		No information at present.
4a	Natural mortality	From direct predation	No information at present.
4b		Not from direct predation	No information at present.
5	Growth rates		Work is ongoing to evaluate changes in growth rate breakpoints with time and bottom temperature. Macleod et al. (2019) and Marsh at al. (2022) showed variability in estimates of growth rate, but no overall trend.
6	Length-weight		No trends in length-weight relationships (Macleod et al. 2019; Marsh at al. 2022).
7	Sex ratio changes		Increase in proportion of females over time likely an artefact of increased fishing depth and not related to climate change (Marsh and Earl, 2023; Abreu et al. 2024).
8	Spatial distribution		Preliminary analysis suggests most dissimilarity in spatial distribution of individuals caught is driven by changes in fishery distribution.
9	Stock structure		TOP at Subarea 48.3 are considered an isolated population, with little connectivity to other subareas (Söffker et al. 2022; Earl et al. 2023). There is currently no evidence of changing stock structure due to climate change or environmental variability.
10	Locations		Biennial groundfish surveys consistently catch the most TOP (largely juveniles) around Shag Rocks (Gregory et al. 2019; Collins et al. 2021 and Hollyman et al. 2023). Spawning hotspot analysis indicates any apparent changes in spawning location are likely driven by changes in fishery distribution rather than being true signals (Bamford et al. 2024).
11	Depredation mortality		Orca and sperm whale presence is recorded and used as a factor in the CPUE standardisation. Estimated orca depredation is included as additional catch in the assessment and projection.

		Estimated depredation has decreased overall since 2000 (Earl et al. 2024, Table 2), though it is unclear if this is related to climate change or environmental variability.

Table 20: Table summarising evidence for changes in stock assessment and population parameters or processes that could be due to the effects of environmental variability or climate change in the Patagonian toothfish fishery in Division 58.5.2 (WG-FSA-IMAF-2024/50).

Parameter or process		Effects of environmental variability/change
Recruitment	Mean recruitment	It is difficult to determine whether there are patterns in recruitment as current analyses related to temporal and spatial variability in the fishing footprint indicated possible issues with tagging data that in turn may have an impact on recruitment estimates derived from the model. Data from the annual fishery independent survey (RSTS) suggests no change in biomass or age class structure of Patagonian toothfish present in waters surveyed.
	Recruitment variability (σR and autocorrelation)	The time series is currently not long enough to evaluate changes in variability, but the depletion rule has not been a constraint in the application of the decision rules in assessments.
Age at maturity		The age at maturity function for HIMI Patagonian toothfish was last re-estimated in 2017 (Yates et al. 2017). There is a current project underway which will allow a re-estimation in the future.
Stock-recruit relationship		The time series of recruitment is not long enough to determine if the stock recruitment relationship is being affected by climate change. Long term monitoring of mean recruitment and its relationship to spawning stock biomass may be able to be used to determine if changes in the relationship occur.
Natural mortality	From direct predation	Not known
	Not from direct predation	Not known
Growth rates		Analysis of length-weight residual patterns across cohorts could be reviewed to consider whether there are any changes in mean size at age.
Length-weight		The length-weight relationship was last estimated in 2019 (WG-FSA-19/32). Comparison to earlier estimates (for e.g. 1999) report similar patterns to this estimate.
Sex ratio changes		Reported annually in RSTS surveys but yet to be investigated in more detail.
Spatial distribution		There have been some changes in fishing effort over time as well as some strong concentration of effort in particular years which make it difficult to determine whether there have been changes in Patagonian toothfish distribution (Masere et al. 2024; Masere and Ziegler, 2024).
Stock structure	Revised	There has been no evidence to suggest the stock structure hypothesis for Patagonian toothfish in HIMI has altered from current stock structure hypotheses.

	Locations of spawning and site fidelity	Not known
Depredation mortality		To date there has been a relatively small amount of depredation documented at HIMI. Further, it seems to be significantly smaller than in other toothfish fisheries (Tixier et al. 2019).

Table 21: Table summarising evidence for changes in stock assessment and population parameters or processes that could be due to the effects of environmental variability or climate change in the mackerel icefish fishery in Division 58.5.2 (WG-FSA-IMAF-2024-36).

Parameter or process	Population	Stock assessment
Recruitment: Mean recruitment, Recruitment variability (σR and autocorrelation)	Icefish surveys show high interannual variability in year class strength. The drivers for interannual changes in recruitment have not been fully explored. Maschette and Welsford (2019) provided and initial hypothesis for the apparent shift in recruitment which occurred between 2008–2011.	Stock assessments for icefish assume no future recruitment in the two-year projection period. The stock assessments are based on the most recent estimate of recruitment from an annual trawl survey and therefore account for interannual variability in recruitment.
Biomass	As a result of highly fluctuating recruitment the population has shown highly variable biomass through time showing up to three-fold increases or decreases from one year to another (See appendix B2).	The lower one-sided 95th confidence interval from a bootstrapped biomass estimate from the most recent trawl survey is used as the initial biomass in the stock assessment. This is done to account for the large interannual variability in observed in biomass estimates.
Length at maturity	Length at maturity has been investigated as part of Maschette et al. (2024), and has shown fluctuation in the size of maturity through time for both males and females with a generally increasing size of 50% maturity since 2008.	There is no maturity component in the stock assessment.
Stock-recruit relationship	The relationship between spawning stock and recruitment has not been thoroughly investigated.	Due to the stock assessment having no recruitment component there is no stock-recruitment relationship in the stock assessment.
Natural mortality	Natural mortality is uncertain. De la Mare (1998) estimated M to be around 0.30 for age 2 and above, and 0.64 for age 3 and above based on a Heincke estimate for survivorship from age a to all older ages but acknowledge that these estimates were highly uncertain due to recruitment and sampling variability.	Within the stock assessment M is fixed at 0.4.
Growth rates	Growth rates appear to have changed through time, with an increasing asymptotic average length ($L\infty$) and a decreasing growth rate coefficient (K) (Maschette et al. 2024).	Within the time series of assessments growth has been estimated four times, as part of the 1997, 2010, 2017 stock assessments and in Maschette et al. (2024).
Length-weight relationship	Annual Length-Weight relationships have shown some fluctuation through time although this is likely due to the presence or absence of size classes in the population (Maschette et al. 2024).	In the stock assessment, estimates from the most recent trawl survey are used.
Sex ratio changes	No evidence of changes in sex ratio in the survey data through time (Maschette et al. 2024).	The stock assessment is an unsexed model.
Spatial distribution	No evidence in the change of spatial distribution through time has been observed (Maschette et al. 2024).	The stock assessment has no spatial components in the model.
Stock structure	Within Division 58.5.2 there have historically been three populations hypothesised. One on Shell Bank to the east of the plateau, one on Pike Bank to the north-west of the plateau and one on the southern part of the plateau centred on Gunnari Ridge.	

	The Pike bank population was heavily over fished prior to the establishment of the Australian and French EEZs and shows little signs of recovery. The fishery is limited to the population on the southern part of the plateau. Gunnari Ridge consistently shows the largest aggregations of adult icefish with Plateau Southeast and Platea West showing a patchier distribution with all age classes present.
Locations of spawning and site fidelity	Gunnari Ridge is the primary area for spawning mackerel icefish. Icefish seem to move in and out of this area throughout the year.

Table 22: Table summarising evidence for changes in stock assessment and population parameters or processes that could be due to the effects of environmental variability or climate change in the Patagonian toothfish fishery in Division 58.5.1 (WG-FSA-IMAF-2024-63).

Parameter or process	Evidence for trends and potential drivers
Recruitment	The assessment model shows decreasing trends of recruitment, since 2007 (Massiot-granier et al., 2024a). This trend could be a sign of a regime shift and a change of productivity. Further investigation is needed to confirm this hypothesis and assess the causes of this decrease (fishing, climate change, etc).
Age at maturity **2024 stock assessment values:** **a50 = 9.25** **ato95 = 8.07**	Patterns of age at maturity from 2007 to 2023 show no evidence of trends over time (WG-FSA-IMAF-2024/63, Figure 3 and 4). However, estimations of a50 for females and males separately indicate that females become mature long after the males. In the stock assessment models, maturity is common to males and females. Therefore, maturity parameters might change over time due to changes in sex ratio.
Stock-recruit relationship	Recruitment is assumed to follow a Beverton-Holt relationship, whereby the stock recruitment (SR) is a function of the spawning stock biomass (SSB), the pre-exploitation equilibrium unfished spawning stock biomass (B_0), and the parameter steepness h, defined as $h = SR(0{,}2B_0)$ $$SR(SSB) = \frac{SSB}{B_0} \Big/ \left(1 - \frac{5h-1}{4h}\left(1 - \frac{SSB}{B_0}\right)\right)$$ Series of recruitment is too short to analyse potential changes of the stock-recruitment relationship due to climate change. Furthermore, comparing recruitment estimates with a recruitment series obtained with surveys (fishery-independent) would help to investigate variations of the stock-recruitment relationship.
Natural mortality	Not known.
Growth rates **2024 stock assessment values:** **k = 0.0662** **t0 = -1.12** **Linf = 170**	Except for years 2013, 2014 and 2015, for which estimated values of t_0 are lower, there is no temporal trend of growth (WG-FSA-IMAF-2024/63, Figures 7 and 8).
Length-weight	Patterns of length-weight relationship show that females tend to have a higher condition (higher weight/length ratio) in the most recent years. This pattern may result from increased sampling of mature females during the reproductive period and will be investigated further. No evidence or variability over time of length-weight relationship is showed for the males (WG-FSA-IMAF-2024/63, Figure 11).
Sex ratio changes	Since 2016, inter-annual changes of sex-ratio can be observed, with males-biased catches in the most recent years (2020–2021–2022), Figure 12. However, the proportion of males in the catch does not exceed 57% during the period 2007–2022 and 54.8% in the last three years.
Spatial distribution	Recent analysis of fishing effort data was conducted (Le Clech, 2024; Masere et al. 2024). Further investigation is needed to assess if the spatial distribution itself has changed.
Stock structure	There is no evidence to suggest that the stock structure for Patagonian toothfish in Kerguelen has changed.

Locations of spawning and site fidelity	Ongoing work is conducted to assess spawning locations. Data are too poor to estimate a site fidelity among the years.
Depredation mortality	No significant trend has been observed, with the depredation rate fluctuating around 4.5%.

Table 23: Table summarising evidence for changes in stock assessment and population parameters or processes that could be due to the effects of environmental variability or climate change in the Antarctic toothfish fishery in Subareas 88.1 and 88.2A-B (WG-FSA-IMAF-2024-71).

1a	Recruitment	Mean recruitment	Patterns in recruitment from the assessment model showed no evidence of trend over time (Dunn and Devine 2024).
1b		Recruitment variability (σ_R and autocorrelation)	The time series is currently not long enough to formally evaluate changes in variability, but the depletion rule was not a constraint in the application of the CCAMLR decision rules in the most recent assessment (Dunn and Devine 2024). Recruitment patterns have indicated an approximate decadal cycle and yield calculations propose using recent 10-years estimated recruitment where this was lower than the historical mean recruitment (Dunn and Devine 2024).
2	Age at maturity		No analyses have investigated potential changes in age or length at maturity (Parker and Marriott 2012).
3	Stock-recruit relationship		Recent recruitments are consistent with the stock relationship recruitment assumptions, but the time series of recruitment is not long enough to determine if the stock recruitment relationship was affected by climate change (Dunn and Devine 2024). Long term monitoring of mean recruitment and its relationship to spawning stock biomass may be able to be used to determine if changes in the relationship occur in future years.
4a	Natural mortality	From direct predation	Not known
4b		Not from direct predation	Not known
5	Growth rates		Age-length residual patterns across cohorts suggest that there have been small long-term fluctuations in mean size at age, following a roughly decadal cycle (Dunn & Parker 2019).
6	Length-weight		Patterns of length-weight relationship showed no evidence of trends or variability over time (Dunn & Parker 2019).
7	Sex ratio		No evidence of changes in sex ratio in the catch or the changes RSSS that may be explained by climate change (Devine 2024).
8	Spatial distribution		No evidence of a change in the spatial distribution for distribution Antarctic toothfish in the Ross Sea region from the analysis of fishing effort data (Devine 2024). However, any changes in spatial distribution outside the historical fishing footprint are not known.
9	Stock structure		No new evidence to suggest the stock structure hypothesis for Antarctic toothfish in the Ross Sea has altered from current stock structure hypotheses (Hanchet et al. 2008).
10	Locations of spawning and site fidelity		Not known
11	Depredation		No evidence for any changes in rates or occurrence of mortality depredation from either fisher or observer observations - only rare instances of depredation mortality have been observed in the Ross Sea (Devine 2024).

Table 24: Annotated table of **WG-FSA** workplan updated for 2024. Items tasked to WG-FSA from the Scientific Committee Strategic Plan (SC-CAMLR-41, Table 8). Numbers refer to the numbering in the original tables. DSAG – Data Services Advisory Group, SISO – Scheme of International Scientific Observation, AUS – Australia, CHN – People's Republic of China, ESP – Spain; FRA – France, JPN – Japan, KOR – Republic of Korea, NZ – New Zealand, ZAF – South Africa, UK – United Kingdom, USA – United States.

Theme	Priority research topic	Priority research topic task	Timeframe	Contributors	Secretariat participation
1. Target species	(a) Develop methods to estimate total fish by-catch for the krill fishery	(iii) Data collection – SISO, vessels Priority: High	2024–2025	Secretariat	Yes
	(b) Develop stock assessments to implement decision rules for krill	(i) Krill management approach (synthesis of krill recruitment, spatial scale, krill flux, biomass estimates, predator risk) Priority: High (1) Subarea 48.1 (2023) Priority: High (2) Other areas (48.2 and 48.3) Priority: High	2024–2025	WG-ASAM-2024/ WG-EMM-2024	Yes
		(ii) Methods to account for uncertainty in stock status Priority: Low			
		(iii) Develop krill management approach as a multiannual cycle Priority: Medium	Upon completion of (i)		
		(iv) Krill management strategies that are robust to climate change Priority: High	2027	WG-SAM-2027/ WG-EMM-2027	Yes

Theme	Priority research topic	Priority research topic task	Timeframe	Contributors	Secretariat participation
	(c) Develop methods to estimate biomass for finfish	(i) Data collection – SISO and vessels Priority: High			
		(1) Conversion factors Priority: mostly done	2025	Secretariat, FRA and NZ	Yes
		(2) Tagging protocols Priority: done	2023	Dr Jones/Mr Arangio	Yes
		(3) Ross Sea data collection program update Priority: Medium	2025	All involved Members (NZ Lead)	Yes
		(ii) Accounting for potential spatial bias in assessments. Priority: Urgent	2024–2025	WG-SAM and Members	
(c.1)	Connectivity of target and non-target species using new technologies	(i) Pop-up satellite tag investigations (ii) Otolith microchemistry (iii) Microsatellite markers and population genomic analyses (iv) Emerging technologies Priority: Low/Medium	2025–2028	All involved Members	
	(d) Develop stock assessments to implement decision rules for finfish target species	(i) Research to develop new assessments Priority: Low		WG-SAM	
		(1) Research plan evaluations Priority: Required	Annual	WG-SAM/WG-FSA	Yes
		(2) Subarea 88.2 fishery structure Priority: Low	2027 2023–2027	(NZ lead) All involved Members	Yes
		(3) Stock structure and connectivity (cross ref modelling of spatial structure, done in Areas 48, 58 and Subareas 88.1 and 88.2) Priority: Low		JPN/NZ/CHN/KOR/USA Members	Yes

Theme	Priority research topic	Priority research topic task	Timeframe	Contributors	Secretariat participation
		(ii) Develop new assessment tools			
		(1) Casal2 development Priority: done	2023–2025	NZ/All involved Members	
		(2) Casal2 data limited assessment. Priority: high	2024-2025	ZAF, ESP, JPN and other Members	Yes
		(iii) Provide precautionary catch limits Priority: Required	Annual	WG-FSA regular updates	Yes
		(iv) Developing sex disaggregated assessment models for areas with combined sex assessments Priority: Medium	2026	Members	
	(e) Management strategy evaluations for target species (Second Performance Review, Recommendation 8 independent review)	(ii) Development and testing of data-limited fishery decision rules Priority: Medium	2024–2025	Interested Members (WG-FSA-2024, paragraph 7.2)	Yes
		(iii) Finfish management strategies that are robust to climate change Priority: Urgent	2024	AUS/NZ/UK Interested Members	Yes
		(iv) Analysis of current and alternative decision rules Priority: High (see also WG-SAM-2024 Table 2, then 1, task (e)(i))	2024	Members and WG-SAM-2024	Yes

Theme	Priority research topic	Priority research topic task	Timeframe	Contributors	Secretariat participation
	(f) Refine stock assessment procedures	i) Improve methods for inclusion of ageing data, e.g.: • Determining the CVs on the age compositions and effective sample sizes Priority: Medium • Determining the effect of different target levels of precision for age determination, Priority: Medium ii) Incorporating environmental and ecosystem parameters in toothfish population models Priority: Medium iii) Investigate the impact of covarying productivity parameters. Priority: Medium	2024–2028 2024–2025 2026–2027	WG-SAM	
		iv) Continuing development of stock assessment diagnostics Priority: ongoing v) Developing methods to validate and pool multimember age data • Determining how differences in toothfish growth over time impacts the interpretation of age from otoliths Priority: ongoing	2026–2027 2026–2027		Y
2. Ecosystem impacts	(a) Ecosystem monitoring (Second Performance Review, Recommendation 5)	(i) Structured ecosystem monitoring programs (CEMP, fishery) (2) Fishery via SISO Priority: Medium (3) Research surveys Priority: Medium / High		Regular monitoring Members fishing under CM-24-01 Surveys	Yes

Theme	Priority research topic	Priority research topic task	Timeframe	Contributors	Secretariat participation
		(iii) Invasive species Priority: Low			
	(c) By-catch risk assessment for krill and finfish fisheries	(i) Monitoring status and trends Priority: High	Annual	Secretariat	
		(ii) By-catch species catch limits Priority: High	2026	Members	
		(iii) Review of by-catch decision rules Priority: Medium	2027		
		(iv) By-catch mitigation methods Priority: Low	2026	Members	
		(v) Improving species identification Priority: High • Identification guides • Identification data	Annual	Members	
		(vi) Biological parameters of by-catch species Priority: High	2026	SCARFISH Members	
	(d) Habitat protection from fishing impacts	(i) Habitat classification, bio-regionalisation and monitoring Priority: Low			
		(ii) VME identification and management Priority: Low	2025	Members	Yes

Theme	Priority research topic	Priority research topic task	Timeframe	Contributors	Secretariat participation
		(iii) Protection of biodiversity and ecosystems (Second Performance Review, Recommendation 7) (1) Ecosystem impacts from krill and finfish fishing, including analyses whether research and sampling design is able to detect such impacts Priority: Low (2) Physical disturbance of longline fishing on benthic ecosystems Priority: Low (3) Suitability of reference areas for comparison between fished and unfished areas Priority: Medium	2027	Members and WG-EMM	Yes
	(e) Monitoring and adaptation to effects of climate change, including acidification	(i) Develop methods to detect change in ecosystems given variability and uncertainty (Second Performance Review, Recommendation 6) Priority: Medium		Members and WG-EMM	
Administrative topics	(a) Advise on database facilities required through DSAG Priority: ongoing		Annual	DSAG	Yes
	(b) Advise on quality control and assurance processes for data provided to and supplied by the Secretariat Priority: ongoing		Annual	DSAG	Yes

Theme	Priority research topic	Priority research topic task	Timeframe	Contributors	Secretariat participation
	(c) Refine the scheme of international scientific observation (SISO) for: (1) finfish Priority: Medium/ High (2) krill Priority: High		2027 2024–2025		Yes
	(d) Further develop data management systems Priority: Medium	(1) Quality assurance Priority: ongoing	Annual	DSAG	Yes
		(2) DOI Priority: Low		DSAG	Yes
		(3) Review Data access rules Priority: Low		DSAG	Yes
	(e) Communication of progress, internal and external Priority: ongoing		Annual	Convener	Yes
	(f) Working group terms of reference Priority: Done		2022	SC-CAMLR-41	Yes
	(g) Scientific Committee Symposium in 2027 (Include annual review) Priority: Medium		2027	SC Chair	Yes

Figures

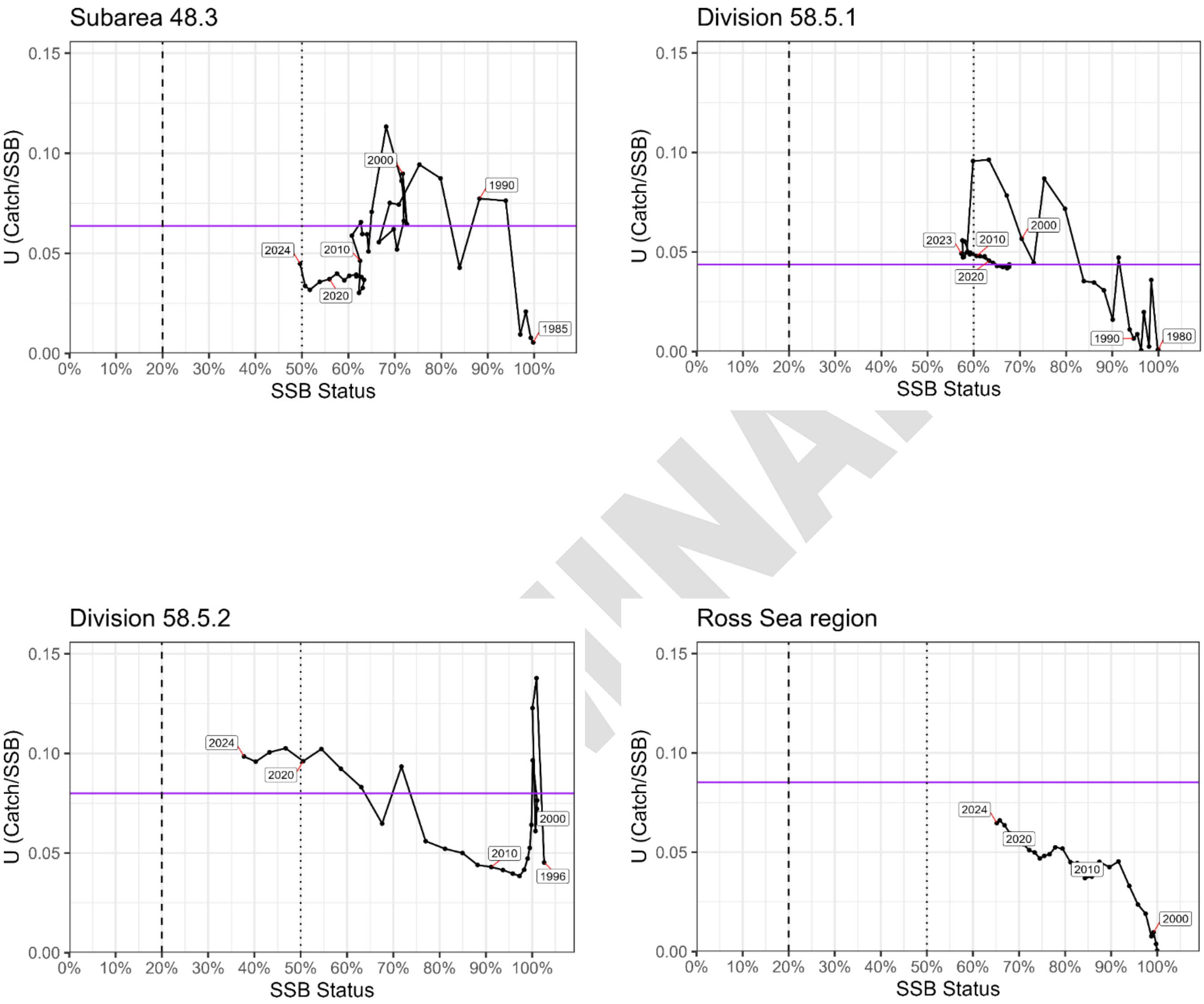

Figure 1: Kobe plot for the Subarea 48.3, Division 58.5.1, Division 58.5.2 and Ross Sea region fisheries. Dashed lines indicate the 20% depletion limit, dotted lines indicate the 50% (60% for 58.5.1) target, and purple lines indicate the harvest rate that would be expected to reach and maintain the target in the long term.

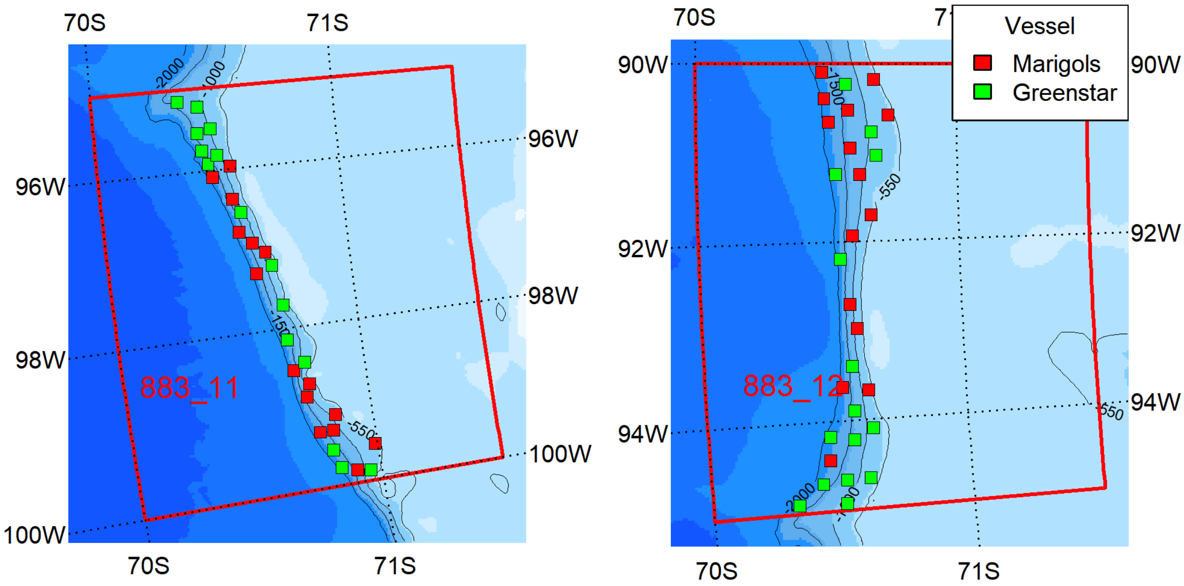

Figure 2: Station locations in new Research Blocks 88.3_11 and 88.3_12 in Subarea 88.3 for the research plan outlined in WG-FSA-IMAF-2024/52.

Appendix A

List of Participants

Working Group on Fish Stock Assessment and Incidental Mortality Associated with Fishing
(Hobart, Australia, 29 September to 11 October 2024)

Chair	Dr Marco Favero National Research Council (CONICET, Argentina)
Chair	Mr Nathan Walker Ministry for Primary Industries
Chair	Mr Sobahle Somhlaba Department of Agriculture, Forestry and Fisheries
Argentina	Mr Manuel Novillo CONICET (Consejo Nacional de Investigaciones Científicas y Técnicas)
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	Dr Eunjung Kim National Institute of Fisheries Science
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	Professor Hyun-Woo Kim Pukyoung National University
	Professor Hyuk Je Lee Sangji University
	Dr Sangdeok Chung National Institute of Fisheries Science (NIFS)
	Mr Sang Gyu Shin National Institute of Fisheries Science (NIFS)
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	Mr Alistair Dunn Ocean Environmental
	Mr Jack Fenaughty Silvifish Resources Ltd
	Mr Enrique Pardo Department of Conservation
Norway	Dr Ulf Lindstrøm Institute of Marine Research

	Mr James Clark MRAG
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	British Antarctic Survey
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	Dr Mark Belchier British Antarctic Survey
	Ms Lisa Readdy Centre for Environment, Fisheries and Aquaculture Sciences (Cefas)
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	Dr Erica Mason NOAA
	Dr George Watters National Marine Fisheries Service, Southwest Fisheries Science Center
	Dr Jefferson Hinke National Marine Fisheries Service, Southwest Fisheries Science Center

Appendix B

Agenda

Working Group on Fish Stock Assessment
(Hobart, Australia, 1 to 13 October 2023)

1. Opening of the meeting
   - 1.1 Introduction
   - 1.2 Adoption of the agenda
   - 1.3 Review of the work plan
   - 1.4 Review of CCAMLR fisheries in 2023/2024 and notifications for 2024/2025
2. Krill
3. Icefish
   - 3.1 *Champsocephalus gunnari* in Subarea 48.3
   - 3.2 *Champsocephalus gunnari* in Division 58.5.2
   - 3.3 Research plans submitted under CM 24-01 targeting *Champsocephalus gunnari* in Subarea 48.2
4. Toothfish
   - 4.1 General toothfish issues
     - 4.1.1 Biology, and ecology of target species
     - 4.1.2 Age determination for toothfish
     - 4.1.3 Conversion factors for toothfish
   - 4.2 Toothfish stock assessment workplan
     - 4.2.1 Focus topic of spatial bias in tag-based assessments
     - 4.2.2 Development of management strategy evaluations
     - 4.2.3 *Dissostichus eleginoides* in Subarea 48.3
     - 4.2.4 *Dissostichus eleginoides* in Division 58.5.1

4.2.5. *Dissostichus eleginoides* in Division 58.5.2

4.2.6 *Dissostichus mawsoni* in Subarea 88.1 and SSRUs 882AB

4.2.7 *Dissostichus eleginoides* in Subarea 48.4

4.2.8 *Dissostichus mawsoni* in Subarea 48.4

4.3 Exploratory Fisheries with research plans

4.3.1 *Dissostichus mawsoni* in Subarea 48.6

4.3.2 *Dissostichus mawsoni* in Subarea 58.4.1/2

4.3.3 *Dissostichus mawsoni* Subarea 88.2

4.4 Research plans targeting toothfish notified under CM 24-01

4.4.1 *Dissostichus mawsoni* in Subarea 88.1

4.4.2 *Dissostichus mawsoni* in Subarea 88.3

4.5 Other areas (58.4.3a, 58.4.3b and regions of 58.5.1, 58.5.2, 58.6, 58.7 outside national jurisdiction)

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

5.1 Fish bycatch (macrourids, skates, other)

5.2 By-catch management in krill fisheries

5.3 VME management and habitants of particular concern

5.4 Incidental mortality associated with fishing (IMAF)

5.4.1 Review of current and emerging incidental mortality issues in CCAMLR fisheries

5.4.2 Reporting on net monitoring cable trial on continuous trawlers

5.4.3 Mitigation methods for marine mammals

5.4.4 Mitigation methods for seabirds

5.4.5 Data collection needs from seabird and marine mammal interactions

5.4.6 Review of WG-IMAF work programme and future work

6 Scheme of International Scientific Observation

7 Future work

8 Other business

9 Advice to the Scientific Committee

10 Adoption of the report and close of meeting

Appendix C

List of Documents

Working Group on Fish Stock Assessment
and Incidental Mortality Associated with Fishing
(Hobart, Australia, 30 September to 11 October 2024)

WG-FSA-IMAF-2024/01	Stick water as potential seabird attractor to krill fishing operations: a review of evidence addressing olfactory cues used by Procellariforms for navigation and foraging Favero, M.
WG-FSA-IMAF-2024/02	Report of the incidental capture of a humpback whale (*Megaptera novaeangliae*) by the traditional Chilean krill trawler Antarctic Endeavour in CCAMLR Subarea 48.2 during the 2023/24 fishing season Delegation of Chile
WG-FSA-IMAF-2024/03	CCAMLR's revised krill fishery management approach in Subareas 48.1 to 48.4 as progressed up to 2023 Working Group on Ecosystem Monitoring and Management and CCAMLR Secretariat
WG-FSA-IMAF-2024/04	Baleen whales and fishing for Antarctic krill: a project to develop best practices in mitigation through understanding the role of fishing gear, operational overlap and current mitigation efficacy Lowther, A., F. Santa Cruz, U. Lindstrøm, B. Krafft, M. Biuw, P. Skogrand and J. Arata
WG-FSA-IMAF-2024/05	Fish by-catch in the krill fishery – 2024 update CCAMLR Secretariat
WG-FSA-IMAF-2024/06	Antarctic toothfish (*D. mawsoni*) age determination: methodical aspects Misar, N.
WG-FSA-IMAF-2024/07	Comments on Krill Biological Sampling with regards to SISO Observers on Krill Fishing Vessels Kasatkina S. and S. Sergeev
WG-FSA-IMAF-2024/08	Krill length and biological compositions in Subarea 58.4.2 based on Russian scientific observations Korzun Yu.., N. Kukharev and N. Misar

WG-FSA-IMAF-2024/09	A proposed update to gear diagrams contained in Conservation Measure CM 25-02 CCAMLR Secretariat
WG-FSA-IMAF-2024/10	Summary of Incidental Mortality Associated with Fishing activities data collected during the 2024 season, and updated extrapolated IMAF and warp strikes. CCAMLR Secretariat
WG-FSA-IMAF-2024/11 Rev. 1	Implementation of the CCAMLR Scheme of International Scientific Observation during 2023/24, updates of forms and instructions for season 2025 and development of a recognition for krill fishery observers CCAMLR Secretariat
WG-FSA-IMAF-2024/12	2024 trend analysis: Estimates of toothfish biomass in Research Blocks CCAMLR Secretariat
WG-FSA-IMAF-2024/13	An integrative taxonomy approach for the identification of fish bycatch in the Antarctic krill fishery Romero-Martinez, M.L., W.D.K. Reid, M.A. Collins, W.P. Goodall-Copestake, J.M. Clark, B. Viney and P.R. Hollyman
WG-FSA-IMAF-2024/14	Progress with recommendations from the CCAMLR Workshop on Climate Change Cavanagh, R. and E. Pardo
WG-FSA-IMAF-2024/15	Defining the relationship between Patagonian toothfish and their environment in Subarea 48.3 Cavanagh, R., T. Jones, J. Cleeland, P. Hollyman, S. Thorpe and M.A. Collins
WG-FSA-IMAF-2024/16	CCAMLR contributions to FAO Status of Fisheries reporting CCAMLR Secretariat
WG-FSA-IMAF-2024/17	Reviewing stock hypothesis of Antarctic toothfish (*Dissostichus mawsoni*) as a part of 2021/22-2023/24 research plan in Subarea 48.6 Okuda, T., M. Mori, R. Sarralde Vizuete and S. Somhlaba
WG-FSA-IMAF-2024/18	Sensitivity analysis of single-sex and age-structured stock assessment model of Antarctic Toothfish (*Dissostichus mausoni*) at Subarea 48.6 Mori, M. and T. Okuda

WG-FSA-IMAF-2024/19	Review of grenadier species-level data as longline bycatch in Subarea 48.6 Sawada, K., M. Mori and T. Okuda
WG-FSA-IMAF-2024/20	PSAT deployment in Subarea 48.6 Okuda, T. and R. Sarralde Vizuete
WG-FSA-IMAF-2024/21	Updated biological parameters of Antarctic Toothfish (*Dissostichus mawsoni*) at Subarea 48.6 with experimental correction of age datasets Mori, M. and T. Okuda
WG-FSA-IMAF-2024/22	Trial to identify daily growth increments in the otolith of a toothfish Okuda, T., M. Tanaka and K. Omote
WG-FSA-IMAF-2024/23	Revised new research plan for Antarctic toothfish (*Dissostichus mawsoni*) exploratory fishery in Statistical Subarea 48.6 from 2024/25-2027/28): Research Plan under CM21-02, paragraph 6(iii) Delegations of Japan, Republic of Korea, South Africa, and Spain
WG-FSA-IMAF-2024/24	Report of research fishing operations at Subarea 48.6 between the 2012/13 and 2023/24 fishing seasons Delegations of Japan, Spain, and South Africa
WG-FSA-IMAF-2024/25 Rev. 1	Continuing research in the *Dissostichus mawsoni* exploratory fishery in East Antarctica (Divisions 58.4.1 and 58.4.2) from 2022/23 to 2025/26; Research plan under CM 21-02, paragraph 6(iii) Delegations of Australia, France, Japan, Republic of Korea and Spain
WG-FSA-IMAF-2024/26	Report on exploratory fishing in Divisions 58.4.1 and 58.4.2 between the 2011/12 and 2022/23 fishing seasons Maschette, D., C. Masere and P. Ziegler
WG-FSA-IMAF-2024/27	Integrated approach to modeling krill population dynamics in the Western Antarctic Peninsula: spatial and ecosystem considerations Mardones, M., L. Krüger, F. Santa Cruz, C. Cárdenas and G. Watters
WG-FSA-IMAF-2024/28	Accounting for spatial trends in fishing within the assessment of Patagonian Toothfish (*Dissostichus eleginoides*) in Subarea 48.3 Earl, T., L. Readdy and S. Alewijnse

WG-FSA-IMAF-2024/29	Assessment of Patagonian Toothfish (*Dissostichus eleginoides*) in Subarea 48.3 Earl, T., L. Readdy and S. Alewijnse
WG-FSA-IMAF-2024/30	Assessment of Patagonian Toothfish (*Dissostichus eleginoides*) in Subarea 48.3: Assessment Diagnostics Earl, T. and L. Readdy
WG-FSA-IMAF-2024/31	Preliminary tag-recapture based population assessment of Antarctic toothfish (*Dissostichus mawsoni*) in Subarea 48.4 - 2024/25 fishing season Readdy, L. and T. Earl
WG-FSA-IMAF-2024/32	Assessment models for Antarctic toothfish (*Dissostichus mawsoni*) in the Ross Sea region to 2023/24 Dunn, A. and J. Devine
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WG-FSA-IMAF-2024/34	Diagnostic plots for the assessment for Antarctic toothfish (*Dissostichus mawsoni*) in the Ross Sea region to 2023/24 Dunn, A. and J. Devine
WG-FSA-IMAF-2024/35	Estimation of release survival of Patagonian toothfish *Dissostichus eleginoides* Devine, J. and M.J. Underwood
WG-FSA-IMAF-2024/36	A preliminary assessment for mackerel icefish (*Champsocephalus gunnari*) in Division 58.5.2, based on results from the 2024 random stratified trawl survey Maschette, D. and P. Ziegler
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WG-FSA-IMAF-2024/44	Update on ACAP activities and advice Agreement on the Conservation of Albatrosses and Petrels
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WG-FSA-IMAF-2024/47	Incorporating spatial and temporal change in fishing and tagging effort into integrated stock assessments Masere, C., D. Maschette and P. Ziegler
WG-FSA-IMAF-2024/48	Marking fishing gear on Ukrainian longline vessels Delegation of Ukraine
WG-FSA-IMAF-2024/49	Inferring Patagonian toothfish dispersal from circadian rhythm in swimming behavior Kim, E. and C.H. Lam

WG-FSA-IMAF-2024/50	Integrated stock assessment for the Heard Island and McDonald Islands Patagonian toothfish (*Dissostichus eleginoides*) fishery in Division 58.5.2 Masere, C. and P. Ziegler
WG-FSA-IMAF-2024/51	Net Monitor Cable mitigation devices on krill vessels Clark, J.M., B. Viney, B. Hanlan, U. Lindstrøm and B.A. Krafft
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CCAMLR-43/BG/10	Reconciliation of CDS data with monthly fine-scale catch and effort data CCAMLR Secretariat
SC-CAMLR-43/11	Report of the Working Group on Acoustic Survey and Analysis Methods (WG-ASAM-2024) (Cambridge, UK, 20 to 24 May 2024)
SC-CAMLR-43/12	Report of the Working Group on Statistics, Assessment and Modelling (WG-SAM-2024) (Leeuwarden, The Netherlands, 24 to 28 June 2024)
SC-CAMLR-43/13	Report of the Working Group on Ecosystem Monitoring and Management (WG-EMM-2024) (Leeuwarden, The Netherlands, 1 to 12 July 2024)

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Appendix D

Proposal for a third CCAMLR workshop on age determination methods

Title: 3rd CCAMLR Age Determination Workshop (WS-ADM3-2025)
Objectives:

1. To develop reference sets with agreed ages for both species of toothfish.
    a. Work with Members to create otolith reference sets for age determination of toothfish.
    b. Outline uses of otolith reference sets as a training tool for new readers.
2. To develop best practice standards for the age preparation methods (especially for age programs supporting stock assessments) including imaging, image diagnostic procedures, age validation analyses, calibration diagnostics, and age database structure and use.

Terms of Reference:

1. Bring together experts to continue to understand differences in otolith interpretation and age estimation, including to conduct comparisons of age reading from static images and physical samples to quantify any differences in age readings and/or biases from different methods.
2. Continue work developing otolith reference collections for both Patagonian and Antarctic toothfish (with agreed ages), where reference sets images and associated ageing data will be held by the Secretariat. The database, developed by the Secretariat to hold the images and associated metadata, will be populated with reference set data submitted by members in advance of the workshop, to test that the database will be fit for purpose during the workshop.
3. Further progress the methodologies for pooling age data among laboratories, including to develop protocols, diagnostics, and procedures for calibration procedures for otoliths to be used in future inter-reader and inter-lab comparisons.
4. Develop the new CCAMLR otolith network arrangements to continue intersessional work
5. Preparations for the workshop will entail otolith preparation and data analysis by Members, to be coordinated intersessionally via SC-CIRC and the existing Discussion Group "CCAMLR Otolith Network".

Convener(s): Dr J. Devine (New Zealand), Dr. C. Brooks (USA), Dr. P. Hollyman (United Kingdom)
Venue: BAS, Cambridge (UK)
Date: 19-23 of May 2025
Duration: 5 days
Invited experts: TBA
Observers or external organisations: None
Funding required by CCAMLR: A$15 000 to support invited experts travel related costs.
Secretariat Support required: Yes – Data Officer and Science Manager
Ability to submit papers: Not required
Outputs: Draft conveners report to WG-SAM-2025 and final report to WG-FSA-2025 summarising the data, outcomes, and recommendations from the ToRs of the workshop.
Reported to: WG-SAM-2025 and WG-FSA-2025

Appendix E

Final report of the co-conveners of the
2nd CCAMLR Ageing Determination Workshop (WS-ADM2)
(University of Colorado, Boulder, CO 22 to 26 April 2024)

Introductions

1.1 The 2nd CCAMLR Ageing Determination Workshop (WS-ADM2) was held at the University of Colorado, Boulder, Colorado, USA from 22 to 26 April 2024. The Workshop was convened by Dr Jennifer Devine (New Zealand), Dr Philip Hollyman (United Kingdom) and Dr Cassandra Brooks (USA), and supported by the CCAMLR Secretariat. Scientists and technical experts from 6 Member nations attended the Workshop.

1.2 Prior to the start of the workshop, laboratories ageing Patagonian and Antarctic toothfish were asked to provide 60 images of prepared otolith samples and their associated metadata for each toothfish species they routinely age to the Secretariat. Two sets of high-resolution images (i.e., the resolution used for ageing) were provided, where one set was annotated with interpretation and the annulus location marked.

1.2.1 Selection criteria for the 60 images stipulated, where possible, otoliths should be from 30 males and 30 females, the last 10 years, be a range of estimated ages encountered across the sampled area, and include a range of readabilities (e.g., easy to read with excellent contrast between successive opaque and translucent zones to difficult, with poor contrast between successive opaque and translucent zones).

1.3 The images were then made available to all participants, who were asked to interpret the images for each toothfish species and preparation method they routinely age and to submit these ages and preparation numbers to the Secretariat to enable analysis prior to the workshop. Discussion and arbitration on interpretation was planned to be integrated into the workshop agenda.

1.4 At the start of the workshop, Drs Hollyman, Brooks, and Devine welcomed the participants (Attachment I) and thanked those that had contributed otolith images and aged other Member nation's otoliths. The Workshop was noted as being an informal meeting with the aim to bring together technical experts involved with age estimation of Antarctic and

Patagonian toothfish to discuss specific aspects of the preparation and age estimation process. The goals were to: discuss interpretation of ageing of images submitted for both species; recommend standard guidelines to improve and validate ages between readers at different laboratories; and provide recommendations on the structure and functionality of an age reading database to be maintained by the Secretariat for toothfish. Outcomes of previous CCAMLR ageing workshops were presented at the start of this workshop to ensure building on work that previous ageing workshops and the CCAMLR otolith network had progressed.

1.5 This report is not an adopted report but is a summary by the Co-conveners for the consideration of the Scientific Committee and its working groups. The intent is that the requests and recommendations outlined below will be reported to WG-SAM-2024 and WG-FSA-2024 for further discussion and agreed at SC-CAMLR-42 according to the Scientific Committee Rules of Procedure.

1.5.1 Table 1 contains the requests and recommendations from WS-ADM2, while the ToRs for the next age determination workshop is given in Attachment IV.

1.6 The terms of reference for the Workshop are given in Attachment II and the final schedule in Attachment III. Very early into the workshop, participants agreed that the terms of reference had been overly ambitious and that the agreement on ages for the building of the reference sets for both Patagonian and Antarctic toothfish would likely need several in-person workshops to complete. Several additional topics were developed to aide this process for future workshops, which included: the use of readability scores; imaging and annotating hardware and software; development of guidelines for imaging otoliths; and the need for young fish for age and growth analyses; and age validation.

1.8 The co-conveners feel that it should be emphasised that the participants felt the in-person meeting was much more productive than the virtual meeting, facilitated understanding of interpretation between the different ageing laboratories, and allowed for collaborative relationships that they plan to continue to build upon.

1.7 This report was prepared by the Co-conveners with support from the Secretariat and contributions from all participants (Attachment I).

Otolith preparation

2.1 Participants from Australia, Japan, Korea, New Zealand, the United Kingdom, and the United States presented on the preparation and protocols used for production ageing within their labs, and some of the issues encountered while preparing and reading otoliths. Both China and Spain also contributed both images and information for the workshop, despite being unable to attend in person, which was also presented on their behalf. Information provided by each lab that participated in-person is summarised in Table 2.

2.2 The number of otoliths prepared for ageing by most production-ageing laboratories was limited by the amount of funding available, and some preparation choices, e.g., number of otoliths per block, were a compromise between best quality and available funding.

2.3 The bake and embed preparation method initiated some discussion over whether otoliths of different sizes and thicknesses might need different durations when baked. It was noted that longer baking times resulted in lighter (not darker) structure definition and that was because the protein structure was changed. Smaller (thinner) otoliths were noted as baking lighter for a 15-minute duration, but this was not obvious once sectioned, and changing baking duration +/- 5 minutes did not have a noticeable difference. Participants noted that the type of oven and baking tray material could affect baking.

2.4 When sectioning otoliths, the UK (BAS) lab mentioned that they will take 3–4 sequential slices per block, which presented multiple opportunities to hit the nucleus, and that this was important when mounting multiple otoliths in a block. Australia noted that they moved from sectioning multiple to single otoliths to ensure the cut is through the primordium and that they have less failures when using a scribe system to find the cutting line.

2.5 Sectioning otoliths generated much discussion about best cutting speeds and blade types, information that was likely useful for laboratories beginning ageing programs (Tables 3 and 4). Some general information not captured in the tables that might also be useful included:

- Slower cutting speeds may prevent the core of the otolith from cracking/disintegrating if the sample is thin sectioned.

- Fast rpm and slow speed generally produce the best cuts for live view/bake and embed preparation methods.

- Conditioning blocks should be routinely used because epoxy will clog the blade.

- A small amount of detergent in the water reservoir works as a lubricant.

2.6 Participants agreed that examples and characteristics of poorly sectioned otoliths by preparation method could be useful training material for those learning otolith preparation, and that this information could be incorporated into the CCAMLR website, complete with drop down menus of images by preparation type or be included in manuals. It was agreed that readability scores indicating unreadable could also indicate poorly sectioned otoliths.

2.7 The UK presented on a large resampling project being conducted to add ages to the historical data for Patagonian toothfish and on new studies with geochemical analyses. Older fish sometimes had crystalised edges with no banding or structure except when using geochemical analyses. It was thought that the structure breaks down at a certain point due to protein matrix not being laid down in the same way or in the same amount due to very slow growth. Most other labs indicated they had not seen edge crystallization in the otoliths they age. Interested participants were encouraged to work together on this topic.

2.8 Participants from the US presented on their connectivity work using, in part, otolith microchemistry (trace elements and stable isotopes) to determine life history pathways and movement and how this might be impacted by the environment or climate change. This work has now expanded from the Ross Sea region to encompassing toothfish stocks around Antarctica.

2.9 Various annotation software packages used by participants were discussed (see Table 5, noting this is not an exhaustive list of available software), with demonstrations of the capabilities of several.

2.9.1 The UK (BAS) presented on their use of mosaics to create one high resolution image using manual stitching, which generally requires a 20% overlap in images. This is an alternative to taking images of the same otolith at multiple magnifications. Several software packages exist for this, some allow manual stitching of images (e.g. Olympus CellSens, ImageJ with Mosaic plugin) and some are able to do this automatically using an attached microscope and camera (e.g. ImagePro).

2.9.2 The amount of time to take mosaic images was ca. 5–10 minutes using manual stitching or 1–2 minutes using Image-Pro. While this is much longer than taking one image under a microscope, participants discussed that the high quality and generation of a single image might mean it is most useful when imaging otoliths for the otolith reference/training set held by the Secretariat.

2.10 Participants from the US presented on developments using pattern recognition to age toothfish and that this worked best on thin sectioned samples which had been clearly imaged.

2.11 Participants from the US presented on a comparison of reads from live view versus from images, which indicated no significant differences in ages determined from either method. Participants discussed that this work was important to publish since such studies in the primary literature were lacking, that it would assist when moving to pool age information from labs using different methods and recommended that those who were interested or have similar data to collaborate on the paper.

Readability scores

3.1 Readability scores for each lab (Table 6) were discussed as being subjective, a reflection of the person reading the otolith (e.g., function of pattern recognition and experience), and potentially influenced by the preparation of the otolith, particularly if the primordium was missed when sectioning. Despite some issues, participants agreed that readability was a good metric to monitor between reads of the same otolith, likely should be included in assessment reporting, and were useful to design training sets from reference sets.

3.2 Participants agreed that the Japanese scale was easiest to use for advanced readers, who already understand the subtle nuances, and that more verbose categories were more useful for training purposes. Participants recommended that all manuals include categories with more context and descriptions, i.e., include both a working readability and a theoretical description.

3.3 Participants discussed that a readability of ‘easy to read’ is exceptionally rare for Antarctic toothfish, but is recorded for Patagonian toothfish, and that higher readability scores are generally used to indicate the uncertainty in the age estimates. Participants agreed that an unreadable otolith should not have an age associated with it, but that some labs may still assign an age.

3.3.1 The UK (BAS) recalled some work that was done to develop a quantitative readability score, but because toothfish otoliths are quite complex, assigning scores often took longer than assigning an age.

3.4 Participants requested WG-SAM to consider feeding back to the otolith network how the readability scores were used within assessments and, if not, what information should be reported for the needs of the assessment.

3.5 Participants requested WG-SAM to consider whether there was a systematic bias created by use of data from different readability scores and whether a bias would impact on the stock assessment.

Interpretation of submitted otolith images

4.1 This workshop was the first time images have been exchanged between multiple toothfish ageing laboratories and then readings were compared. Not all otoliths were re-read and some re-reads were submitted without readability scores.

4.2 The goal of such work was to identify what may be causing differences in the ages and to determine mechanisms to improve consistency. The end goal of this work is to be able to pool information from several ageing laboratories for toothfish stock assessments.

4.2.1 Comparisons of initial and re-read Antarctic toothfish otoliths using the unbaked preparation method did not indicate a clear trend in readability except that fish above age 10 were not easy to read. Three people re-read these otoliths.

4.2.2 Seven readers re-read Antarctic toothfish otoliths that had been prepared using a baked method. No clear patterns emerged except that easy to read otoliths were typically younger fish and those unreadable otoliths were typically from older fish. Fish in the 30–40-year range were missing from the submissions and this was thought to be because these fish are generally considered unreadable by those that submitted data.

4.2.3 Five readers re-read Antarctic toothfish otoliths that had been prepared using thin sections. No trend in readability was visible; otoliths of all ages had classifications of easy and unreadable.

4.2.4 Patagonian toothfish thin sections were re-read by six readers, but there were fewer otoliths in this category. Both Australia and the UK (BAS) had very close agreement in ages.

4.3 Participants agreed that there was no room for inter-lab ageing discrepancies when ageing young fish (when pooling information) as this would have a larger impact on assessments using the data (than discrepancies in older fish ageing).

4.3.1 The impact of uncertainty in ageing (when pooling information) for old fish was low as long as the ageing was accurate enough to put the fish into e.g., the plus group for the assessment. Participants agreed that knowing the age of the plus group could save effort when ageing larger, more difficult fish.

4.3.2 The workshop requested WG-SAM to consider feeding back to the otolith network how stock assessments incorporate age uncertainty into the stock assessment, so that production agers understood the impact of the uncertainty in ageing.

4.4 Overall, there was quite high disagreement among all readers, but readers were incredibly consistent within their own preparation methods. Participants agreed that ageing was not just counting annuli, but using a combination of information from otolith morphology, growth trajectories, measurements (for verification), and other decisions, and that ageing fish was not an exact science, but an estimate.

4.5 This analysis also highlighted that a large enough sample size of all the reference ages was needed to determine identify key differences in ageing between laboratories, but that guidance was needed on determining the sample size.

4.6 Image quality was discussed as having played a large role in the disagreement among readers, e.g., not all parts of the otolith were in focus (e.g., only the edge or only the primordium). This then prompted a larger discussion about the need for developing guidelines for taking images and suggestions for equipment to use (or avoid).

Guidelines for imaging otoliths

5.1 When imaging otoliths for the reference/training set held by the Secretariat, several guidelines were discussed:

1. Ensure that the otolith is worth imaging, e.g., the cut passes through the primordium, the otolith was aligned with the saw, the otolith was not over/under baked.

2. Include several images to encompass how all laboratories typically view otoliths so that the reader does not have to adapt to a new view as this might change their count, i.e., an image of the whole otolith, and a higher magnification image of both the ventral and dorsal side. If the whole otolith cannot be taken in one image, submit multiple images of the whole otolith. This is because one view might show checks (split annuli or doublettes) or have other issues that can be

resolved when using a different view. Ventral and dorsal images at a high magnification are also useful when ageing older fish.

3. Consider using a mosaic software to stitch together multiple images as this might assist obtaining a single high-resolution view of the whole otolith.

4. Include the magnification used when taking the image in the image name.

5. Include a scale bar with the otolith. This is needed to be able to determine if the otolith is from a small (young) or large (old) fish and assist with interpretation of e.g. split annuli.

6. Do not use a background eliminator as this can remove part of the image. A white background is preferable for thin sectioned samples.

7. Ensure that multiple colours (e.g., a rainbow effect) do not occur as this can make interpretation difficult-to-impossible.

8. Ensure the otolith is not under- or over-illuminated, i.e., annuli are visible, parts of the otolith are not too dark (under-illuminated) or washed out (over-illuminated).

9. Ensure that the detail needed to age the fish is in focus or that the focal plane encompasses the correct part of the otolith.

5.2 Luminosity and spectrum of light will have a huge impact on image quality, but guidelines on these will need to be developed at a later stage (under future work).

5.3 Australia mentioned that the newer camera system they had purchased had software issues that could not be resolved and, despite image quality with the camera being much better, had to be returned. Participants agreed that sharing this type of information between labs was invaluable and that it could be easily facilitated by setting up the otolith network or through the CCAMLR discussion group.

5.4 Participants requested WG-SAM to consider recommending to the Scientific Committee that the CCAMLR otolith network restart.

The importance of young fish

6.1 Several labs use measurements to identify and/or verify the first (few) annuli, which were based on measurements from 31 Antarctic toothfish captured in 2001 from the South Shetland Islands (Horn et al. 2003). It was not known whether growth may have changed since that study or if growth might differ between different areas (and species) and was generally agreed that this was an area that might need more work.

6.2 Participants agreed that small fish otoliths were extremely valuable and that there were many needs for these otoliths in age and growth work. The workshop participants requested WG-SAM to consider requesting that the Secretariat update the observer manuals to retain and freeze all small toothfish (< 40 cm), including from the krill fishery and that Members should notify the Secretariat that these collections exist.

6.2.1 The otoliths of these fish could then be made available to a collaborative study of participating Members through the otolith network.

6.3 Cassandra Brooks noted that the newly proposed SCAR Fish Action Group could potentially help with communicating the needs of CCAMLR to SCAR (and vice versa), and this might be the best way to communicate the need for small toothfish to national research programmes.

6.4 Participants also recommended that, where possible, production ageing labs collect some measurements of the first several annuli each time ageing is done, and that this information be included in a database. This information could then be used to periodically assess if potential changes in growth may have occurred.

6.5 Juvenile Patagonian toothfish were available from the UK groundfish survey in 48.3 and information on cohort strength was thus available for validation of ages of younger fish sampled from the commercial fishery.

Validation techniques

7.1 Participants discussed validation techniques previously used to verify toothfish ageing, including tetracycline marking (Horn et al. 2003) and lead radium dating (Andrews et al. 2011, Brooks et al. 2010). Participants noted that previous studies were successful, but currently limited for future use because of expense, and whether other options existed. Participants noted the value of doing potential updated validation studies focused on comparing different geographic areas and different production ageing techniques.

7.2 Techniques for using trace element profiles have become cheaper and recently improvements have meant that e.g., interannual variability is discernible, tracking year classes and year class variability is possible.

7.3 Alternative techniques for visualising growth bands (e.g. acetate peels, x-ray tomography) could be combined with geochemical analyses to link natural environmental cycles to growth and might aid with interpreting juvenile split bands (checks or doublettes). It was further noted that bivalves have similar issues, and the literature could be investigated for further techniques worth exploring.

7.4 Participants agreed that there is a need for labs to go through a validation process, and recommended that new labs just starting ageing programmes, but also those that have been production ageing but have not validated ages, do so. Because many of the techniques are expensive and beyond what production ageing labs would be likely to fund, there is a need for collaborations between ageing facilities and research labs to work together.

7.5 During the workshop, Cassandra Brooks reached out to a lab specializing in bomb carbon dating who has made an offer to collaborate with ageing facilities and to assist in grant proposals to fund this work. Participants who are interested in collaborating are recommended to get in touch with Cassandra Brooks.

Workshopping submitted otolith images

8.1 Initially, participants were to work together on the species they typically age, using both images and live view. However, participants naturally gravitated towards discussing as one larger group, so the workshopping on otolith images was moved to one room with two large screens. The participants agreed that this part of the workshop was a valuable experience, assisted greatly with the understanding of key differences in ageing between the labs, and highlighted the need for, at least, two more workshops to bring together experts from the different laboratories.

8.2 Participants requested that WG-SAM consider recommending to SC that the ageing workshops continue annually in the short-term to ensure work is completed on the CCAMLR otolith reference sets, and to consider requesting funding from SCAF for the next calendar yet to fund participation at the next workshop.

8.3 There was a general consistency between labs in finding the first two annuli, regardless of method used to find it, e.g., using ring definition but differing on whether start at primordium (count outward) or outer edge (count inward), measurements as a guide.

8.3.1 For some images where it was difficult to come to agreement about the first annuli, it was notable that different labs still came to a similar conclusion of the age of the fish.

8.3.2 Different laboratories were more in agreement on the location of the first annulus when ageing older fish.

8.4 Different laboratories use different trajectories when counting rings, and often use a mix of trajectories to verify counts or because annuli definition degrades. Which trajectory was used did not result in differences in the determined age of the fish, suggesting that regardless of trajectory used, there could be agreement in the age of the fish.

8.5 Images of otoliths including the trajectory used to determine the age was agreed to be useful both for training new readers and for illustrating that differences in reading methods can still result in similar ages, and this information may be needed when pooling age information for assessments.

8.6 Differences in counts could occur due to: extra checks (split annuli or doublettes); lack of agreement along the outer edge, or image quality, e.g., the image was not at a high enough magnification; not all parts of the image being in focus; or the resolution of the image or the monitor (screen).

8.7 During the workshopping of the images, the same image was relayed on two separate screens. There were notable differences in image quality that were due to the screens displaying the images, which led to a discussion about needing high resolution (e.g., 4K) monitors when viewing images.

8.8 Labs that read otoliths prepared using a different methodology found that they needed some time to recalibrate their interpretation, e.g., those that use thin sections found other preparation methods were less transparent or "noisier", particularly near the outer edge.

8.9 The inability to change focus (or magnification) when using images further highlighted the need to develop standard guidelines for taking images for reference/training sets.

8.10 Participants agreed that, for older fish, inter-lab differences in counts of 1–2 years was unlikely to matter, but that inter-lab differences for younger fish would have a larger impact on analyses and assessments using this information.

8.11 Japan noted that fish under 10 years old are relatively rare in the samples they read and that the growth trajectory and system of growth check (split annuli/doublettes) of younger fish was less understood.

8.12 Participants agreed that having experience with a range of sizes seemed to be necessary to understand growth patterns. Participants recommended that where fish of certain ages (or sizes) are not present, labs should consider contacting labs that sample fish from the same stock, ask for/prepare sister otoliths for the missing size range, and then work together on interpretation so that they understand the growth patterns in the otoliths.

8.13 Participants discussed using the weight or length of the fish as a proxy for age for fish that might be difficult to discern annuli, and it was generally agreed that this information should not be made available to the person reading the otolith and that this information was generally already available in the size of the otolith, e.g., a small otolith is from a younger fish. The need for a scale bar to be included with all images would also give information on whether the otolith was from a small or large fish.

8.13.1 For some species, weighing the otolith can be used to indicate the age of the fish. Both Australia and the US labs had trialled this for toothfish and found that otolith weight was not useful for indicating the age of the fish.

8.14 The workshopping sessions indicated that there are ‘tips and tricks’ the experienced readers use for reading otoliths which could be useful for new readers, but that these were not rules for reading. That information could be included in manuals or compiled for inclusion on the new otolith network webpages.

8.15 Participants agreed that fatigue can impact counts and that readers should consider reading otoliths earlier in the day, have a maximum number of otoliths one reads each session (where possible), and take regular breaks. Participants noted that discrepancies introduced by fatigue will likely be found for labs that use a second reader.

8.16 Participants initially discussed that they had not observed crystalline structures in the otoliths they aged except for the UK (BAS), but it became apparent during the workshopping sessions that many labs had submitted images where the crystal structure of the otoliths was visible. This sometimes presented as artefacts that might confuse interpretation. All agreed that annotated images showing the different ways crystallization and crystal structure could appear should be included as reference material in a centralized location (e.g., the new otolith network webpage or the CCAMLR WS-ADM2 discussion group).

8.17 Participants commented that workshopping the images together has slightly changed how people read otoliths. Participants were asked, time and funding permitting, to consider re-reading some of the same images they read for the workshop as an exercise (for reporting to WG-FSA in September) to check if this had a noticeable effect on their ageing.

Otolith reference and/or training sets

9.1 The reference sets used by several laboratories were noted as having been made some time ago (e.g., more than 10 years) and that, should changes in growth be occurring, this might not be captured by the reference set. Because of this, there was general agreement that labs could make new references sets or, where possible, augment their reference sets with more recent otoliths and that this effort might be best done by selecting a few additional otoliths each year while undertaking routine production ageing.

9.2 Reference sets may often include several unique otoliths that are easy to distinguish, from which, it might be easy to discern which reference set is being read. This has the potential to create a bias and should be minimized. The participants discussed that one way to avoid this might be to build reference sets based on single otoliths, not blocks, but recognized that if the community was moving to building reference/training sets based on images, this was a moot point.

9.3 Participants agreed that there was no need to develop separate sets for training and reference, but that a training set could be a subset of the reference set, where otoliths were selected for training purposes based on their readability scores.

9.4 Participants discussed that images of otoliths from their individual reference sets could be submitted for the CCAMLR otolith reference set, but that the number of otoliths needed would be determined from work requested for consideration from WG-SAM and WG-FSA.

9.5 Participants requested WG-FSA to consider work to determine whether growth differs by region, as this will determine whether regions could be pooled when creating the CCAMLR otolith reference set collection, to determine whether growth has changed over time (for a stock or wider region), and if it has, how to capture that change in the reference set collections being built.

9.6 Participants requested WG-SAM to consider the total number and the selection of specific variables (e.g., sex, area, lengths, years, season, readability score) needed for the reference otolith collection, and to determine the number of fish per age class needed to capture the variability.

9.7 Participants recommended that the otoliths for the CCAMLR reference set should include images of the whole otolith (or multiple images if the whole otolith cannot be in focus with good illumination) and magnified views of both the dorsal and ventral axes; a scale bar; the magnification used.

CCAMLR Reference set database: structure, function, metadata

10.1 The Secretariat noted that metadata for most otoliths were already held by the Secretariat and that metadata from otoliths collected within a nation's EEZ as part of special research projects are lacking.

10.2 Participants agreed that the reference set held by the Secretariat could be used for both training and calibration.

10.3 Additional information might want to be included with the reference set metadata and might include every read of a reference set. This would allow for tracking of individual read by readers, and this information could be used to check for reader drift or monitor when a new reader could move to production reading.

10.4 The Secretariat noted that the database structure and function had largely been determined from discussions at the 2023 CCAMLR ageing workshop, and that any topics still to discuss will fall under the future work plan.

Future work plan

11.1 Short-term work

- Determine what information should be included on the CCAMLR webpages on ageing, including what information should be available to the public and what should be available to Members only.
- Determine what should be done with the CCAMLR WS-ADM2 discussion pages, e.g., migration to a new discussion board or continue the discussion thread for future workshops.
- Determine best practices for imaging and ensure imaging practices are captured in the age and growth manuals of members.
- Set up the CCAMLR otolith network, including determine what information should be public or private on the CCAMLR otolith network webpages.

11.2 Medium-term work

- Build the webpages for the CCAMLR otolith network.
- Determine what is required to pool ageing data across Members for stock assessments (requires feedback from WG-SAM and WG-FSA).

11.3 Long-term work

- Agree upon ages for the CCAMLR reference set.
- Age validation for those labs who have not gone through the process.

Table 1. Requests and recommendations from the Age Determination Workshop.

REQUEST/RECOMMENDATION	TO WHOM	REPORT PARAGRAPH	IF ACTIONED AND WHERE
RECOMMEND THOSE THAT HAVE DATA ON COMPARISONS OF READS FROM LIVE VIEW VERSUS FROM IMAGES AND HAVE INTEREST, TO JOIN A JOINT PAPER IN THE PRIMARY LITERATURE.	MEMBERS' AGEING LABORATORIES	2.11	
INCLUDE READABILITY SCORE CATEGORIES WITH BOTH A WORKING READABILITY AND A THEORETICAL DESCRIPTION IN AGEING MANUALS TO AID BOTH ADVANCED READERS AND TRAINING PURPOSES.	MEMBERS' AGEING LABORATORIES	3.2	
PROVIDE FEEDBACK TO THE OTOLITH NETWORK ON HOW READABILITY SCORES WERE USED WITHIN ASSESSMENTS AND, IF NOT, WHAT INFORMATION SHOULD BE REPORTED FOR THE ASSESSMENT.	WG-SAM	3.4	WG-SAM-2024 PARAGRAPH 5.33
CONSIDER WHETHER A SYSTEMATIC BIAS WAS CREATED BY USE OF DATA FROM DIFFERENT READABILITY SCORES AND WHETHER SUCH A BIAS WOULD IMPACT THE STOCK ASSESSMENTS	WG-SAM	3.5	SAM WORKPLAN – THEME 1, TASK 10 WG-SAM REQUESTED AGEING LABORATORIES MONITOR AND REPORT WHETHER THE PROPORTION OF UNREADABLE OTOLITHS SHOWED A TREND WITH LENGTH (PARAGRAPH 5.33)
PROVIDE FEEDBACK TO THE OTOLITH NETWORK ON HOW STOCK ASSESSMENTS INCORPORATE AGE UNCERTAINTY, SO THAT PRODUCTION AGE READERS UNDERSTAND THE IMPACT OF THE UNCERTAINTY IN AGEING	WG-SAM	4.3.2	SAM WORKPLAN – THEME 1, TASK 10
RECOMMEND TO SCIENTIFIC COMMITTEE THAT THE CCAMLR OTOLITH NETWORK RESTART	WG-SAM	5.4	SCIENTIFIC COMMITTEE HAS ENDORSED RESTARTING THE CCAMLR OTOLITH NETWORK (SC-CAMLR-42 PARAGRAPH 2.133)
REQUEST THE SECRETARIAT UPDATE THE OBSERVER MANUALS TO RETAIN AND FREEZE ALL SMALL TOOTHFISH (< 40 CM), INCLUDING FROM THE KRILL FISHERY	WG-SAM	6.2	WG-SAM-2024 PARAGRAPH 5.37
REQUEST THAT MEMBERS NOTIFY THE SECRETARIAT WHEN COLLECTION OF SMALL TOOTHFISH (< 40 CM) EXIST	MEMBERS' DATA COLLECTION PROGRAMS	6.2	

COLLECT, WHERE POSSIBLE, MEASUREMENTS OF THE FIRST SEVERAL ANNULI EACH TIME AGEING IS DONE AND INCLUDE THIS INFORMATION IN A DATABASE	MEMBERS' AGEING LABORATORIES	6.4	
VALIDATE AGEING FOR ALL NEW LABS STARTING AGEING PROGRAMMES AND THOSE THAT HAVE BEEN PRODUCTION AGEING, BUT THAT HAVE NOT VALIDATED AGES.	MEMBERS' AGEING LABORATORIES	7.4	
REQUEST/RECOMMENDATION	TO WHOM	REPORT PARAGRAPH	IF ACTIONED AND WHERE

Table 1. Continued.

RECOMMEND THOSE INTERESTED IN COLLABORATING ON BOMB CARBON DATING OF OTOLITHS TO CONTACT CASSANDRA BROOKS	MEMBERS' AGEING LABORATORIES	7.5	
RECOMMEND TO SCIENTIFIC COMMITTEE THAT THE AGEING WORKSHOP CONTINUE ANNUALLY IN THE SHORT-TERM TO ENSURE WORK IS COMPLETED ON THE CCAMLR OTOLITH REFERENCE SETS AND TO RECOMMEND FUNDING FROM SCAF TO SUPPORT PARTICIPATION	WG-SAM	8.2	WG-SAM-2024 PARAGRAPH 5.38
WHERE FISH OF CERTAIN AGES OR SIZES ARE NOT PRESENT, CONSIDER CONTACTING AGEING LABORATORIES THAT SAMPLE FISH FROM THE SAME STOCK FOR SISTER OTOLITHS (IN THOSE AGE/SIZE RANGES) AND THEN WORK TOGETHER ON INTERPRETATION AND UNDERSTANDING OF THE GROWTH PATTERNS.	MEMBERS' AGEING LABORATORIES	8.12	
CONSIDER WORK TO DETERMINE WHETHER GROWTH DIFFERS BY REGION AS THIS INFORMATION IS NEEDED TO DETERMINE WHETHER OTOLITHS COULD BE POOLED WHEN CREATING THE CCAMLR OTOLITH REFERENCE SET COLLECTION, AND IF GROWTH HAS CHANGED FOR A STOCK/WIDER REGION OVER TIME.	WG-FSA	9.5	
CONSIDER THE TOTAL NUMBER AND SELECTION OF OTOLITHS WITH CERTAIN CHARACTERISTICS (E.G., SEX, AREA, LENGTH, SEASON, READABILITY SCORE), AND THE NUMBER OF FISH PER AGE CLASS NEEDED TO CAPTURE THE VARIABILITY, FOR THE OTOLITHS IN THE CCAMLR OTOLITH REFERENCE SET COLLECTION.	WG-SAM	9.6	WG-SAM-2024 PARAGRAPH 5.39 SAM WORKPLAN – THEME 1, TASK 9

RECOMMENDED THAT IMAGES OF OTOLITHS FOR THE CCAMLR OTOLITH REFERENCE SET COLLECTION INCLUDE THE WHOLE OTOLITH (OR MULTIPLE IMAGES IF THE WHOLE OTOLITH COULD NOT BE IN FOCUS WITH GOOD ILLUMINATION), MAGNIFIED VIEWS OF BOTH THE DORSAL AND VENTRAL AXES, A SCALE BAR, AND THE MAGNIFICATION USED.	MEMBERS' AGEING LABORATORIES	9.7

Table 2. Summary of participating laboratory otolith preparation details.

MEMBER	SPECIES	METHOD OF SELECTION	OTOLITH PREPARATION	BAKE TEMPERATURE, TIME, BAKE SHEET MATERIAL	NO. SAMPLES PER BLOCK WHEN EMBEDDING	NO. PREPARED SAMPLES PER SLIDE/BLOCK	RESIN TYPE
AUSTRALIA	TOP AND TOA	2 FISH PER 1 CM LENGTH BIN. 1:1 SEX RATIO	THIN SECTION METHOD	NA	1	1	COMPSET 5-2-1 (BLOCKS) & CLEAR CASTING RESIN (SLIDES)
JAPAN	TOP AND TOA	10 RANDOM PER SET AND ADDITIONAL FISH TO ENSURE 10 MALES AND 10 FEMALES FOR EACH 5CM LENGTH BIN	THIN SECTION METHOD	NA	1	1	2-1 EPOXY CASTING RESIN
UK	TOP	4 FISH PER 1CM SIZE CLASS FOR M AND F. ALSO JUVENILE TOP FOR GROUNDFISH SURVEY	THIN SECTION METHOD	NA	4	4 (3–4 REPLICATES OF EACH)	2-1 EPOXY CASTING RESIN
KOREA	TOA	5 FISH PER 1 CM LENGTH BIN IN 883. 10 FISH PER SET IN OTHER AREA'S	BAKE AND EMBED METHOD	285 ˚C FOR 15 MINUTES	4	4	EPOKWICK FC RESIN (BUEHLER) AND

							EPOKWICK FC HARDENER
NEW ZEALAND	TOA	ALL RECAPTURED FISH; 1:1 SEX RATIO, 2 AREAS (N70 & S70-SRZ COMBINED, RSSS), 5 FISH PER 1-CM LENGTH BIN (500 MAX PER AREA)	BAKE AND EMBED INTENT TO MOVE TO THIN SECTION METHOD	285 ˚C FOR 15 MINUTES	40	8	METCAST ATL EPOXY RESIN TP33 AND METCAST ATL HARDENER (HP33) AT 4:1 RATIO; SHELLEYS' QUICKFIX EPOXY (TO ATTACH OTOLITHS TO BLOCK)
USA	TOP AND TOA	RANDOM SELECTION OF OTOLITHS	BAKE AND GRIND METHOD	185 ˚C FOR 4 MINUTES, TRAY TURNED HALFWAY, PORCELAIN SAMPLE TRAY	1	1	

Table 2. Continued.

MEMBER	SAW	SAW SPEED (RPM)	BLADE TYPE	BLADE DIMENSIONS	NUMBER OF BLADES USED	SECTION THICKNESS	GRINDING/POLISHING, PAPER GRIT USED	COVER SLIP (Y/N)	OIL/ETHANOL
AUSTRALIA	BUEHLER ISOMET LOW SPEED SAW	LEVEL 6 (600 RPM)	ISOMET DIAMOND WAFERING	125 X 0.40 X 12.7 MM	4 WITH SHIMS (0.38 MM)	350 UM	NONE	YES	NO

			BLADES (15 HC DIAMOND)		BETWEEN BLADES				
JAPAN	MARUTO MC201N		CBN BLADE 0.5TMM	125 × 0.5 × 30 MM	1	0.2 MM	SOUTH BAY TECHNOLOGY 900 #800-2000	NO	NO
UK	STRUERS MINITOM	100 - 400 RPM	HIGH CONCENTRATI ON DIAMOND BLADE (METPREP, CAT. NO. 10 12 50)	125 X 0.40 X 12.7 MM	1	300–400 UM	NONE	YES	NA
KOREA	BUEHLER ISOMET LOW-SPEED SAW	LEVE L 3 OR 4	DIAMOND WAFERING BLADE BUEHLER 4-INCHES LC	102 X 0.3 X ?? MM	1	NA	BUEHLER ECOMET 4000	NO	ETHANOL
NEW ZEALAND	BUEHLER ISOMET HIGH SPEED PRO PRECISION SAW	3500 RPM	EXTEC DIAMOND WAFERING BLADE AND ISOMET DIAMOND WAFERING BLADES (15 HC DIAMOND)	102 X 0.3 X 12.7 MM	1	NA	NONE	NO	PARAFFIN OIL
USA	NA	NA	NA	NA	NA	NA	CRYSTAL MASTER 8 DIAMOND POLISHER[†]	YES	NO

[†] Dorsal side is ground and polished, mounted to slide with loctite (series 349-part number 34931), set under UV light for 4 hours; then ventral side is ground, polished, and covered with flotexx (liquid coverslip).

Table 3. Summary of participating laboratory microscope details.

	AUS	JPN	UK	KOR	NZ	USA
PREPARATION METHOD	THIN SECTION	THIN SECTION	THIN SECTION	BAKE AND EMBED	BAKE AND EMBED	BAKE AND GRIND
MICROSCOPE TYPE	STEREO MICROSCOPE	STEREO MICROSCOPE	COMPOUND	STEREO MICROSCOPE	STEREO MICROSCOPE	STEREO MICROSCOPE
MICROSCOPE MODEL	LEICA MZ95	OLYMPUS SZX7	OLYMPUS BX50	OLYMPUS SZX16	LEICA M125 (IMAGING); LEICA M80 (READING)	LEICA M80
MICROSCOPE LIGHTING	TRANSMITTED LIGHT TOP & TOA	TRANSMITTED LIGHT	TRANSMITTED	DIRECT LIGHTING	DIRECT (REFLECTED) LIGHTING	DIRECT (REFLECTED) LIGHTING
CAMERA MAKE/MODEL	LEICA DFC450	WRAYCAM-NOA2000	OLYMPUS SC180	IMTCAMUSB3.0_14	LEICA DMC2900	FLEXCAM I5
MAGNIFICATION(S) USED	1.6 (OVERALL IMAGE)	1.6 OR 2.5	4	1.6	1.6	1.25 (WHOLE OTOLITH), 2.5 FOR DORSAL AND VENTRAL HALVES (3 PICS TOTAL)
AREA OF INTEREST (E.G. WHOLE OTOLITH, DORSAL, VENTRAL)	WHOLE, VENTRAL & DORSAL	WHOLE OTOLITH	WHOLE OTOLITH	WHOLE OTOLITH	WHOLE OTOLITH	WHOLE, VENTRAL & DORSAL
IMAGES/LIVE VIEW USED TO AGE	IMAGE	IMAGE	LIVE VIEW	IMAGE	LIVE VIEW	IMAGE

IMAGING SOFTWARE	LEICA APPLICATION SUITE	MICRO STUDIO	OLYMPUS CELL-SENS	I-SOLUTION IMT	LAS V4.13 LECIA APPLICATION	LEICA APPLICATION SOFTWARE X
ANNOTATION SOFTWARE	IMAGE-J	WINDOWSPAINT	IMAGE-J AND RFISHBC	I-SOLUTION IMT	IMAGE-J	APPLE PREVIEW - LIKELY TO CHANGE
COMMENTS			IMAGES ARE USED FOR SOME INTER-READER COMPARISON WORK. IMAGE-PRO (MEDIA CYBERNETICS) USED FOR LIVE-STITCHING OF IMAGE MOSAICS		TYPICALLY, DO NOT IMAGE OR ANNOTATION OTOLITHS FOR ROUTINE AGEING	ALSO USE A SECOND DISSECTING MICROSCOPE: LEICA S9I WITH THE SAME SOFTWARE WITH THE BUILT IN LEICA S9D AND S APO CAMERA, BUT MAGNIFICATION USED IS 2 (WHOLE) AND 5.5 VENTRAL/DORSAL)

Table 4. Summary of participating laboratory ageing protocols.

	AUS	JPN	UK	KOR	NZ	USA
NO. READERS	2 (100% OF SAMPLES)	2 (100% OF SAMPLES)	2 (FOR ~20% OF SAMPLES)	1	1	2 (100% OF SAMPLES)
RE-READ TRIGGER	0–3=0 3–8=1 8–14=2	DISCREPANCY >10%	0–5 = 0 6–10 = 1 11–15 = 2	DISCREPANCY OF >2 YEARS	CV <5%	NONE

	14–17= 17–20=4 >20=5		16–20 = 3 21–25 = 4 >26 = 5			
RANDOMIZE RE-READS (Y/N)	N	N	N	N	N	N
FOLLOW CERTAIN TRAJECTORY (Y/N)	Y	Y	Y	Y	Y	Y
USE MEASUREMENT TO FIND 1ST ANNULUS (Y/N)	TOP= Y, TOA=N	Y	N	Y	Y	N

Table 5. Summary of imaging and annotation software discussed during the workshop.

Software name	Pros	Cons
ImageJ	Easy to use	Points, once burnt in, are immovable
	Point markers auto-count; no more work than counting on the screen	
	Can burn in annotations that are easy to view when sharing images	
	Freeware	
	Easy to move points if save as annotation layer	
	Specific plugins available (extends usability)	
Image-Pro	Integrates with microscopes	Very expensive
	Creates mosaics automatically	ca. 90% of capabilities are available with ImageJ
RFishBC (R package)	Developed for age structures and back-calculating size-at-age	Need to include the scale bar for back calculation. If not scale bar, need to use same resolution for all images.
	Easy to set-up and use	Use is slightly more complicated when measurements are not along a straight axis
	Relies on images being in one location, which it then cycles through for annotation	
	Outputs an excel spreadsheet with measurements between each annuli	
	Annotated images are automatically saved as a new image, making it easy to share files and compare results	
	Can add in information, e.g., whether last annuli should be counted as a full or partial year	

Table 6. Summary of readability scores by ageing lab (as defined during the first ageing workshop in 2023).

RANK	AUSTRALIA	JAPAN	REPUBLIC OF KOREA	NEW ZEALAND	SPAIN	UK
1	SECTIONS WHERE THE OPAQUE AND TRANSLUCENT ZONES ARE EXTREMELY UNCLEAR OR DISCONTINUOUS AND/OR THE SECTION DOES NOT GO THROUGH THE PRIMORDIUM, WHERE THE COUNT IS NOT POSSIBLE OR WOULD BE HIGHLY UNRELIABLE, SHOULD BE	VERY EASY TO SEE	OTOLITH VERY EASY TO READ; EXCELLENT CONTRAST BETWEEN SUCCESSIVE OPAQUE AND TRANSLUCENT ZONES.	OTOLITH VERY EASY TO READ; EXCELLENT CONTRAST BETWEEN SUCCESSIVE OPAQUE AND TRANSLUCENT ZONES.	OTOLITH UNREADABLE	OTOLITH IS VERY CLEAR AND EASILY READABLE. CONTRAST BETWEEN GROWTH ZONES IS VERY GOOD.

	MARKED UNREADABLE.					
2	THE SECTION IS THROUGH THE PRIMORDIUM, BUT THE OPAQUE ZONES ARE UNCLEAR AND NOT CONTINUOUS FOR VERY LONG SECTIONS, OR THERE ARE LARGE AREAS WHERE OPAQUE BANDING IS NOT DISTINGUISHABLE (OFTEN IN THE CENTRE), LEAVING THE COUNT WITH A HIGH DEGREE OF UNCERTAINTY.	EASY TO SEE	OTOLITH EASY TO READ; EXCELLENT CONTRAST BETWEEN SUCCESSIVE OPAQUE AND TRANSLUCENT ZONES.	OTOLITH VERY EASY TO READ; EXCELLENT CONTRAST BETWEEN SUCCESSIVE OPAQUE AND TRANSLUCENT ZONES.	OTOLITH READABLE WITH DIFFICULTY; POOR CONTRAST BETWEEN SUCCESSIVE OPAQUE AND TRANSLUCENT ZONES	OTOLITH IS CLEAR AND READABLE. CONTRAST BETWEEN GROWTH ZONES IS GOOD. ONE GROWTH ZONE MAY BE UNCLEAR.

3	OPAQUE ZONES ARE VISIBLE AROUND MOST OF THE SECTION AND FAIRLY DISTINGUISHABLE, BUT SOME UNCERTAINTY STILL EXISTS IN DIFFERENTIATION AND INTERPRETATION OF THE BANDING.	NORMAL	OTOLITH READABLE; LESS CONTRAST BETWEEN SUCCESSIVE OPAQUE AND TRANSLUCENT ZONES THAN IN 2, BUT ALTERNATING ZONES STILL APPARENT; POTENTIAL ERROR 2 OPAQUE ZONES.	OTOLITH READABLE; LESS CONTRAST BETWEEN SUCCESSIVE OPAQUE AND TRANSLUCENT ZONES THAN IN 2, BUT ALTERNATING ZONES STILL APPARENT; POTENTIAL ERROR 2 OPAQUE ZONES.	OTOLITH READABLE; LESS CONTRAST BETWEEN SUCCESSIVE OPAQUE AND TRANSLUCENT ZONES THAN IN 2, BUT ALTERNATING ZONES STILL APPARENT	OTOLITH IS READABLE BUT CONTRAST BETWEEN ZONES IS LOWER THAN 1 & 2. TWO GROWTH ZONES MAY BE UNCLEAR.
4	OPAQUE ZONES ARE CLEAR OVER ALMOST ALL OF THE OTOLITH SECTION, BUT THERE IS PERHAPS ONE AREA THAT	HARD TO SEE	OTOLITH READABLE WITH DIFFICULTY; POOR CONTRAST BETWEEN SUCCESSIVE OPAQUE AND	OTOLITH READABLE WITH DIFFICULTY; POOR CONTRAST BETWEEN SUCCESSIVE OPAQUE AND	OTOLITH VERY EASY TO READ; EXCELLENT CONTRAST BETWEEN SUCCESSIVE OPAQUE AND	OTOLITH IS DIFFICULT TO READ. CONTRAST BETWEEN ZONES IS POOR AND THREE GROWTH

	HAS SOME AMBIGUITY E.G., TOWARDS THE OUTER EDGE.		TRANSLUCENT ZONES; POTENTIAL ERROR 3 OPAQUE ZONES.	TRANSLUCENT ZONES; POTENTIAL ERROR 3 OPAQUE ZONES.	TRANSLUCENT ZONES	ZONES MAY BE UNCLEAR.
5	OPAQUE ZONES ARE CLEARLY VISIBLE AROUND THE PROXIMAL HALF OF THE OTOLITH ENABLING AN ACCURATE COUNT OF THE BANDS AND CONFIDENCE IN REPEATABILITY OF THE COUNT.	UNREADABLE	OTOLITH UNREADABLE.	OTOLITH UNREADABLE		OTOLITH UNREADABLE

Attachment I. List of Participants

Steve Parker, CCAMLR Secretariat

Andy Nicholls, Australia

Kenichiro Omote, Japan

Mio Tanaka, Japan

Kota Sawada, Japan

Miran Kim, Korea

Sangdeok Chung, Korea

Colin Sutton, New Zealand

Jennifer Devine, New Zealand

Phil Hollyman, UK

Christopher Jones, USA

Cassandra Brooks, USA

Wendy Roth, USA (Brooks Lab)

Hayley Kwasniewski, USA (Brooks Lab)

Rose Leeger, USA (Brooks Lab)

Ashley McKenzie, USA (Brooks Lab)

Peyton Thomas, USA (Brooks Lab)

Apologies from: China, Spain, Ukraine, South Africa

Attachment II. Workshop TORs

2nd CCAMLR Age Determination Workshop (WS-ADM2-2024), 22-26 April 2024

Agenda (from SC-23-115):

1. Refresher on otolith preparation methodology from each laboratory.
2. Agree on interpretation of the otolith images submitted for each species.
3. Provide an agreed-upon annotated set of images to the Secretariat as an ageing reference set (of min 100 otoliths) for each toothfish species.
4. Draft guidelines for developing an otolith reference set for production ageing.
5. Agree and advise on age database structure and required functionality.
6. Agree upon metadata to be held with the reference sets.

Attachment III. Workshop schedule

Monday April 22

9:00 Introductions, Welcome & Meeting Logistics (all conveners).
9:30 Background on CCAMLR age & growth workshops & desired outcomes (Jennifer).
10:00 Presentations (max 15 minutes each) on otolith preparation methodology from each laboratory (include methods, stats, goals of aging, use of reference set).
11:00 Coffee break
11:30 Finish presentation of otolith prep methods from each lab.
12:30 Lunch break
1:30 Present summary of reader comparisons: Examine CVs across different agers overall. Use this to discuss & workshop with images and/or otoliths on slides in the lab.
3:00 Coffee break
3:30 Continue discuss and workshop of different agers continued (choosing otoliths that had largest CVs, separated by species).
5:00 End Day 1
6ish Convene at Cassandra's House for casual Pizza dinner.

Tuesday April 23

9:00 Recap from Monday and discuss outstanding questions. Goals and agenda for Tuesday.
9:30 Discussion of imaging software available with examples (Phil).
10:30 Coffee break
11:00 Discuss and workshop of different agers continued (choosing otoliths that had low CVs/high agreement among agers; all one group).
12:00 Lunch break
1:00 Fill in tables for report on microscope details, prep details, ageing protocols
2:00 Discuss software for taking/stitching together mosaics of images with examples (Phil)
2:15 Coffee break
2:45 Discuss and workshop of different agers continued (mid-range CVs, one group).
5:00 End Day 2; Dinner on own.

Wednesday April 24

9:00 Recap from Tuesday and discuss outstanding questions; goals & agenda for Wednesday.
9:30 Validation of ageing (Cassandra & Colin)
10:20 Coffee break
10:50 Continue to review interpretation and come to an agreement on the age for reference set (choosing otoliths that had medium-high CVs; all one group).
12:00 Lunch break
1:00 Continue to review interpretation and come to an agreement on the age for reference set (choosing otoliths that had medium-high CVs; all one group).
2:30 Coffee break
3:00 Discussion of readability scores between labs and usage.
3:30 Discussion on how to build a reference or training set, development of best practice guidelines.
4:00 End Day 3; Dinner on own.

Thursday April 25

9:00	Recap from Wednesday and discuss outstanding questions, including discussion on validation methods (not as expensive and possible collaboration) and differences in live view vs images results from US (with offer to pool data from multiple countries and publish a paper together).
10:30	Coffee break
11:00	Lab session - image review of younger fish (juvenile split bands)
12:15	Lunch break
1:15	Development of guidelines for taking images for the CCAMLR reference set
2:30	Coffee break - and group photo
3:00	Group discussion about reviving CON (goals, logistics, funding, etc.).
3:30	R-package on imaging -training session
4:00	End day 4.
6:00	Group dinner downtown Boulder - Bohemian Biergarten

Friday April 26

9:00	Prairie dog visit (meet at SEEC Rm 372)
11:00	Recap on recommendations and requests to WGs, discuss future work plan
12:30	Lunch break
1:00	Any outstanding discussion items
2:30	Coffee break
3:00	Any outstanding discussion items
4:30	Next steps; closing
5:00	Meeting ends

Attachment IV. Proposal for a third CCAMLR workshop on age determination methods

Title: 3rd CCAMLR Age Determination Workshop (WS-ADM3-2025)
Host: TBD
Objectives:

3. To develop reference sets with agreed ages for both species of toothfish.
   a. Use the CCAMLR otolith image library to create production ageing reference sets.
   b. Outline how members should approach building their own otolith reference sets as a training tool for new readers.
4. To develop best practice standards based on the age preparation methods including diagnostic procedures, imaging, and age database structure and use.

Terms of Reference:

6. Bring together experts to continue to understand differences in otolith interpretation and age estimation, including conduct comparisons of age reading from static images and physical samples to determine if there are any differences in age readings and/or biases from a particular method.
7. Continue work developing the otolith reference collection for both Patagonian and Antarctic toothfish (with agreed ages).
8. Further progress pooling age data for assessments, including develop protocols, diagnostics, and procedures for 'blind' reads of otoliths to be used in future inter-reader and inter-lab comparisons
9. Develop the new CCAMLR otolith network format

Convener(s): Dr J. Devine (New Zealand), Dr. C. Brooks (USA), Dr. P. Hollyman (United Kingdom)
Venue: To be determined
Date: late April 2025 (date to be determined)
Duration: 5 days
Invited experts: TBA
Observers or external organisations: None
Funding required by CCAMLR: A$15 000 to cover invited experts travel related costs.
Secretariat Support required: Yes – Data Officer and Science Manager
Ability to submit papers: Not required
Outputs: Conveners report to WG-SAM-2025 and WG-FSA-2025 summarising the data, outcomes, and recommendations from the ToRs of the workshop.
Reported to: WG-SAM-2025 and WG-FSA-2025

Appendix F

Draft Krill Vessel Bycatch Data Collection and Reporting Survey

This survey is designed to collect information on how vessels in CCAMLR's krill fisheries collect and report their by-catch data, as there are currently no detailed instructions on methods to achieve this, and individual vessels employ different crew and operational arrangements. CCAMLR requires vessels operating in krill fisheries to report the total number of individuals and weight of bycatch by species, or to the lowest taxonomic level possible on a haul-by-haul basis using the C1 form. Please provide as much information as you can on the process in the questions below, and in the descriptive sections. Please only provide information on how vessels report by-catch data, not on procedures for observers to report their by-catch information

Vessel Type (please select one)	
Traditional Trawl	
Continuous Trawl	
Traditional and Continuous Trawl	
Location of by-catch sampling (select as many as applicable)	
Trawl net	
Dewatering Room	
Fish Pond/ Tank	
Factory Conveyer	
Other (please describe)	
Who is responsible for collecting by-catch specimens (select as many as applicable)	
Deck Crew	
Factory Crew	
Bosun	
Fishing Master	
Officers	
Observer	
Other (please describe)	
Who is responsible for recording and reporting the by-catch data (select as many as applicable)	
Deck Crew	
Factory Crew	
Bosun	
Fishing Master	
Officers	
Observer	

Other (please describe)	
Who is responsible for identifying by-catch species (select as many as applicable)?	
Deck Crew	
Factory Crew	
Bosun	
Fishing Master	
Officers	
Observer	
Other (please describe)	
What training do personnel undergo to assist in identifying by-catch species (select as many as applicable)?	
Theoretical (e.g. books, posters, video, online courses)	
Practical (on land)	
Practical (on vessel)	
Other (please describe)	
Title of person responsible on vessel responsible for by-catch identification	
Do you use CCAMLR identification guides on your vessel (please select one)?	
Yes	
No	
Unknown	
If known, please provide names of guides used	
Do you use national identification guides, or other by-catch ID publications on your vessel (please select one)?	
Yes	
No	
Unknown	
If known, please provide names of guides used	
Equipment/ layout on vessel	
Do you have a dedicated by-catch identification area?	
Do you have a scientific laboratory on the vessel?	
Do you have a binocular microscope or other magnification device to assist with identification? If yes please list equipment	
Do you have facilities to store by-catch samples? If yes please list (e.g. fridge, freezer, storage in alcohol)	

Do you photograph species which you cannot identify and request identification assistance from other institutes?	
General description	
Please provide a general description the process of collecting, identifying reporting by-catch data. If you employ specific procedures on your vessel please outline these. For example, are large fish removed by the crew for identification before the observer takes any 25kg subsample? Does your vessel attempt to collect data on very small larval fish, or do they rely on the observer for this?	
Suggestions to improve the collection and reporting of by-catch data	
Please provide suggestions on how you think the collection and reporting of by-catch data by vessels can be improved. For example, please suggest changes to the C1 form which would aid in reporting data. Would dedicated instructions on how to collect data for vessels be helpful?	