Annex 8

Report of the Working Group on
Fish Stock Assessment 2023 (WG-FSA-2023)
(Hobart, Australia, 2 to 13 October 2023)

Contents

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Opening of the meeting

1.1 The 2023 meeting of the Working Group on Fish Stock Assessment (WG-FSA) was held in Hobart, Australia, from 2 to 13 October 2023. While registered participants were able to follow the meeting online through Zoom, only participants who were present in the room were able to directly contribute to the meeting and comment on report text.

Introduction

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

1.3 Dr D. Agnew (Executive Secretary) welcomed all participants to the CCAMLR Secretariat. He looked forward to seeing the outcomes of the meeting being presented to the Scientific Committee and the Commission and noted the that the large number of papers submitted to the meeting highlights the level of engagement by Members in progressing the work of CCAMLR.

Adoption of the agenda

1.4 The Working Group reviewed and adopted the agenda (Appendix B).

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

1.6 The Working Group noted that scheduling the various topics during the meeting was complicated by having WG-IMAF occurring at the same time, which prevented individuals or small delegations from attending both meetings and made meeting planning and rapporteuring assignments complex.

1.7 In this report, paragraphs dealing with advice to the Scientific Committee have been highlighted. These paragraphs are listed under “Advice to the Scientific Committee”.

1.8 The report was prepared by S. Rodriguez-Alfaro (European Union), J. Cleeland (Australia), J. Devine (New Zealand), A. Dunn (New Zealand), T. Earl (United Kingdom), M. Eléaume (France), J. Fenaughty (New Zealand), P. Hollyman (United Kingdom), D. Maschette, S. Kawaguchi and C. Masere (Australia), F. Massiot-Granier (France), T. Okuda

(Japan), F. Ouzoulias (France), S. Parker (Secretariat), G. Robson (United Kingdom), M. Santos (Argentina), S. Thanassekos (Secretariat), G. Watters (USA), M. Williamson (South Africa) and G. Zhu (China).

Review of terms of reference and the work plan

1.9 The Working Group reviewed the terms of reference developed during SC-CAMLR-41 and distributed in SC-CIRC 23/52. The Working Group noted that the revised terms of reference explicitly include the effects of climate change in the Working Groups advice to the Scientific Committee. The Working Group further noted that having the terms of reference readily available for review at the start of each meeting was helpful and recommended that these be provided along with the agendas for the Working Group meetings.

1.10 The Working Group recalled the workplan agreed from SC-CAMLR-41 Table 8 and agreed to revisit it under Future Work, to identify tasks that have been completed and new tasks that may arise during the meeting.

Review of CCAMLR fisheries in 2022/2023 and notifications for 2023/2024

2.1 CCAMLR-42/BG/08 Rev. 1 presented a summary of all notifications received by the Secretariat for research fisheries, exploratory fisheries for toothfish and krill fisheries for the 2023/24 fishing season.

2.2 The Working Group welcomed this contribution and noted that the vessel Helena Ndume (formerly known as Matilda), notified by Namibia to fish in Subareas 88.1 and 88.2, submitted a preliminary assessment of the potential significant adverse impacts on vulnerable marine ecosystems required by Conservation Measure (CM) 22-06 after the deadline of 1 June 2023.

2.3 The Working Group noted the paper included a notification under a Research Plan submitted by Uruguay for Subarea 48.6 (WG-SAM-2023/07) which has not yet been scientifically evaluated by either WG-SAM (WG-SAM-2023, paragraph 8.1) or WG-FSA. The Working Group noted two papers (WG-FSA-2023/01, WG-FSA-2023/02) that relate to this vessel notification were discussed under the Scheme of International Scientific Observation.

2.4 The Working Group noted SC-CAMLR-42/BG/01, which presented a brief overview of catches of target species from directed fishing on toothfish, icefish and krill in the Convention Area in the 2021/22 and 2022/23 seasons, and from research fishing under CM 24-05.

2.5 CCAMLR-42/BG/09 detailed the operation of the fishery forecasting algorithms for the fisheries in the 2022/23 fishing season and assessed the implementation of the current procedures.

2.6 The Working Group welcomed the paper and noted that the algorithm for forecasting toothfish closures was generally working well and had stabilised in recent years. The Working Group considered that a forecasting procedure was not required in areas covered by a Research Plan as vessels coordinate to manage catch and large overruns are uncommon. The Working Group also noted that, in the future, a summary of the outcomes from the forecast estimates

should be presented in the Secretariat's annual catch report paper (i.e., SC-CAMLR-42/BG/01) instead of a separate paper, unless there were significant issues that should be brought to the attention of the Working Group.

Recommendations from other Working Groups

2.7 SC-CAMLR-42/09 presented the Report of the Working Group on Statistics, Assessment and Modelling (Kochi, India, 26 to 30 June 2023). Several paragraphs of the WG-SAM report explicitly indicated the necessity of further discussion, submission of a revised paper, and reporting progress at WG-FSA-2023, including:

(i) an updated version of WG-SAM-23/13, the risk assessment for the Antarctic starry skate (*Amblyraja georgiana*)

(ii) validation of Casal2 models compared with the CASAL models

(iii) revision of the Chilean research proposal for *Dissostichus* spp. in Subarea 48.2

(iv) further results of Ukrainian icefish research in Subarea 48.2

(v) referred items in the report of the joint COLTO–CCAMLR Workshop for tagging toothfish and skates

(vi) developing the terms of reference of the in-person workshop for age determination.

2.8 SC-CAMLR-42/10 presented the Report of the Working Group on Ecosystem Monitoring and Management (Kochi, India, 3 to 14 July 2023). The report highlighted the status of the review of CCAMLR's Ecosystem Monitoring Program (CEMP) and topic areas that enhanced CEMP may include:

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

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

(iii) supporting MPA design and monitoring.

2.9 WG-EMM-2023 also noted the development of a revised protocol for sampling length frequency distribution of krill and that further development would occur through the Krill Fishery Observer Workshop (WS-KFO-2023) and be made available for review by WG-FSA-2023.

Data collection forms and instructions

2.10 WG-FSA-2023/06 presented an update on the status, priorities for the development of fishery data forms and manuals and identified the need to coordinate changes to vessel and observer forms simultaneously to standardise appearance and terminology to reduce ambiguity.

The Working Group noted the substantial efforts and developments made recently to improve the functionality and data collection of various vessel and observer forms.

2.11 The Working Group recommended the Scientific Committee consider replacing CE reporting in the longline fishery with submission of the C2 form if the reporting period was every 5 days or greater, given that there is some duplication between the CE and C1 or C2 forms.

2.12 The Working Group noted that the C1 form is used in both finfish and krill trawl fisheries and recommended that the current form be separated into finfish and krill-specific data collection forms as both fisheries have different data collection requirements.

2.13 The Working Group recommended to the Scientific Committee that a trawl fisheries data workshop occur during the intersessional period to discuss the revisions to the C1 form including the potential replacement of CE reporting in the krill fishery with submission of the C1 form.

2.14 The Working Group noted that the C2 forms and manuals have been recently revised and updated, and requested the Secretariat to revise the manual to reflect that tagging data is not required to be reported to CCAMLR by vessels in Division 58.5.2.

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

2.16 The Working Group noted that research vessels which undertake research trawls surveys are regulated under CM24-01 Annex A and should report data using the C4 form. The Working Group recommended that the Scientific Committee review the C4 form in light of Scientific Committee requirements (e.g. changes to the CEMP).

2.17 The Working Group noted that C5 forms are currently used by only a small number of Members and requested that the Secretariat work directly with those Members to revise this form.

2.18 The Working Group requested that the Secretariat continue to keep a register of issues with forms and manuals and present a summary of issues with proposed revisions to relevant Working Groups as required.

2.19 The Working Group requested the Secretariat to group forms, instructions, and manuals together on the CCAMLR website for easy downloading as this information is currently in several locations and can be difficult to find.

2.20 The Working Group noted the proposal to modify the observer logbook to include the revised skate injury codes provided in Table 1. The Working Group noted that this revision was based on recent developments reported in WG-FSA-2022/19 and included several new codes to support future post-release survival analyses and to include superficial injuries, bruising on the disc or tail and healed injuries in the mouth/jaw region which could be reflective of past capture events.

2. 21 The Working Group recommended the skate injury codes be incorporated into the observer logbook for the 2024/25 season on the tag release, tag recapture and biological data collection sheets, including multiple codes for a single skate.

2.22 The Working Group tasked the Secretariat with assessing the feasibility of developing a photo repository for images of tags recovered from recaptured skates that can be linked to tag metadata and noted a photo naming convention already existed (WG-FSA-15/76) and could be implemented after skate tag recapture.

Illegal, unreported and unregulated fishing

2.23 CCAMLR-42/15 Rev. 1 presented a summary of information received by the Secretariat in relation to illegal, unreported and unregulated (IUU) fishing in 2022/23 relevant to CCAMLR, as well as unidentified gear retrieved from October 2022 to August 2023, including proposed updates, amendments, inclusions and removals from IUU vessel lists.

2.24 The Working Group welcomed this contribution and noted the challenges with attributing unidentified gear to IUU activity. It recommended that future reports separate observations of unidentified gear into different gear types to enable the identification of IUU activity using gill nets. Furthermore, the Working Group noted that improvements to vessel forms for lost gear and observer forms for recovered gear would provide greater insight into IUU activity.

2.25 The Working Group considered methods, including the marking of fishing gear, to ascertain whether gear found belonged to the legal fishery, which would help improve estimates of IUU fishing activity and recalled that the 'Unidentified fishing gear in the Convention Area' e-group had been created to address this issue.

2.26 The Working Group noted that the limited ability to identify IUU fishing activities can impact the scientific advice by the Working Group.

2.27 The Working Group noted that the analysis of the VMS data provided by Bolivia for the proposed NCP IUU Vessel *Cobija* for the period 19 November 2017 to 15 April 2018 indicated the vessel navigated to a known fishing location in Division 58.4.3b, where it possibly undertook fishing activities. The Working Group noted that the direct transit to and from this location would indicate knowledge of prior fishing locations in the area.

2.28 WG-FSA-2023/21 presented evidence from albatrosses equipped with GPS and a radar-detection device of a possible detection of IUU activity in the BANZARE Bank region in Division 58.4.3b in 2018 and 2019. The area where detections were made was nearby where Australian Research Vessel (RV) *Aurora Australis* found illegal fishing gear in 2020.

2.29 The Working Group welcomed the study and noted the region where the IUU detections were made was also near the location in Division 58.4.3b where CCAMLR-42/15 Rev. 1 reported IUU activity in 2017 and 2018. The Working Group noted that the use of evidence from tagged albatrosses to detect IUU vessels may increase the mortality risk to all albatrosses and that this issue should be considered by WG-IMAF.

Marine debris

2.30 WG-EMM-2023/14 reported on the CCAMLR Marine Debris Monitoring Programme (MDMP) that was established in 1986 to monitor marine debris in the Convention Area. The

MDMP data included data submitted by CCAMLR Members from beach surveys, seabird colony surveys, observations of marine mammal entanglements, hydrocarbon soiling events, opportunistic sightings, gear lost by fishing vessels, and marine debris (including fishing gear from other sources) observed at-sea by SISO observers. The paper noted that while spatial patterns in the amount of longline fishing gear lost generally reflect spatial patterns in fishing effort, some areas show higher rates of loss, likely due to a combination of sea ice dynamics, local currents, and seafloor characteristics.

2.31 The Working Group welcomed the report and noted that current C2 forms do not allow for the reporting of loss of depredation mitigation devices, specific components of gear lost, or an indication of where the loss occurred.

2.32 The Working Group noted the marine debris programme summary (WG-EMM-2023/14) was developing two forms to improve documentation of items, including fishing gear lost from longline vessels, as part of the C2 form, as well as a form to be included in observer logbooks to document marine debris including fishing gear recovered during trips.

2.33 The Working Group suggested the Secretariat include an "other" free text field for vessels to note other items lost and the date the item(s) were lost to aid in linking to the location of the vessel, as items can be lost outside of fishing activities.

2.34 The Working Group noted that a standalone lost marine debris form for fisheries other than longline could be implemented immediately instead of waiting for developments to the C1 form for the krill and finfish trawl fisheries, but noted that if a separate form was needed, the relevant CMs would need modification.

2.35 The Working Group noted that observers currently record any items lost overboard or found at sea in cruise reports, but that a form would allow more detail and structured data.

2.36 The Working Group discussed that other vessels other than fishing vessels, such as tourist vessels, can report marine debris in a similar manner using the 'opportunistic marine debris' form, as having reports from all vessels would improve the available information.

2.37 The Working Group recommended that the Scientific Committee consider whether marine debris lost by the vessel should be reported as part of C1, C2 or C5 forms or in a new form.

Krill

3.1 WG-FSA-2023/34 presented a preliminary analysis of seasonal and annual variations in sea ice within Subareas 48.1 and 48.2 and how they may affect the ability of krill-fishing vessels to access important fishing areas. Trends presented in the paper indicate that the period when sea ice limits access to important krill-fishing areas in the Bransfield Strait has decreased from about 4 to 3 months (over the period 1997-2022), from 5 to 2 months around Elephant Island (over the period 1980-2022), and from 6.5 to 4 months in Subarea 48.2 (over the period 1980-2022). The authors conclude that sea ice determines access to krill-fishing grounds and is the primary factor that determines where krill fishing occurs. The authors further conclude that access should be considered during the development of the revised management strategy for the krill fishery, particularly during the austral winter.

3.2 The Working Group agreed that sea ice plays an important role in determining where the krill fishery operates, however it noted that ARK's Voluntary Restricted Zones (VRZs) have also affected the distribution of krill fishing. The VRZs in Subarea 48.1 may have contributed to an increased concentration of krill fishing in Subarea 48.2, and this concentration of fishing occurs in relatively close proximity to breeding colonies of krill-dependent predators. The Working Group recommended this situation be further considered by WG-EMM.

3.3 The Working Group noted that as sea ice cover continues to decline, areas on the continental shelf and near shore will become more accessible to vessels. Since these areas are critically important to krill-dependent predators, the Working Group considered that the Scientific Committee and its working groups should pay careful attention to the issue of distributing krill catches onshore and offshore as well as within fishing seasons.

3.4 The Working Group agreed that it will be important to monitor changes in sea ice and to consider these changes during the implementation of the revised management strategy for the krill fishery. As access to fishing grounds changes in response to sea ice, it may be necessary to change the distribution of catch limits between seasons or among management units.

3.5 WG-FSA-2023/64 discussed the selectivity function described by Krag et al. (2014) and used in recent applications of the Grym for krill. The authors summarised several shortcomings in the work by Krag et al., including that the results were based on observations collected from three different krill fishing vessels in three different fishing seasons, and thus the study had not adequately controlled for differences between vessels and years. The authors concluded that the results of Krag et al. (2014) should not be used in applications of the Grym for krill.

3.6 The Working Group noted that there are no alternatives to the selectivity function described by Krag et al. (2014), and, thus, it remains the best available science. It noted that WG-EMM also determined that the selectivity function developed by Krag et al. is the best available science (WG-EMM-2023, paragraph 4.24). A selectivity function is required to simulate fishery removals in the Grym, and the authors of WG-FSA-2023/64 were encouraged to develop, test and submit an alternative selectivity function for further consideration.

3.7 The Working Group recalled the reports from WG-SAM-2023 (paragraph 3.3) and WG-EMM-2023 (paragraph 4.23), and recommended further work investigating whether, for krill, results from the Grym would be sensitive to changes in the parameterization of fishery selectivity. It noted that this question could be investigated through a set of sensitivity tests (e.g., by comparing gamma values produced with different parameter values in the selectivity function) and by comparing length-frequency data collected by SISO to expectations from the model developed by Krag et al. (2014).

3.8 WG-FSA-2023/53 presented an analysis of the intrinsic productivity, inferred from the Length Based Spawning Potential Ratio (LBSPR) method, of krill in Subarea 48.1; this work was conducted by a current CCAMLR Scholarship recipient, Mr. Mauricio Mardones (Chile). Using selectivity and life-history parameters, LBSPRs were estimated from fits to length frequency data from SISO. Life-history parameters were taken from recent applications of the Grym to krill in Subarea 48.1 (e.g., WG-FSA-2021/39). The length frequency data were binned by fishing season and management unit, with management units defined as in recent applications of the spatial overlap analysis for the krill fishery in Subarea 48.1 (see, e.g., WG-EMM-2022/17 and WG-FSA-2022/39). The paper documented differences in the size composition of the krill catch among management units as well as interannual changes within management units. These differences and changes in size composition were considered to

reflect differences and changes in the Spawning Potential Ratio, with the highest ratios occurring in the Elephant Island management unit, and the smallest ratios occurring in the Extra (Gerlache Strait) management unit. Spawning Potential Ratios in the Elephant Island management unit showed an increasing trend, driven by shifts in the size compositions of the catch from this area. The authors concluded that spatial differences in the Spawning Potential Ratio could inform development of the revised management strategy for the krill fishery, for example by characterising spatial differences in intrinsic productivity to inform spatial overlap analyses.

3.9 The Working Group congratulated Mr. Mardones and welcomed his work as a new CCAMLR Scholar. The Working Group acknowledged it was unaware whether the LBSPR approach had previously been applied in a spatially disaggregated manner and noted that, given the connectivity of krill between management units in Subarea 48.1, it might be useful to compare the results from the current analysis with five management units to new results from an analysis in which all management units are combined. Such a comparison might allow for consideration of temporal variation in Spawning Potential Ratio for the subarea as a whole. The Working Group further asked whether targeted fishing within management units (e.g., in areas with high krill densities) and changes in sampling requirements for observers (e.g., which might affect observed size compositions) might bias results from the LBSPR approach. Some participants commented that, in their view, it was unlikely the krill fishery is affecting the intrinsic productivity of the krill stock in Subarea 48.1 given the low harvest rates occurring therein.

3.10 WG-FSA-2023/54 identified four spatial inconsistencies, or mismatches, in different components of the work to establish a revised management approach for the krill fishery in Subarea 48.1. First, the polygon defining the Joinville management unit is cropped in one spatial overlap analysis (WG-EMM-2022/17) but not in another spatial overlap analysis (WG-FSA-2022/39) nor in calculations of areas (WG-ASAM-2023/01). Second, polygons defining the Powell Basin and Drake Passage management units are cropped in both spatial overlap analyses but not in calculations of total krill biomass (WG-ASAM-2023, Table 1). Third, a small area near the tip of the Antarctic Peninsula (in and around Antarctic Sound) is included within the Powell Basin management unit in one spatial overlap analysis and within the Drake Passage management unit in the other overlap analysis. The authors questioned whether this small area near the tip of the Antarctic Peninsula could be excluded from future implementation of the revised management approach for the krill fishery. Finally, both spatial overlap analyses and calculations of areas all use different map projections, which leads to different catch limits and estimates of biomass in each management unit.

3.11 The Working Group did not provide a recommendation on how to address the first mismatch (whether the Joinville management unit should be cropped) but noted that this mismatch is likely to only have a small effect on calculations related to the revised management approach for the krill fishery.

3.12 The Working Group did not agree about whether or how to address the second mismatch (whether the Powell Basin and Drake Passage management units should be cropped). The Working Group noted that WG-ASAM advised the use of very conservative estimates of krill density in the Powell Basin and Drake Passage management units, but it also noted that biomass estimates are calculated by multiplying these density estimates by the areas (km2) of the management units. The Powell Basin and Drake Passage management units are very large and cropping them (or not) thus significantly affects the estimate of total krill biomass in Subarea

48.1 and the catch limit that would, on the basis of the spatial overlap analysis, be distributed through all management units. It was also noted that it might be appropriate to split the Drake

Passage management unit into two or more smaller units. However, to avoid unintended concentration of fishing due to changes in the distribution of krill, management units should be at an appropriate spatial scale for management.

3.13 The Working Grouped noted that there are few acoustic estimates of krill density in the Powell Basin and Drake Passage management units, and new acoustic surveys in these units might reduce uncertainty associated with extrapolating density estimates to these large areas.

3.14 The Working Group did not provide a recommendation how to address the third mismatch (how to treat the small area near the tip of the Antarctic Peninsula). However, the Working Group noted that krill fishing occurs in and around Antarctic Sound at a low level and agreed that this area should not be excluded from the implementation of the revised management approach for the krill fishery.

3.15 To address the fourth mismatch (use of different map projections), the Working Group noted the recommendations in WG-ASAM-2023 (paragraph 3.9) on geospatial operations within CCAMLR. Noting that the use of georeferenced polygons is a widespread discussion within CCAMLR, the Working Group reviewed and expanded on these recommendations to assist in future implementations.

3.16 The Working Group noted that the map projection proposed by WG-ASAM-2023 is consistent with the projection endorsed by WG-FSA-2019 (paragraph 4.34). It discussed the differing sources of coastline data and the classification of land, permanent sea ice, and glaciers within. The Working Group noted that currently the SCAR Antarctic Digital Database (ADD) only has coastline south of 60° S and suggested an expansion of this in the future to the entire CCAMLR area would be beneficial to the CCAMLR community.

3.17 The Working Group noted that there are few Southern Ocean geospatial specialists actively developing methods of data quality control and analysis. As such, the Working Group thanked Dr Michael Sumner (Australia) for his continuing work in this field and assistance to the CCAMLR Secretariat on these matters.

3.18 Building upon recommendations from WG-ASAM-2023 and the Secretariat, the Working Group recommended the Scientific Committee request Members apply the following geospatial rules:

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

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

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

(iv) vertices be added where polygons meet (see Figure 1)

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

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

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

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

(ix) all maps cite data sources and projection used

3.19 In order to enable this the Working Group requested:

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

(ii) the Secretariat work with Members to develop standard tests and diagnostics to verify the validity of spatial polygons.

3.20 WG-FSA-2023/68 presented updated precautionary catch limits for *Euphausia superba* in Divisions 58.4.1 and 58.4.2-East based on recent biomass estimates from a 2019 survey conducted by Japan in Division 58.4.1 and a 2021 survey conducted by Australia in Division 58.4.2-East. These biomass estimates were combined with Grym stock assessments to estimate precautionary harvest rates for krill in Divisions 58.4.1 and 58.4.2-East and derive precautionary catch limits.

3.21 The authors of WG-FSA-2023/68 recommended that:

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

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

(iii) the current trigger levels in CM 51-03 for both subdivisions of Division 58.4.2 remain in force until such time that an updated spatial overlap analysis can inform on a spatial allocation of catch within this Division.

3.22 The Working Group welcomed the efforts by Australia and Japan to bring forward updated catch limits for these two divisions following the same process agreed in 2019 and undertaken in 2021 for Subarea 48.1 (WG-FSA-2021/39).

3.23 The Working Group noted that the parameters for this assessment had been reviewed and agreed by WG-EMM-2023 (paragraphs 4.6 to 4.8). It further noted the size of maturity is larger in East Antarctica compared to that for Southwest Atlantic sector, and considered whether this is a biological characteristic of krill in this region or the result of bias that may have arisen through the length-frequency observations. The authors of WG-FSA-2023/68 clarified that the demographic data for Divisions 58.4.1 and 58.4.2-East were collected by

different research groups in different field seasons, yet the parameter values were almost identical, indicating that these maturity parameters reflect actual krill biology in these regions.

3.24 The Working Group noted that the catch limits recommended in WG-FSA-2023/68 are based upon updated biomass estimates in these Divisions, which did not survey within the sea-ice zone (WG-ASAM-2021, paragraph 2.26).

3.25 Some participants noted that the use of these results may need further discussion, due to the biomass being estimated based on a survey that may not have included areas which may be important krill habitats (e.g., sea-ice zone).

3.26 Some other participants noted the biomass estimates have been agreed by WG-ASAM-2021, SC-CAMLR-2021, published within peer reviewed literature and further discussed by WG-ASAM-2023, and provide the best available estimates of biomass in these areas. They also considered these estimates to be precautionary in this area.

3.27 The Working Group endorsed the assessment on the harvest rates for *E. superba* in Divisions 58.4.1 and 58.4.2-East.

3.28 The Working Group recommended the Scientific Committee consider the proposed catch limits in Tables 2 and 3 be used to update CMs 51-02 and 51-03. The Working Group further recommended the current trigger levels in CM 51-03 remain in force for both subdivisions of Division 58.4.2 until such time that an updated spatial overlap analysis can inform on a spatial allocation of catches within this Division.

3.29 WG-FSA-2023/14 presented preliminary results from a pilot implementation of an integrated assessment model for krill in Subarea 48.1 using the Casal2 framework. The authors cautioned the Working Group to consider the potential of the assessment rather than the specific results, and, in this regard highlighted how an integrated assessment will enable use of multiple data sets and multiple types of data collected by multiple Members (see also WG-SAM-2023/25). The authors also highlighted how commonly used model-selection approaches (e.g., AIC) can be used within an integrated assessment framework to evaluate competing hypotheses. Personnel from the U.S. AMLR Program plan to further develop integrated assessment models for krill, including diagnostics presentations and comparisons with alternative modelling frameworks (e.g., Stock Synthesis 3), with the aim of using such an assessment to provide management advice in the next 3-5 years.

3.30 The Working Group welcomed the work to develop an integrated assessment for krill in Subarea 48.1 and reiterated the previous advice of WG-SAM (WG-SAM-2023, paragraphs 4.2 and 4.3), particularly advice related to diagnostics and comparisons with the Grym. The Working Group noted this model could be useful for estimating selectivity within the krill fishery.

3.31 The Working Group noted that Dr. D. Kinzey (USA) has now retired and thanked him for his efforts to progress krill modelling over the past decade.

3.32 If a new scientist is hired to continue Dr. Kinzey's work, participants offered to assist with Casal2 and suggested that they subscribe to the Casal2 GitHub repository (WG-SAM-2023, paragraph 6.31) hosted by the Secretariat.

Krill fishery observer workshop

3.33 SC-CAMLR-42/05, the Report of the Krill Fishery Observer Workshop (WS-KFO), was presented by Professor G. Zhu (China) and Dr S. Kawaguchi (Australia), the co-conveners of WS-KFO-2023. The Workshop gathered CCAMLR krill scientists, scientific observers, and the fishery operators to review and discuss management of appropriate workload, refinement of sampling and reporting protocols.

3.34 The Working Group thanked the co-conveners and congratulated the Workshop for its successful outcomes, which helped improving the understanding of how the observers are operating on krill vessels, explored the ways to address difficulties that observers are facing in the field, and considered improved sampling protocols to ensure the data quality.

3.35 The Working Group noted the increasing and diversifying sampling tasks required within the observers' demanding workload. It was noted that sometimes observer deployments may extend for a long time (see WG-FSA-2023/07 Rev. 2) due to unexpected conditions, for example, the impact of COVID-19 restrictions, and the Working Group reiterated the importance of ensuring the health and wellbeing of the observers.

3.36 The Working Group noted the importance of work that observers are undertaking as it contributes to the conservation of Antarctic marine living resources and that providing feedback to the observers on how the collected data are used for the management is also important.

3.37 The Working Group noted that observers are sometimes asked to support data collection that are the vessel's responsibility. The Working Group recalled 'Functions and tasks of Scientific Observers appointed in accordance with the Scheme of International Scientific Observation' described in Appendix 2 of the 'Scheme of International Scientific Observation Scientific Observer's Manual-Krill Fisheries' which clarifies SISO responsibilities and that these need to be conveyed to both the observers and the vessels to provide clarity on their responsibilities.

Fish by-catch observation

3.38 The Working Group noted the difficulty that observers face when they encounter high numbers and frequencies of by-catch species in their by-catch samples. The Secretariat clarified that occurrence of high by-catch levels is low, but it is important to ensure that accurate data are collected for these rare events.

3.39 The Working Group confirmed that by-catch should be sorted and weighed from the entire 25 kg subsample. If it is impractical to measure and count all individuals of a species due to large numbers, then observers may only measure an agreed threshold number of individuals (e.g., 200 individuals per species) which could then be scaled using the total weight of the subsample for the species to determine a total sampled number and length composition. The Working Group noted that more work could be needed to determine the sample number required and that changes to the observer form could be required (see paragraph 3.41 (iii)).

3.40 The Working Group noted that some data collected by observers are rarely used or are currently being collected because they were previously required to address specific questions. Additionally, some data fields in the observer logbook may need modification to improve the clarity and reduce the uncertainties in the observation.

3.41 The Working Group reviewed the krill observer logbook and recommended that:

(i) The 'feeding colour' column be removed from the 'krill biological' tab, as this data is not used.

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

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

3.42 The Working Group noted that otoliths of toothfish are valuable for stock assessment and the understanding of life history, and therefore retaining such samples when toothfish are in the by-catch may be valuable. The Working Group further noted that a mechanism to deliver these otoliths to Members ageing toothfish would need to be developed.

3.43 The Working Group agreed that fish by-catch in the krill fishery provides an excellent opportunity to inform studies of early life history of fishes in the Convention area, and discussed the value of having "focus species" on which to collect biological data, especially on early life stages, from fish by-catch in the krill fishery (e.g., during a "Year of *C. gunnari*" collection of biological data could be prioritized for this species). The table of prohibited species for directed fishing in Area 48 in CM 32-03, combined with analyses of fish by-catch data to understand the distributions of bycaught fishes, provide useful guidance to decide on priority by-catch species for focused data collection.

Krill length-frequency data collection protocol

3.44 The Working Group endorsed the updated krill length-frequency data (LFD) collection protocol developed by WG-EMM and WS-KFO and recommended the Scientific Committee consider them be included in the krill observer manual, and further made the following comments.

(i) Seasonal length-frequency and maturity data are essential for the development of a Krill Stock Hypothesis and informing future length-based stock assessments of krill, and hence decision making related to krill-fishery management.

(ii) Requirements for minimum numbers of measurements and levels of precision depend on the questions to be addressed. The Working Group clarified that there will be multiple types of data analysis, with specific analyses depending on the questions being addressed, and data requirements may change as these analyses progress.

3.45 The Working Group recommended that the current requirement to measure the length of at least 200 krill should be continued until otherwise advised based on a review of research questions and data-collection needs, to be completed by each Working Group (see paragraphs 3.47 and 3.48).

Priority data collection in the krill fishery

3.46 The Working Group noted that this was the first occasion that estimated observer time allocation for tasking in the krill fishery had been summarised. The Working Group clarified that estimates of total time required for observers in the krill fishery to complete tasks are based on a time budget for one experienced observer. It is estimated that time required to complete all tasks is 14.5 hours and 12.2 hours for continuous and traditional trawlers respectively, assuming all tasks are completed once in a single day. However, as every task is not necessarily undertaken every day, the actual average daily time required for the observers to undertake tasks as specified in conservation measures is approximately 6.5 to 7 and 4.2 to 4.7 hours respectively for continuous and traditional trawlers under the current SISO program depending on the time of year.

3.47 The Working Group agreed on the usefulness of Table 1 from SC-CAMLR-42/05 as a guidance to design sampling instructions for the observers so that data collection can be as efficient as practicable and achieve levels of sampling and data-quality standards required for the management of CCAMLR fisheries, while ensuring the wellbeing of the observers.

3.48 The Working Group noted that WG-EMM, WG-ASAM, WG-IMAF and WG-SAM may have additional and different priorities for data collection from the krill observer program, all of which may lead to different requirements for data resolution and the types of data to be collected. For example, WG-EMM has data-collection needs for the development of a Krill Stock Hypothesis, and WG-ASAM requires krill LFD for fishery-based acoustic biomass estimates. Therefore, to establish a data-collection plan across all Working Groups the Scientific Committee may need a list of data requirements from each Working Group.

3.49 The Working Group recommended that the Scientific Committee task all Working Groups to review their list of priority questions, within their respective Terms of Reference, that need to be addressed from krill-fishery observer data. The Working Group recommends that all Working Groups provide details of data requirements to include number of samples and the spatial and temporal scales required to address these questions.

3.50 The Working Group noted that once a list of data collection requirements to address the priority questions from all Working Groups had been compiled, the Scientific Committee consider assigning priorities to the data collection tasks taking into account the wellbeing of the observers with regards to their workload.

Fish

Trend analysis rules

4.1 WG-FSA-2023/71 summarised the method to link tagged, released and recaptured toothfish and skates in the tagging database held by the Secretariat. The paper noted that over 98% of the tags recaptured were linked to their release event and that improvements to that percentage were generally small because the overall data quality was high, particularly in recent years. The paper also presented a summary of tagged fish movements as requested by WG-FSA (WG-FSA-2022, paragraph 4.10).

4.2 The Working Group thanked the Secretariat and noted that detailed reports would only be needed when the integrated toothfish assessments are updated or an important change to the analysis is conducted.

4.3 The Working Group noted that the summary of tagged fish movement was useful to help understand potential stock connectivity between areas. The Working Group requested that the Secretariat add the biological information of tagged fish and diagrams of fish movement presented in WG-FSA-2023/71 to the Fishery Reports (in the relevant Species Descriptions) and consider publishing a paper on the analysis of movements of tagged fish in the scientific literature in collaboration with interested Members.

4.4 The Working Group noted that investigating historical tagging data quality issues might be a suitable topic for a future scholarship project.

4.5 WG-FSA-2023/05 presented biomass estimates for research blocks in data-limited fisheries using the trend analysis decision rules, following provisional estimates that were presented to WG-SAM-2023 (WG-SAM-2023/16).

4.6 The Working Group thanked the Secretariat for the work and noted that IBSCO bathymetry data are presented at a finer resolution then GEBCO bathymetry data and could be evaluated for use in the seabed area calculations for the trend analysis.

4.7 The Working Group recommended catch limits for research blocks in data-limited toothfish fisheries for the 2023/24 season using the trend analysis decision rules as given in Table 4.

4.8 The Working Group noted the latest vulnerable biomass estimates as will used for the trend analysis calculations next year for Division 58.5.2 and the Ross Sea region; in Division 58.5.2 (assessment presented in WG-FSA-2023/26 Rev. 1), the 2023 estimate was 25 043 tonnes (CV 0.0976), and in the Ross Sea region (assessment presented in WG-FSA-2023/13), the 2023 estimate was 89 809 tonnes (CV 0.0594).

4.9 WG-FSA-2023/08 described Agent-Based Models (ABMs) to support Management Strategy Evaluations (MSEs) of the CCAMLR trend analysis and illustrated the core components of the model as recommended by WG-SAM-2023, paragraph 7.3(i).

4.10 The Working Group noted that the development of ABMs had been requested by WG-FSA (WG-FSA-2022, paragraphs 4.66 to 4.67), and that the paper was helpful to aid understanding of how ABMs work.

4.11 The Working Group recalled that ABMs can have advantages over other approaches because the model can accommodate “memory”, where past events can be used to influence future events among groups of individuals in the model, allowing the ABM framework to simulate processes such as site fidelity and migration scenarios, and evaluate how these may affect the Chapman estimates of biomass.

4.12 The Working Group noted the recommendations of WG-SAM (WG-SAM-2023 paragraph 7.3(iii)) that in addition to the ABM, other approaches of simple and medium complexity be developed to be compared with the ABM approach in management strategy evaluations (MSEs).

4.13 The Working Group recalled that WG-SAM-2023 (paragraphs 7.3 to 7.4) included a list of tasks to further the ABM work and encouraged Members to collaboratively engage on this work program using a dedicated e-Group as recommended (WG-SAM-2023, paragraph 7.4).

Age determination

4.14 WG-FSA-2023/43 Rev. 1 presented the report of the Age Determination Workshop (WS-ADM-2023), co-convened by Dr P. Hollyman (United Kingdom) and Dr J. Devine (New Zealand), held virtually from 9 to 11 May 2023, and attended by 36 participants from 12 Members. The workshop terms of reference were outlined in WG-FSA-2022 paragraph 4.20. The report noted that progress had been made against all the terms of reference, but that assistance was needed from WG-SAM and WG-FSA to progress several tasks. To further develop age determination and quality control procedures, an in-person workshop with ageing experts from each lab was recommended to assess agreement on otolith age interpretation and to develop agreed reference sets for the different processing methods.

4.15 The Working Group welcomed the report (Appendix D) and the progress made in ageing methodologies. The Working Group agreed that a second ageing workshop should be conducted to bring together ageing experts to develop best practice guidelines and reference sets. The Working Group noted the tasks the Workshop had asked WG-FSA to consider for their work plan.

4.16 The Working Group recommended that when ageing otoliths for the next workshop, different laboratories age the same otoliths (using sister otoliths if different processing methods are used), read them without knowledge of fish length, area, or other biological characteristics, and complete an evaluation of reader comparison for WG-SAM-2024 and conduct statistical analyses such as estimating CVs.

4.17 The Working Group recommended the Secretariat address recommendations in paragraphs 6.1.2 and 6.1.3 of the paper when developing the ageing database and otolith library (Appendix D, Table 3).

4.18 The Working Group recommended that the Scientific Committee consider the following recommendations from the Age Determination workshop:

(i) All papers that use production ageing data include the distribution of the readability scores, add readability scores to inter-reader comparison plots to indicate where potential biases may arise, and standardise reporting methods, such as by creating common scripts to be added to the CCAMLR GitHub or to the e-Group for the Workshop on Age Determination (WG-FSA-2023/43 Rev. 1, paragraph 2.12.5)

(ii) the Scientific Committee resurrect the CCAMLR Otolith Network for Members to exchange knowledge and work together for ageing purposes (WG-FSA-2023/43 Rev. 1, paragraph 2.17.1)

(iii) Members continue to work on age validation methods, particularly for non-toothfish species (WG-FSA-2023/43 Rev. 1, paragraph 3.1.1)

(vi) Members create sets of up to 60 high-quality images, including notations (where currently available), for each species they age, beginning with toothfish, which will then be used by to build the reference otolith set (WG-FSA-2023/43 Rev. 1 paragraph 7.1.1)

(v) Members submit otolith images for Antarctic and Patagonian toothfish to the Secretariat by 1 March 2024 (WG-FSA-2023/43 Rev. 1 paragraph 7.1.2).

4.19 The Working Group recommended that WG-SAM consider paragraphs 2.12.3 and 2.16.2 in WG-FSA-2023/43 for inclusion in their workplan in 2024 and give this work a high priority (Appendix D, Table 3).

4.20 The Working Group recommended that the Scientific Committee support the second Workshop on Age Determination Methods (WS-ADM2). The workshop would be conducted in-person and provide a Conveners' report that details the ages agreed by the Workshop for a reference set of otoliths.

4.21 The Working Group recommended the Scientific Committee endorse the WS-ADM2 arrangements, objectives and terms of reference as detailed in the Proposal for a workshop for age determination (Appendix E).

4.22 Paper WG-FSA-2023/12 presented an alternate, lower cost method for preparing toothfish otoliths, and length and age composition data and growth curves for Antarctic toothfish in the Ross Sea region caught by the Russian longline vessel, *Sparta*, in the 2018/19 season.

4.23 The Working Group thanked the author for the paper and noted that new approaches to reduce the cost of preparing otoliths was welcome, but that the paper did not address the health and safety issues with this approach, which are very important. The Working Group noted that it was helpful to have more Members ageing otoliths and that validation of age data was important to ensure ages are consistent with other data from the same area.

4.24 The Working Group recalled that large numbers of otoliths had been collected in the Amundsen Sea by Russian vessels (WG-FSA-2023/62, Table A2.2 and Appendix 4) and encouraged ageing of these otoliths be given a high priority once reference set ages had been validated. The Working Group encouraged Russian age technicians to take part in the next Age Determination Methods Workshop (paragraph 4.16).

4.25 The Working Group noted that growth relationships using data from individual vessels or years should determine whether they are consistent with similar work and, if different, investigate potential causes for the difference, and that when presenting statistical analyses, that more detail is needed, such as the error distribution, whether otoliths were randomly selected for ageing, and whether the age composition was scaled to the catch.

Tagging workshop

4.26 SC-CAMLR-42/03 presented the report of the COLTO–CCAMLR Tagging Workshop held in Hobart, Australia, 14 to 17 March 2023. The workshop had requested that WG-FSA consider:

(i) requesting observers record details of fish handling aids and other tagging equipment using video clips and photos which could be helpful in designing and communicating innovations across the fleet

(ii) reviewing an increase in the minimum tag-size overlap statistic (currently 60%)

(iii) advising on how to incorporate depredation on tagged fish within the stock assessment.

4.27 The Workshop requested that the Secretariat consider and develop proposals to progress the following recommendations:

(i) including information on tagging procedures, which was part of a survey carried out from 2019 to 2020 by the Secretariat but did not include all vessels, as part of the fishery notification process to aid in documenting and better understanding tagging performance among vessels

(ii) updating the Commercial Data Collection Manual – Longline Fisheries to include guidance for holding tank design subject to vessel configuration constraints

(iii) including a viability assessment of the fish kept in holding tanks to be included in the Commercial Data Collection Manual – Longline Fisheries and that the tagging training manual be updated to reflect the categories for fish fate, matching those in the electronic logbooks

(iv) collecting additional information on release operations from vessels using moon pools to understand how their use might affect release mortality of toothfish and skates

(v) using shortened alpha-numeric sequences on tags in the future as this could potentially reduce transcription errors

(vi) developing a list of common tag release and recapture data errors to be included as part of the tag training manual, as this would assist those collecting tagging data in identifying part of the process that were error prone

(vii) considering a mechanism to enable the reporting of a subset of information on tag recaptures directly to vessels upon request, to further engagement in the CCAMLR tagging program.

4.28 The Working Group recommended updating both the Commercial Data Collection Manual – Longline Fisheries and the Observer Longline Manual to specify the conditions that exclude fish from being tagged and released and to specify guidelines regarding the recapture of tagged fish (SC-CAMLR-42/03, paragraph 2.38)

4.29 The Working Group noted that observers currently record information on tagging aides used by vessels and that COLTO is currently exploring providing a reward innovation and improvements in equipment designed to recover fish in the best condition during landing.

4.30 The Working Group recalled that CapMarine agreed to revise the observer tagging training manual including its translation, and COLTO had agreed to translate any needed

materials for the vessel (Appendix F; WS-TAG-2023, paragraph 2.12; WS-TAG-2023, Appendix E).

4.31 The Working Group suggested that both self-sticking and waterproof paper posters could be created by the Secretariat for the vessels and distributed with tagging kits.

4.32 In discussing tagging fish representative of the size distribution of the catch (paragraph 4.26), the Working Group recalled that WG-SAM-12/24 had investigated the tag overlap statistic and determined that a high overlap statistic was needed to improve precision in the assessments. The Working Group noted that only 5% of the vessels had a tag overlap statistic less than 60% since the 2019 season and that the mode was at 85% (Figure 2).

4.33 The Working Group noted that there were valid reasons that a lower tag overlap statistic could occur, and that reporting on this to the Working Group would improve understanding of these factors and enable targeting additional training resources to vessels as required (SC-CAMLR-42/03, paragraphs 1.14 and 2.44).

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

4.35 The Working Group recalled WG-SAM-2023/18, which highlighted that non-random sampling may introduce bias in length frequency distributions of the catch (WG-SAM-2023, paragraph 5.5). The Working Group agreed with WG-SAM-2023, which recommended the Secretariat amend the biological sampling forms to record if the sampling associated with a biological sample was random or non-random.

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

4.37 The Working Group recommended that Scientific Committee consider the following recommendations from SC-CAMLR-42/03 relative to the tagging programme for inclusion in working group workplans in 2024:

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

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

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

4.38 WG-FSA-2023/74 presented the reconciliation of the *Dissostichus* spp. Catch Documentation Scheme (CDS), and monthly fine-scale catch and effort data. The Secretariat had been asked to review the thresholds by WG-FSA-2022 (paragraph 3.6) to determine whether the relative (10%) and absolute (200 kg) thresholds were appropriate to identify records for further investigation. These thresholds were able to identify that 30% of records had a

weight difference of 200kg or less and 88% had a percentage difference in weight of 10% or less and asked for advice from WG-FSA on whether these thresholds should be kept or revised.

4.39 The Working Group thanked the Secretariat for their work and noted that some errors will occur because of conversion factors, but that the new C2 form and e-CDS upgrade has been designed to eliminate some of these issues. The Working Group recalled that since reconciliation had begun, many Members had begun to report on their own reconciliations undertaken during inspections of their vessels which has resulted in better reporting. The Working Group noted that reporting of catches from Subareas 88.1 and 88.2 in CDS documents had often been problematic due to the confusion arising from the management of the Ross Sea crossing the two Subareas.

4.40 The Working Group noted that the current thresholds captured most problems and that there was no need to modify the thresholds. The Working Group recommended that future reconciliations be kept to the last two years, and that the current thresholds of a relative (10%) and an absolute (200kg) difference were appropriate to identify records for further investigation.

Incorporation of climate change in advice

4.41 WG-FSA-2023/63 presented a summary of the report from Australia's Heard Island and McDonald Island Fishery Climate Change Adaptation Workshop and introduced the Handbook for the Adaptation of Fisheries Management to Climate Change, which had been presented to the Climate Change Workshop (WS-CC-2023/02). The Handbook outlines adaptive and ecosystem-based management approaches designed to guide fisheries managers, scientists and industry through a risk assessment process to identify options for responding to climate change. WS-CC-2023 (paragraphs 2.10 to 2.11) noted that the approach provided by this handbook could be used for initial risk assessments of stocks within CCAMLR and WG-FSA was asked to review the suitability of the approach for application to CCAMLR's adaptation of fisheries management to climate change.

4.42 The Working Group noted the approaches presented would provide a useful framework for CCAMLR to develop a similar approach to determine the effects of climate change on the management of CCAMLR's resources. The Working Group further noted that the handbook could be part of a toolbox on the theme of climate change. It noted that stock assessments should summarise parameters that might be affected by climate change, the underlying trends or patterns in those parameters, and whether assessments were currently integrating any trends (paragraph 4.44).

4.43 The Working Group noted two long-term survey series undertaken within the Convention Area (WG-FSA-2023/45 and WG-FSA-2023/49) have not detected any substantial change in fish species composition. However, the Working Group noted that the shift in range for many species could be a gradual process, and that long-term data series on species composition are valuable to detect range shifts or new species entering the Convention Area.

4.44 The Working Group noted paper WS-CC-2023/20 which built on the advice from paragraph 3.51 of SC-CAMLR-XXXVII to provide a template to document changes to parameters and productivity assumptions through time. The Working Group reviewed and

refined the table, noting that not all the parameters suggested could be precisely measured. The Working Group further noted that whilst trends in parameters may be observed, it may not be possible to determine the underlying drivers.

4.45 The Working Group considered the recommendations from WS-CC-2023, including investigations of temporal trends in biological parameters. As a practical approach to this issue, it developed an example of a table of parameters and processes that could be investigated within stock assessments (Table 5), which could be included in future iterations of the stock annex for each fishery.

4.46 The Working Group noted that climate change is now explicitly included in the terms of reference for WG-FSA and recommended its inclusion as an agenda item in future meetings.

General considerations of integrated toothfish stock assessments

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

4.48 The Working Group expressed gratitude to all scientists involved as this endeavour had required significant time and effort. It noted the panel's recommendations, including on the transition to the use of Casal2 software, the estimation of biological parameters, the generation of fishery-independent data, analyses of parameter trends in space and time, incorporation of environmental and ecosystem parameters, evaluation of biases introduced by interannual spatial patterns in fishing effort and tagging data, undertaking retrospective analyses, exploration of alternative methods for determining recruitment used in projections, investigations of alternative decision rules, and use of Management Strategy Evaluations (MSE).

4.49 The Working Group further noted that the review panel concluded no evidence of statistical trends in biological parameters such as size at maturity or size at age were evident in Subarea 48.3. It also noted that there was no evidence that size or maturity of catches were misrepresented in the assessment models, and the fact that all toothfish fisheries catch a proportion of juvenile fish was accounted for in the estimate of stock status and catch limits and was consistent with CCAMLR decision rules. The independent review panel concluded that the 2021 assessment for *D. eleginoides* in Subarea 48.3 was consistent with best practice and the best available science to estimate status and catch limits in this fishery.

4.50 The Working Group noted that significant progress has been made to address the recommendations of the 2018 independent review (SC-CAMLR-XXXVII/02 Rev. 1), and that this had been recognised by the 2023 independent review panel. The Working Group also noted that the transition from CASAL to Casal2 was recommended by the 2023 independent review

panel, and this work had been completed with this year's assessments (WG-FSA-2023/13, WG-FSA-2023/15 Rev 1., WG-FSA-2023/17, WG-FSA-2023/18, WG-FSA-2023/26 Rev 1.).

4.51 The Working Group recommended that the Scientific Committee note the conclusion by the independent review panel that the reviewed integrated assessments for *D. eleginoides* in Subareas 48.3 and 48.4, and Division 58.5.2, and *D. mawsoni* in the Ross Sea region were consistent with global best practice and constituted the best available science for CCAMLR to make decisions regarding the status and catch limits for these stocks.

4.52 The Working Group summarised its responses to the summary recommendations in SC-CAMLR-42/02 Rev. 2 to guide future stock assessment work in Table 6 and developed a high priority workplan (paragraphs 4.52-4.59).

Work programme for addressing issues in the integrated toothfish stock assessments

4.53 The Working Group discussed the effects of spatial distribution of fishing effort and tag-recapture data on abundance and recruitment estimates from stock assessments. The Working Group also noted that several of the integrated assessments showed strong trends in the recruitment estimates over time.

4.54 To evaluate the impact of tagging data on biomass and recruitment estimates in the stock assessment over time, a 'tagging retrospective analysis' was conducted during the meeting, where tagging data were incrementally removed year-by-year from the 2023 stock assessments in Subarea 48.3, Division 58.5.1, Division 58.5.2 and the Ross Sea. The results of these analyses are presented for each stock below.

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

4.56 The Working Group noted that assumptions of future recruitment strongly influence the management advice resulting from the integrated stock assessments.

4.57 The Working Group recommended that the Scientific Committee undertake work to evaluate biases introduced by interannual spatial patterns (specifically those identified from the tagging retrospective analyses), exploration of alternative methods for determining recruitment used in projections, investigations of CCAMLR decision rules with MSE (paragraph 4.58). The Working Group recommended that these were high priority items and should be progressed with urgency over the short term.

4.58 While more specific recommendations for each assessment are given in the following sections of the report, the Working Group recommended the following work be conducted, with methods to be presented to WG-SAM-2024 and then conclusions of the research to WG-FSA-2024:

(i) Analyses of current and alternative decision rules, including building on the work of WG-FSA-2019/08, WG-SAM-2021/08, SC-CAMLR-38/15 and WG-FSA-2023/28 to investigate alternative rules and assumptions about future

recruitment, and addressing the recommendations 6.1 and 6.2 of the report of the independent review (SC-CAMLR-42/02 Rev. 2)

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

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

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

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

4.59 The Working Group recommended that Members conducting these assessments work collaboratively over the intersessional period and develop approaches to addressing the high priority and urgent concerns identified above.

4.60 The Working Group agreed that the assessments will need to be revised with models that address the issues identified in the priority workplan (paragraphs 4.53 to 4.59). Specifically in Subarea 48.3, Division 58.5.1, Division 58.5.2 and the Ross Sea the revisions will be needed in the short term.

Secretariat verifications of CASAL and Casal2 model runs

4.61 In assessment years, the Secretariat verifies that stock assessments submitted to WG-FSA using CASAL (Table 7) are reproducible, using a three-step verification process:

(i) CASAL version: all assessments are required to use the same version of CASAL for WG-FSA-23 all assessments used CASAL v2.30-2012-03-21 rev.4648;

(ii) Parameter files verification: the files population.csl, estimation.csl and output.csl used in each assessment reported in meeting papers are used as inputs to a CASAL run performed by the Secretariat. If no errors are reported during the process, the files are considered as verified;

(iii) Maximum Posterior Density (MPD) estimate verification: the virgin spawning stock biomass (B_0) estimate produced by a given model run is compared to that reported in the accompanying meeting paper.

4.62 CASAL versions and parameter files were successfully verified for the CASAL assessments submitted to WG-FSA in 2023. Verifications of the MPDs produced the same B_0 estimates as supplied (Table 7).

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

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

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

(iii) using the proposed yield from MCMC projections, the risks (1 and 2) are consistent with the decision rules

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

4.64 All steps but (iv), since this is the first iteration of Casal2 assessments producing advice and cannot be compared to those assessments using previous versions of Casal2, were successfully verified (Table 8).

4.65 The Working Group recommended future Casal2 stock assessment reports include a table collating the values to be verified (Table 9), with, for the purpose of the Secretariat verifications, MPD values rounded to the nearest integer and risks rounded to two significant digits.

Area 48

Champsocephalus gunnari in Subarea 48.3

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

4.67 The Working Group noted that in recent years, low amounts of fishing effort were being deployed in Subarea 48.3 and that this had resulted in very low catches by the fishery.

4.68 WG-FSA-2023/45 reported on a bottom trawl survey in Subarea 48.3 in February 2023, that the UK undertook as part of its regular monitoring program. The mean biomass of *C. gunnari* was estimated at 61 567 tonnes. The survey caught *D. mawsoni* (2) for the first time in the survey history.

4.69 The Working Group noted that both *C. gunnari* and *D. eleginoides* showed high estimates of biomass in this survey and recommended including time series of relative biomass indices for these species and other prominent species in future iterations of the survey reports.

4.70 WG-FSA-2023/38 presented an assessment for *C. gunnari* in Subarea 48.3 fitting a length-based assessment in R with the FLCore package using the results of the trawl survey described in WG-FSA-2023/45. Projecting forward from the lower 5th percentile of biomass resulted in yields of 5 138 tonnes for 2023/24 and 3 579 tonnes for the 2024/25 season. These

yields allow for 75% escapement of the unfished projected biomass and satisfy the CCAMLR decision rules.

4.71 WG-FSA-2023/60 presented a Stock Annex describing the method used in the assessment presented in WG-FSA-2023/38, intended as a public-facing document for inclusion with the fishery reports on the CCAMLR website.

4.72 The Working Group recommended that the Stock Annex be included in the fishery reports on the CCAMLR website.

Management advice

4.73 The Working Group recommended that the catch limit for *C. gunnari* in Subarea 48.3 should be set at 5 138 tonnes for 2023/24 and 3 579 tonnes for 2024/25 seasons.

4.74 WG-FSA-2023/44 and WG-FSA-2023/46 presented results from a survey conducted by Argentina in Subarea 48.3. The papers covered a range of research undertaken in the survey, including oceanography, acoustic and zooplankton sampling, biogeochemistry, and fish sampling. The papers noted that fish sampling was hindered by the adverse hydrometeorological conditions experienced by the cruise, as well as the difficulty of the underwater topography for carrying out the hauls leading to the net being damaged.

4.75 The Working Group noted the large amount of work on a wide range of research issues was undertaken during the survey. It also noted that the acoustic data may be useful to WG-ASAM in developing the krill fishery management in this area, particularly in relation to the krill detected near the seafloor. The Working Group further noted that despite the low sample sizes due to trawl gear issues, the length compositions of icefish measured in this survey were consistent with those presented in WG-FSA-2023/45.

4.76 The Working Group noted the survey had many objectives which had been achieved, however the survey only caught a single *D. eleginoides* so the specific objectives concerning spatial distribution and length composition of that species could not be addressed.

4.77 WG-FSA-2023/61 presented analyses of reproductive potential of three icefish species (*C. gunnari, Pseudochaenichthys georgianus, Chaenocephalus aceratus*) and *Notothenia rossii* sampled during the survey described in WG-FSA-2023/46. The results were generally consistent with those of the previous Argentinian survey in this Subarea undertaken in 2013 (WG-FSA-2013/59).

4.78 The Working Group noted the utility of research into reproductive potential, but suggested the low sample sizes in this study may limit the power to accurately estimate the size at maturity of these species.

4.79 The authors noted that more research related to the environmental variables analysed (WG-FSA-2023/44) will be presented to the relevant Working Groups in 2024.

Icefish research survey proposal in Subarea 48.2

4.80 WG-FSA-2023/48 presented the results of an acoustic and trawl survey for *C. gunnari* undertaken in Subarea 48.2 by Ukraine. The paper noted that all components of the survey had been completed, however few *C. gunnari* were encountered. It further noted that the survey contained a large workload for the observers on board and thanked Australia for providing the 38-kHz acoustics equipment.

4.81 The Working Group recalled the discussion from WG-ASAM-2023 (paragraphs 7.1 to 7.4) regarding calibration of the acoustic equipment. The Working Group noted that the video data in the net combined with the acoustic data collected during the survey would be useful for detecting differences in krill distribution in the water column and recommended results be presented to WG-ASAM for consideration once analyses had been finalised.

4.82 WG-FSA-2023/03 presented a research plan notified under CM 24-01 for a continuation of the acoustic and trawl survey for *C. gunnari* in Subarea 48.2 in the 2023/24 and 2024/25 seasons. The authors noted during the meeting that due to vessel issues, research would not be undertaken in the 2023/24 season and that the research plan should be resubmitted next year (Table 10).

4.83 The Working Group recommended the research plan be considered by WG-ASAM-2024, requesting advice on any modifications to the survey which may facilitate the collected acoustic data being used in the Subarea 48.2 krill fishery management strategy.

Dissostichus eleginoides in Subarea 48.3

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

4.85 WG-FSA-2023/15 Rev. 1, along with WG-FSA-2023/16, WG-FSA-2023/31 and WG-FSA-2023/56, presented an updated integrated assessment model for *D. eleginoides* in Subarea 48.3 using Casal2, associated diagnostics, the characterization of the toothfish fishery in Subarea 48.3 and the stock annex. WG-FSA-2023/15 Rev. 1 indicates that the current status of the stock is at 47% of B_0. Projections indicate that a constant catch of 2 000 tonnes in the 2023/24 and 2024/25 seasons would be consistent with the CCAMLR decision rule after accounting for recent mammal depredation rates.

4.86 The Working Group noted the large amount of work presented and involved in transitioning to Casal2. It also noted the autocorrelation in some MCMC chains for the survey selectivity parameters and recognised that it might be related to the inclusion of the survey data as proportions at length.

4.87 The Working Group noted that the projection uses the lognormal empirical randomisation method of recruitment estimated using recruitment strengths from 1993 to 2016, but with the application of a multiplier of 0.85 to reflect the previous CASAL projections.

4.88 The Working Group noted that the package R4casal2 has been very useful in producing diagnostics, and that using a standard approach helped improve the comparability between different assessments.

4.89 The Working Group encouraged further work to investigate the effects of including survey and tag compositions by age rather than by length, and to investigate whether alternative survey selectivity parameterisation may be more appropriate.

4.90 The Working Group noted that the assessment continued to show trends in the likelihood profiles, with successive tag release events being consistent with smaller estimates of the initial spawning stock size B_0 (WG-FSA-2023/16, Figure 23).

4.91 The tagging retrospective analysis for this assessment conducted during the meeting indicated results which were consistent with the trends in the likelihood profiles, showing that the SSB_0 estimates throughout the assessment period increased as successive years of tag recaptures were removed. This was associated with trends in recruitment becoming less steep. After the removal of five years of tagging data, trends in SSB and SSB status showed a less steep decline in the final years of the assessment (Figure 3).

4.92 During the meeting, three sensitivity analyses based on the retrospective run with tagging data up to 2014 were also conducted. The MPD was projected forward with the proposed catch limit of 2 000 t from WG-FSA-2023/15 Rev. 1 and either the same recruitment assumptions as the assessment (0.85 multiplier applied to a lognormal-empirical distribution) or recruitments resampled from the last 10 years of the assessment. These runs resulted in SSB status at the end of the 35-year projection period being at 58% (lognormal) or 46% (10-year recent recruitment series) compared with 50% of SSB_0 using the assessment and forecast proposed for advice (Figure 4).

4.93 The Working Group recommended that the Stock Annex (WG-FSA-2023/56) be included as part of the Fishery Reports on the CCAMLR website.

4.94 WG-FSA-2023/15 Rev. 1 proposed that the catch limit for *D. eleginoides* in Subarea 48.3 be set at 2 000 tonnes for 2023/24 and 2024/25 (which corresponds to a total removal of 2 098 tonnes including depredation) based on the outcome of the assessment and the application of the decision rule.

4.95 The Working Group noted that although the catch limits follow the Decision Rule, catches at the level of this catch limit would be expected to reduce the stock status further below the 50% target in the short term, however spatial bias and patterns in recent recruitment make this conclusion uncertain.

Management advice

4.96 The Working Group recommended that the catch limit for *D. eleginoides* in Subarea 48.3 be set at 2 000 tonnes for the 2023/24 season based on the outcome of this assessment.

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

Dissostichus eleginoides in Subarea 48.4

4.98 The fishery for *D. eleginoides* in Subarea 48.4 operated in accordance with CM 41-03 and associated measures. The catch limit for *D. eleginoides* in Subarea 48.4 in 2022/23 was 23 tonnes and 5 tonnes were taken. Details of the fishery for *D. eleginoides* in Subarea 48.4 and the stock assessment are contained in the Fishery Report (https://fisheryreports.ccamlr.org/).

4.99 WG-FSA-2023/17, along with WG-FSA-2023/18, WG-FSA-2023/30 and WG-FSA-2023/57, presented a new Casal2 integrated assessment model and bridging analysis *D. eleginoides* in Subarea 48.4, associated diagnostics, the characterization of the toothfish fishery in Subarea 48.4, and the stock annex. The 2023 assessment included updated catch data to 2023 and observations to the end of 2022, minor data revisions, re-estimation of length-weight parameters, tag loss rates and inclusion of an updated maturity ogive. It indicated that the current status of the stock is at 59.5% of B_0. Projections indicate that a constant catch of 19 tonnes in the 2023/24 and 2024/25 seasons would be consistent with the CCAMLR decision rule as it would achieve 64% of B_0 after a 35-year period.

4.100 The Working Group welcomed the updated assessment and noted that the proposed catch limit was based on projections that achieve an SSB of 64% of B_0 after a 35-year period because recruitment was estimated to be sporadic, and there remains uncertainty about whether recruitment occurs within Subarea 48.4, or whether the recruitment comes from part of the Subarea 48.3 stock.

4.101 The Working Group noted there were variations in annual age-composition data as well as some spikes in the fits to tagging data by length which may in part be due to low fishing effort and sampling size.

4.102 The Working Group recommended that the stock annex (WG-FSA-2023/57) be included as part of the fishery reports on the CCAMLR website.

4.103 The Working Group noted that effort within Subarea 48.4 was spread consistently throughout the fishable area and so advice could be provided for two years.

4.104 WG-FSA-2023/17 proposed that the catch limit for *D. eleginoides* in Subarea 48.4 be set at 19 tonnes for 2023/24 and 2024/25 based on the outcome of the assessment and the application of the CCAMLR decision rules.

4.105 The Working Group agreed that a catch limit of 19 tonnes for *D. eleginoides* in Subarea 48.4 for 2023/24 and 2024/25 would be consistent with CCAMLR's decision rules.

Management advice

4.106 The Working Group recommended that the catch limit for *D. eleginoides* in Subarea 48.4 be set at 19 tonnes for the 2023/24 and 2024/25 seasons based on the outcome of this assessment.

Dissostichus mawsoni in Subarea 48.4

4.107 The fishery for *D. mawsoni* in Subarea 48.4 operated in accordance with CM 41-03 and associated measures. The catch limit for *D. mawsoni* in Subarea 48.4 in 2022/23 was 42 tonnes and 26 tonnes were taken. Details of the fishery for *D. mawsoni* in Subarea 48.4 and the stock assessment are contained in the Fishery Report (https://fisheryreports.ccamlr.org/).

4.108 WG-FSA-2023/39, along with WG-FSA-2023/30, presented an updated estimation of the local biomass of *D. mawsoni* in CCAMLR Subarea 48.4 from tagging returns, giving a five-year average of 1 130 tonnes since 2019. Applying the CCAMLR agreed precautionary assumption of setting harvest rates based on a 5-year average biomass, and harvest rate of $\gamma = 0.038$, results in catch limit of 43 tonnes for the 2023/24 season.

4.109 The Working Group recalled that a precautionary approach has been applied by treating *D. mawsoni* in Subarea 48.4 as a separate stock. Based on the biological characteristics of the catches in Subarea 48.4 and the surrounding regions, *D. mawsoni* around the southern South Sandwich Islands are hypothesised as being part of a much larger stock that extends south into Subareas 48.2, 48.6 and possibly 48.5. The current method of assessment, based on tag returns, consequently, is considered to provide an estimate of the local biomass.

4.110 The Working Group noted that the method was appropriate to assess local biomass and that an integrated stock assessment was not currently under development for the population of Antarctic toothfish in Subarea 48.4. It noted initial evidence of a northward shift *D. mawsoni* in Subarea 48.4 and that both *Dissostichus* species co-occur in other areas within the CAMLR Convention area such as in the northern parts of Subarea 88.1.

Management advice

4.111 The Working Group recommended that the catch limit for *D. mawsoni* in Subarea 48.4 be set at 43 tonnes for the 2023/24 season.

Research plans targeting *D. mawsoni* in area 48 notified under CM 21-02 or CM 24-01

4.112 The Working Group considered the advice of WG-SAM-2023 and reviewed updates on research plans in Area 48 that were presented in WG-SAM-23, considering the recommendations from WG-SAM-23 and the trend analysis results.

4.113 Research plans were evaluated against the agreed criteria outlined in WG-FSA-2019/55. The results following the review schedule presented in Table 10 are presented in Table 11.

4.114 WG-FSA-2023/36 set out a proposal by Chile to undertake research for *Dissostichus* spp. under CM 24-01 in Subarea 48.2 during the 2023/24–2025/26 seasons, previously submitted to WG-SAM-2023 (WG-SAM-2023/05). There are four specific objectives:

(i) explore the connectivity based on the modelling of spatial distribution, relative abundance, and length and age structure

(ii) review the fisheries potential impacts on dependent and related species

(iii) improve the hauling and tagging process to help with standardisation procedure

(iv) improve the knowledge of near-bottom and seabed marine ecosystems using scientific electronic monitoring.

4.115 The survey design is based on five fishing zones, 48.2 N and 48.2 S and areas A, B and C, with 12 sets distributed across four depth strata. For the 2023/24 season, the authors propose a total catch limit of 379 tonnes, divided into 150 tonnes for 48.2N and 48.2S and 229 tonnes for areas A, B, and C.

4.116 The Working Group noted the discussion from WG-SAM-2023 (paragraphs 8.2 to 8.9) and noted that it was unclear how this feedback had been fully incorporated into the revised research plan.

4.117 In particular, the Working Group noted the previous research activities on *Dissostichus* spp. undertaken by Ukraine (WG-FSA-2019/51), and the UK (WG-FSA-2021/22) on connectivity, catch rates, and *Dissostichus* species composition in this region of Subarea 48.2, as the proposed research area in WG-SAM-2023/05 overlaps with areas from these previous studies.

4.118 The Working Group noted it was unclear why most of the research objectives could not be completed with existing data in this region and recommended that this be undertaken to inform future research proposals based upon the results.

4.119 The Working Group further noted that integrating previous discussions from evaluations of research in Subarea 48.2 by WG-SAM and WG-FSA would assist in improving the planning of this research proposal.

4.120 In relation to the survey design, the Working Group noted that there had been some revisions to the proposal, taking into account the evaluation of WG-SAM-2023, but that this had not been fully addressed.

4.121 The Working Group noted that the distribution of the two species was mapped in WG-FSA-21/22, and that this information should be used in the survey design. The Working Group noted that small numbers of *D. eleginoides* had only been encountered in the northern portion of each of the areas defined in WG-FSA2023/36. The Working Group recommended that the location of the sets be redesigned not only by depth strata but also by target species distribution.

4.122 Although this research is designed to be effort limited, the WG-SAM-2023 recommended the calculation of a precautionary catch limit using CPUE obtained from previous research activities, and a CPUE-by-seabed area calculation. This information was not included in the revised proposal presented to WG-FSA.

4.123 WG-SAM-2023 noted that macrourids were likely to be the main by-catch taxa in this region and recommended that there should be some additional analyses undertaken on by-catch rates from previous research activities by Ukraine and the UK. The analysis was not included in the revised analysis presented to the Working Group. The Working Group further recalled previous advice that ten biological specimens per haul were insufficient rates of by-catch sampling (WG-FSA-2019, paragraph 4.166).

4.124 The Working Group noted that CM 41-05, CM 41-11, CM 22-06 and CM 22-07 are not applicable to the research plan outlined in WG-FSA-2023/36.

4.125 The Working Group noted that a representative from Chile was not present to answer questions about the research and recommended that a revised research plan be presented at WG-SAM-2024.

4.126 WG-FSA-2022/42 presented a report of multi-Member research on *D. mawsoni* conducted in Subarea 48.6 between 2012/13 and 2022/23 by Japan, South Africa and Spain, noting the achievement of the milestones detailed in the research objectives. The authors have now successfully transitioned from CASAL to Casal2 for assessing *D. mawsoni* at Subarea 48.6, and thanked NZ colleagues for their support in achieving this.

4.127 WG-SAM-2023/01 Rev. 1 provided an update to the efforts involved in the research plan pertaining to Subarea 48.6 in 2021/22–2023/24 under CM 21-02, paragraph 6 (iii) and evaluated in Table 11. The authors noted that South Africa will be unable to participate in fishing activities in 2023/24 due to vessel availability but would still be contributing to other milestones as planned. As a result of the reduction in the number of vessels from three to two, catch allocations were revised to ensure that the same amount of research would be achieved.

4.128 The Working Group recommended continuing the research fishing at Subarea 48.6 according to the research proposal in WG-SAM-2023/01 Rev. 1.

4.129 The Working Group recommended that the catch limits for Subarea 48.6 be based on the trend analysis as shown in Table 4.

Area 58

Champsocephalus gunnari in Division 58.5.2

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

4.131 The results of a random stratified trawl survey in Division 58.5.2 undertaken during March 2023 were summarised in WG-FSA-2023/49. The survey-recorded catch of Patagonian toothfish (*D. eleginoides*) was 66.8 t, and the catch of mackerel icefish (*C. gunnari*) was 16 t.

4.132 The Working Group noted that estimates of assessed by-catch were within the range of abundance observed in previous surveys, and the species composition has not changed. The biomass estimates for *Channichthys rhinoceratus* were at the second-highest reported levels since 2012. Biomass estimates of grey rockcod (*Lepidonotothen squamifrons*) showed an increase in biomass over the 2022 estimate, but the biomass of *Macrourus* spp. remained stable. Murray's skate (*Bathyraja murrayi*) experienced an increase in biomass to the previous years' estimates whilst the estimated biomass for the other *Bathyraja* species was lower than last year.

4.133 WG-FSA-2023/10 presented a preliminary assessment of *C. gunnari* in Division 58.5.2 using the generalised yield model in R (Grym) following the results of the trawl survey described in WG-FSA-2023/49. Bootstrapped biomass estimates had a mean of 16 127 tonnes,

with a one sided lower 95% confidence bound of 10 092 tonnes, mainly comprised fish of age 3+. Projecting forward, the proportion of the one-sided lower 95th confidence bound of fish aged 1+ to 3+ (4 631 tonnes) gave yields of 714 tonnes for 2023/24 and 599 tonnes for 2024/25 that allow for 75% escapement and therefore satisfy the CCAMLR decision rules.

Management advice

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

Dissostichus eleginoides in Division 58.5.1

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

4.136 WG-FSA-2023/67 Rev.1 presented an updated integrated assessment model for the Kerguelen Islands *D. eleginoides* fishery in Division 58.5.1 up to the end of 2021/22. Key additions and updates to the assessment model included the incorporation of data up to 2022, an updated calculation of the depredation rate (sperm whale and lice) and re-estimation of the stock recruitment variability by estimating year class strength using results from a four-year otolith reading program.

4.137 The Working Group supported the ongoing addition of aging data into the stock assessment as well as the proposed survey to be conducted in the coming season.

4.138 The updated assessment model run in CASAL estimated B_0 at 224 760 tonnes (95% CI: 206 390 – 249 520 tonnes). The estimated SSB status in 2022 was 66.3% (95% CI: 63 – 70.3%).

4.139 A comparative model developed in Casal2 demonstrated strong consistency in key results. A Casal2 model including updated historical tag-recapture data showed improved residuals between observed and expected number of tag recaptures (WG-FSA-2023/24 Rev. 1).

4.140 The Working Group welcomed the presentation of a Stock Annex for the Kerguelen Islands EEZ *D. eleginoides* fishery in Division 58.5.1 (WG-FSA-2023/59) and recommended that this be published as a part of the CCAMLR Fishery Report for this area.

4.141 During the meeting, additional sensitivities were run on tag recapture data. The MPDs of the retrospective runs with tagging data excluded year-by-year back to 2016, showed a small amount of change in patterns of SSB and percent SSB and limited changes in most recent recruits and year class strength between the retrospectives from 2016 to 2022 (Figure 5). The authors of WG-FSA-2023/67 Rev. 1 noted that changes observed shall be investigated in the short term in the light of a potential spatial bias in tag-recapture data.

4.142 The Working Group agreed that the catch limit set by France of 5 020 tonnes for 2023/24 that accounts for depredation was consistent with the CCAMLR decision rules for the model runs presented.

Management advice

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

4.144 WG-FSA-2023/28 explored how different recruitment projections under potential regime shifts in Patagonian toothfish stocks might influence associated SSB calculations. An investigation into whether re-estimation of SSB_0 according to stock productivity (dynamic SSB_0) might impact historical, current and future stock status. For this work, the Patagonian toothfish fishery in Division 58.5.1 was used as a case study.

4.145 Six different recruitment scenarios were considered:

(i) scenario R: lognormal distribution with a mean of 1 (method used in the current Kerguelen stock assessment) and a variance sampled from the range of observed values of recruitment between 2001 and 2017 (lognormal empirical method)

(ii) scenario R1: recruitment sampled from the whole series of recruitment (2000-2017) (empirical sampling method)

(iii) scenario R2: recruitment variations sampled from the 2000-2006 period (empirical sampling method)

(iv) scenario R3: recruitment variations sampled from the 2007-2017 period (empirical sampling method)

(v) scenario R4: recruitment variations sampled from the 2013-2017 period (empirical sampling method)

(vi) scenario R5: constant low recruitment for 2017-2030 and constant medium recruitment for 2031-2057.

4.146 Results from scenarios with the highest recruitment values (R2) were the most optimistic with regard to SSB_0 and stock status. Scenarios R and R1 were ranked behind this and resulted in stock status above 60% of SSB_0 in both cases. Results from scenarios R3 and R4 demonstrated different trajectories with resulting stock status of 28% and 34% of SSB_0 respectively. R5 provides a result which splits these two patterns in line with the differing scenarios that were used.

4.147 Re-estimation of SSB_0 according to stock productivity (dynamic SSB_0) produced a significant impact on past, current and future stock status. In general, scenarios with lower recruitments leading to lower SSB_0* corresponded to higher SSB stock status ratios.

4.148 The Working Group thanked the authors for this interesting and timely paper and strongly encouraged further development, testing and exploration of the themes covered.

Dissostichus eleginoides in Division 58.5.2

4.149 The fishery for *D. eleginoides* in Division 58.5.2 operated in accordance with CM 41-08 and associated measures. In 2022/23, the catch limit for *D. eleginoides* was 3 010 tonnes. Details of the fishery and the stock assessment are contained in the Fishery Report (https://fisheryreports.ccamlr.org/).

4.150 WG-FSA-2023/26 Rev. 1 presented an updated assessment for Patagonian toothfish (*D. eleginoides*) at Heard Island and McDonald Islands in Division 58.5.2. Starting with the 2021 assessment model that was used to provide management advice, this paper presents a bridging analysis and sensitivity analyses, and proposes a new assessment model for 2023. The 2023 assessment included updated catch data to 2023 and observations to the end of 2022, including new ageing data from the Random Stratified Trawl Survey (RSTS) and commercial fishery, re-estimated growth parameters, and an updated annual cycle to reflect the recent timing of the RSTS survey taking place prior to the main fishing season. The base-case model using Casal2 estimated B_0 at 64 520 tonnes (95% CI: 60 419 – 69 241 tonnes) and the current status (B2023) at 39.4% of B_0 (95% CIs 39.1 – 39.5% B_0). Based on the result of this assessment and the application of the CCAMLR decision rules, the paper recommended a catch limit of 2 660 tonnes for the 2023/24 and 2024/25 seasons.

4.151 The Working Group welcomed the updated assessment and noted a concentration in the spatial extent of fishing effort after 2018 and that in addition the spatial spread of releases showed small areas of high tagging concentration in 2018, 2020 and 2021. Since high spatial concentration of tagged and recaptured fish in small areas can strongly influence tag-based abundance estimators if individuals are unlikely to mix within the wider population, 323 individuals which had been subsequently recaptured in the same small areas had been excluded from the base-case assessment.

4.152 The tagging retrospective analysis for this assessment conducted during the meeting indicated that relative to tagging data up to 2018, tagging data after 2018 caused a downward bias on estimates of B_0, a more rapid decline in SSB status over the entire fishery period, and as a consequence a lower SSB status in 2023 (Figure 6). Estimates of spawning stock biomass in 2023 were 40% when using the tagging data up to 2022, 44% when using tagging data up to 2018, and 47% of SSB_0 when using tagging data up to 2014. The Working Group also noted that survey catchability q dropped from 1.21 when using all tagging data to more realistic levels below 1 in the tagging retrospective analysis (e.g., 0.90 when using tagging data up to 2018 and 0.83 when using tagging data up to 2014).

4.153 The Working Group further noted that the recruitment estimated by the stock assessment using tagging data up to 2018 decreased in the 1990s and increased to near average after 2010 compared to those estimated by the assessment with all tagging data (Figure 6). The Working Group noted that this pattern of elevated recruitment in recent years was more consistent with the observations from the trawl surveys.

4.154 The Working Group recalled that tagging data provide information on absolute abundance. It noted that the observed trends in estimated spawning biomass and recruitment by the tagging retrospective analysis could be explained by an increasing spatial concentration of tagging data which would result in much smaller biomass estimates in recent times compared to relatively large biomass estimates from earlier years. To account for this, the stock assessment estimated larger recruitment in the earlier part of the estimated time series and

smaller recruitment in the latter part of the time series. This could have also resulted in a conflict between observations from trawl surveys and the tagging data.

4.155 During the meeting, two sensitivities based on the retrospective run with tagging data up to 2018 were also run. The MPD was projected forward with the catch limit of 2 660 t proposed by WG-FSA-2023/26 Rev. 1 and recruitment sampled from either the full estimated recruitment time series (1986 to 2017) or from only the last 10 years of estimated recruitment (2008 to 2017). These runs resulted in SSB status at the end of the 35-year projection period of 60% (1986 to 2017 recruitment) and 43% of SSB_0 (2008 to 2017 recruitment, Figure 7).

4.156 Based on these analyses, the Working Group noted that the stock status in 2023 may not be as pessimistic and the estimated recruitment may not have declined as strongly as that predicted by the stock assessment model presented in WG-FSA-2023/26 Rev. 1.

4.157 The Working Group noted that although the proposed catch limits follow the CCAMLR Decision Rules, catches at the level of the catch limit proposed in WG-FSA-2023/26 Rev. 1 would be expected to reduce the stock status further below the 50% target in the short term, however spatial bias and patterns in recent recruitment make this conclusion uncertain.

Management advice

4.158 The Working Group recommended that the catch limit for *D. eleginoides* in Division 58.5.2 be set at 2 660 tonnes for the 2023/24 season based on the outcome of this assessment.

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

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

Dissostichus eleginoides in Division 58.6

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

4.162 WG-FSA-2021/45 presented an updated integrated CASAL assessment model for the Crozet Islands *D. eleginoides* fishery in Subarea 58.6 up to the end of 2021/22. Further model diagnostics were included in WG-FSA-2023/66. The assessment model updated the previous assessment model by (1) updating data to the end of 2021/2022, (2) updating depredation rates, (3) including catch-at-age data for the 2010-2022 period, and (4) estimating year class strength for 2000-2016. The base-case assessment model estimated B_0 at 51 570 t (95% CI: 49 900-56 160 t). The estimate of the current SSB was 69% (95% CI: 66.1-72.4%) and the current catch limit of 930 tonnes satisfied the CCAMLR decision rules.

4.163 The Working Group welcomed the updated assessment and noted that the model now estimates year class strengths that were made possible by a 4-year reading program for otoliths from 2020-2024 which has resulted in 3 694 aged otoliths and has the aim of reading 4 500 otoliths by the end of 2024.

4.164 The Working Group noted that the model accounts for recent catches in waters adjacent to the Crozet EEZ on the Del Cano Rise in the Southern Indian Ocean Fisheries Agreement (SIOFA) Area and assumes that these catches have undergone the same depredation rate as catches inside the Crozet EEZ. These catches ranged from 0 to 40 tonnes per year with an average of less than 24 t between 2003 and 2016. Catches increased to more than 138 t in 2017 and 2018 and then decreased to 50 t in 2019. Since then, SIOFA has approved a catch limit of 55 t on the Del Cano Rise (SIOFA CMM-15 (2023)).

4.165 The Working Group noted the updated Stock Annex for the *D. eleginoides* at Crozet Islands fishery (WG-FSA-2023/58) and recommended that the CCAMLR Fishery Report for this area be updated with this Stock Annex.

4.165 The Working Group agreed that a catch limit of 930 tonnes (which would be total removals of 1 352 tonnes, including depredation and catches on Del Cano Rise in the Southern Indian Ocean Fisheries Agreement (SIOFA) Area) for *D. eleginoides* in Subarea 58.6 for 2023/24 would be consistent with CCAMLR's decision rules for the precautionary yield for this fishery.

Management advice

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

Research plans in area 58 notified under CM 21-02

4.168 WG-FSA-2023/47 presented a report on exploratory fishing activities undertaken by Australia, France, Japan, Republic of Korea, and Spain in Divisions 58.4.1 and 58.4.2 between the 2011/12 and 2022/23 fishing seasons, noting the achievement of the milestones detailed in the research objectives.

4.169 The Working Group welcomed the report and congratulated the Members involved for the large body of work presented. It noted, in particular, the significant amount of age data collected, as well as the continuous progress with the collection of such data.

4.170 WG-SAM-2023/03 presented a multi-Member proposal for continuing research in the *D. mawsoni* exploratory fishery in East Antarctica (Divisions 58.4.1 and 58.4.2) from 2022/23 to 2025/26, including the research objectives, methods, and milestones in accordance with Annex 24-01/A Format 2.

4.171 The Working Group welcomed the paper and commended the clarity of the information presented. It noted that the research plan in WG-SAM-2022/04 for Division 58.4.2 was agreed

in 2022 and therefore does not need to be evaluated by WG-FSA-23, and that the research plan for Division 58.4.1 (WG-SAM-2023/03) has been evaluated by WG-FSA-23.

4.172The Working Group noted the importance of testing and updating stock structure hypotheses of toothfish across East Antarctica and links to other areas. It noted the recently updated stock hypothesis for toothfish in Divisions 58.4.1 and 58.4.2 (WG-SAM-2022/09) and that a comprehensive understanding of stock structure and ecology of this species benefits from the incorporation of information pertaining to biological information, migratory patterns, oceanography and genetic data. The Working Group further noted the value of collecting oceanographic data using CTD sensors during fishing operations to inform oceanographical models.

Management advice

4.173 The Working Group recommended the research proposal as detailed in WG-SAM-2023/03 for Division 58.4.1 proceed.

4.174 The Working Group recommended that the catch limits for Divisions 58.4.1 and 58.4.2 to be based on the trend analysis as shown in Table 4.

Area 88

4.175 WG-FSA-2023/37 Rev. 1 presented a study on levels of genetic diversity and population structure of the Antarctic toothfish in Areas 58 and 88 by using a combination of the Patagonian toothfish specific (N=7) as well as developed Antarctic toothfish microsatellite markers (N=7). The authors noted the similarity between Areas 58 and 88 for both *D. eleginoides* and *D. mawsoni* markers, with a higher diversity within Subarea 88.1, including genetic variability between samples collected in different years.

4.176 The Working Group noted that the annual variability in genetics may reflect the role of the Ross Sea as an oceanographic sink for a number of larval areas from the Amundsen Sea, Bellingshausen Sea, Banzare bank and Ross Sea depending on annual variability in currents. The Working Group noted that this may also reflect sampling bias or contamination of the samples. The Working Group encouraged further work, noting that analysis including age may provide more detailed information than the current analysis splitting the samples into juvenile and adult.

4.177 The Working Group noted that the widespread connectivity of *D. mawsoni* was consistent with existing hypotheses about the circumpolar connectivity of areas. The Working Group further noted that regional oceanographical features may generate local stocks, and suggested the Members collect further data to test stock structures in the Southern Ocean.

4.178 WG-FSA-2023/25 presented investigations into the diet composition and feeding strategies of *D. mawsoni* in Subareas 88.1 and 88.3, conducted based on stomach content analysis of specimens collected during the 2022/23 fishing season. The authors noted that in Subarea 88.1 there was a transition in the dominant prey items around 100 cm from molluscs to fish, whereas in Subarea 88.3 fish predominated in the diet across all lengths.

4.179 The Working Group noted that accounting for the digestion state of the stomach contents may provide useful information on whether the toothfish had been consuming by-catch species caught on the longline before landing and recommended that future work could include analysis on the stomach contents of by-catch species to provide further information on trophic interactions.

Subarea 88.1 and SSRUs 882AB - *D. mawsoni* in the Ross Sea region

4.180 The exploratory fishery for *D. mawsoni* in Subarea 88.1 operated in accordance with CM 41-09 and associated measures. In 2022/23, the catch limit for *D. mawsoni* was 3 495 tonnes. Details of this fishery and the stock assessment are contained in the Fishery Report (https://fisheryreports.ccamlr.org/).

4.181 SC-CAMLR-42/BG/29 presented a description of a low-cost ocean sensor to capture temperature and depth information trialled in the Ross Sea during the 2022/23 season. These sensors are currently widely deployed throughout New Zealand's EEZ in partnership with the commercial fishing sector to provide temperature and depth information through the water column.

4.182 The Working Group noted the value of data collected by these devices which is particularly relevant in informing regional changes relevant to climate change. Additionally, the benefits of ease of operation and automatic downloading of data and that the two-year battery life and the intervals between calibrations are practical. While there was a current depth limit of 1 000 m, further developments were underway to extend the depth limit. The Working Group noted the importance of coordinating data collection with the standards for data used in oceanography models and that output from these sensors adhered to international data sharing standards, data formatting and metadata collection. The Working Group noted the benefits of such data being collated and available through organisations such as SOOS.

4.183 WG-FSA-2023/09 presented the results from the 2023 Ross Sea shelf survey (RSSS). The estimated relative biomass index of toothfish in 2023 was one of the lowest of the series. Biological data and samples were collected from 1662 toothfish; samples and measurements were also collected on by-catch species and the environment. A total of 155 toothfish were tagged and released with an 92% tag length overlap statistic; no tagged fish were recaptured. The catch limit of 99 t was not exceeded, as catches in all strata were lower than the previous years.

4.184 The Working Group thanked the authors of the paper and noted that this survey was the twelfth in the time series, was an important monitoring tool in the Ross Sea region MPA and provided standardised information on abundance and age structure for use in the stock assessment, as well as for improving understanding of the ecosystem in the area.

4.185 The Working Group noted that the catch rates in the 2023 Survey were around half of the levels seen in the previous survey, but that the catch length distribution was similar to previous years. The Working Group therefore concluded that the low catch rates did not seem to be caused by a failure of recruitment, but instead by a factor affecting catchability such as timing of the survey, or sea lice reducing catchability by removing bait. The Working Group encouraged further work to analyse oceanographic data, such as salinity and temperature, to evaluate whether these may be related to the lower catchability.

4.186 The Working Group recommended that the recruitment index from this survey continues to be monitored and evaluated within the stock assessment model. The Working Group recommended that the standardisation of the annual biomass index should be investigated with additional variables, including time of season, to evaluate if this was a significant effect.

4.187 The Working Group reviewed the continuance research proposal for Ross Sea shelf survey (WG-SAM-2023/02). The Working Group noted that the Ross Sea shelf survey has a catch limit as agreed in SC-CAMLR 41 (SC-CAMLR 41, paragraph 3.138):

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

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

4.188 WG-FSA-2023/19 presented a characterisation of the toothfish fishery in the Ross Sea region. Scaled length distributions showed no decrease in the size of fish caught through time in any of the management areas. There was a small change in the sex ratio of Antarctic toothfish, with a gradual pattern of more males caught in all areas until 2015. The number of Antarctic toothfish recaptured over the last five years of the mark-recapture program was higher than the average annual number of recaptures over the past decade.

4.189 The Working Group noted the value of the fishery characterisation in summarising the activity of the fishery and, in particular, welcomed the information about tag recapture and CPUE, which provide information to validate the harvest rate and trends in abundance estimated by the integrated assessment.

4.190 WG-FSA-2023/51 proposed changes to the Ross Sea region Data Collection Protocol (RSDCP). It includes: (i) a new field that allows noting the additional samples, to be added to the observer biological sample and tag recapture forms and the C2 tag recapture form, and (ii) the reintroduction of the skate injury condition field on both observer and C2 forms.

4.191 The Working Group recommended that the C2 and observer data forms be updated to include these fields for the 2023/24 season (paragraph 2.21).

4.192 WG-FSA-2023/13 presented an update of the Bayesian sex- and age-structured integrated stock assessment model for Antarctic toothfish (*D. mawsoni*) in the Ross Sea region (RSR; Subareas 88.1 and Small-Scale Research Units (SSRUs) 88.2A-B) with Casal2. Further model diagnostics were included in WG-FSA-2023/22. The model estimated B_0 at 77 855 t (95% CIs 71 954–85 115 t) and the current stock status (B_{2023}) at 64.3% B_0 (95% CIs 61.3–67.3% B_0). The recommendation for the catch limit is 3 499 t for RSR Antarctic toothfish in the 2023/24 and 2024/25 fishing seasons.

4.193 The Working Group welcomed the updated stock assessment and noted the model sensitivity runs exploring alternative selectivity assumptions, and that the work so far did not fully explain the catch at age compositions. The Working Group encouraged further work on selectivity assumptions and noted the flexibility within the Casal2 model framework to test these assumptions.

4.194 The Working Group welcomed the inclusion of a retrospective analysis among the model diagnostics, showing the effect of running the assessment on shorter time series of data, while keeping the biological parameters and model structure consistent. The Working Group noted that this analysis was recommended by the 2023 independent review of CCAMLR

toothfish assessments, (paragraph 4.47), and may provide information about whether there are trends in processes such as recruitment that are not consistent with the model assumptions.

4.195 WG-FSA-2023/13 proposed that the catch limit for *D. mawsoni* in the Ross Sea be set at 3 499 tonnes for 2023/24 and 2024/25 based on the outcome of the assessment and the application of the decision rule.

4.196 The Working Group noted that a catch limit for the Ross Sea region (Subarea 88.1 and SSRUs 882A–B), set at 3 499 tonnes for 2023/24 and 2024/25 based on the assessment, assuming a catch split of 19% for the area north of 70°S, 66% for south of 70°S, and 15% in the Special Research Zone, would be consistent with the precautionary yield estimated using the CCAMLR decision rules.

4.197 During the meeting, additional sensitivities were run using the tag data retrospectives. The MPDs of the retrospective runs with tagging data excluded year-by-year back to 2013 showed that there was only a small amount of change in the spatial bias from the tag data, with patterns of SSB, percent SSB, recruits, and year class strength showing very similar values between the retrospectives from 2013 to 2023 (Figure 8).

4.198 The Working Group noted that although the effects of spatial bias were not so apparent in the Ross Sea fishery, there was still the potential for spatial bias in the tag data and assumptions about future recruitment in the assessment to impact management advice.

4.199 WG-FSA-2023/55 presented the updated Stock Annex for the Ross Sea region. The Working Group recommended that the CCAMLR Fishery Report for this area be updated with this Stock Annex.

Management advice

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

4.201 The WG recommended that SC require a revised stock assessment addressing the issues identified in the workplan (paragraphs 4.52-4.57) be provided to WG-FSA in 2024.

Subarea 88.2

4.202 WG-FSA-2023/62 presented a characterisation of the fishing and tagging programme in the Amundsen Sea Region. It highlighted that there was an improvement in the numbers of recaptures of tagged toothfish within the four research blocks. However, data on recaptured fish was limited due to an uneven distribution of fishing effort on the seamounts in SSRU 88.2H.

4.203 The Working Group noted that although fishing in SSRU 88.2H had extended to an additional seamount in the last year, effort was still concentrated on only two seamounts. The Working Group recommended that further information was needed about whether the

requirement in CM 41-10 paragraph 12 to spatially spread effort had been successful, and that the analysis be updated and presented to WG-FSA in 2025 with an additional two seasons of data.

Management advice

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

4.205 The Working Group recommended that the catch limits for Subarea 88.2 SSRUs 882C-H be based on the trend analysis as shown in Table 4.

Subarea 88.3

4.206 WG-FSA-2023/20 Rev. 1 presented a research plan for Subarea 88.3 which updated the research plan with the recommendation from the Scientific Committee to integrate the Ukrainian research with the Korean and New Zealand research plan. The combined vessel research plan proposed to continue the research on *Dissostichus* spp. in Subarea 88.3, which began in 2021/22, in 2023/24.

4.207 The Working Group noted that the research had made much progress, and that the research plan made no significant changes to that which had previously been endorsed.

Management advice

4.208 The Working Group recommended continuing the research outlined in WG-FSA-2023/20 Rev. 1 for the 2023/24 season.

4.209 The Working Group recommended that the catch limits for Subarea 88.3 be based on the trend analysis as shown in Table 4

By-catch

By-catch management in krill fisheries

5.1 WG-FSA-2023/69 presented the findings of a machine learning approach for otolith shape-based species discrimination. The approach combined a neural network with a triplet loss function which reduced the allometric growth effects on the ability to discriminate species. A total of 14 established machine learning methods of discrimination were tested, with the combination of a neural network and the triplet loss function resulting in a classification accuracy of 96%.

5.2 The Working Group noted the effectiveness of the outlined techniques. The number of samples used in the study was also discussed (159 in total between four species), and the

Working Group suggested that more samples would likely improve the classification accuracy, noting that the technique could potentially be extended to other hard structures found, for example, in diet samples.

5.3 The Working Group recommended excluding the effect of allometric growth in future otolith shape-based species discrimination studies.

5.4 WG-FSA-2023/P01 presented an analysis of fatty acid profiles and energy density of muscle and gonad tissue from *C. gunnari* collected in Subarea 48.2. The findings suggested that ovarian development during spawning in this species utilises energy from feeding, as opposed to energy stored in the tissues, known as an income breeding strategy. The paper highlighted the importance of fish by-catch sample collection from krill fishery operations as an important source of information for developing the understanding of Antarctic fish ecology.

5.5 The Working Group noted the utility of this approach for investigating species ecology, as well as broader food web structure. Several ongoing similar projects were noted on the food web ecology for Patagonian (Subareas 48.3 and 48.4) and Antarctic (Subarea 48.4) toothfish, using the same methods that will be presented to future working groups.

5.6 WG-FSA-2023/04 presented an overview of an ongoing project aiming to improve the identification of fish by-catch in the krill fishery. The three-part project will:

(i) utilise integrative taxonomy to collate and identify fish collected from the krill fishery in all subareas, aiming to cover all available species and life history stages that interact with the fishery

(ii) systematically review the available literature to collate data on reproductive aspects of by-catch species

(iii) develop enhanced field guides for fishery observers, focused on images of key ID features.

5.7 The authors noted that of the 86 species investigated during the systematic review, 15 appeared to be missing key information (e.g., reproductive timings, larval duration). A list of species for which samples are missing in the study was presented, with the aim of requesting engagement with Members to provide samples and imagery if available. Members were encouraged to contact the authors to collaborate.

5.8 The Working Group thanked the authors for presenting the project at an early stage in order to engage with other Members, highlighting the need for this work and the potential for it to produce valuable resources for fisheries observers and the wider community. It further suggested that a compendium of life history characteristics resulting from the systematic review could help to address the lack of risk assessments in the krill fisheries for by-catch populations.

5.9 WG-FSA-2023/73 presented an updated summary of fish by-catch in the krill fishery, which implemented recommendations by WG-FSA-2022, including the estimation of total by-catch weights by species and providing spatial and temporal patterns in by-catch as well as length frequency distributions. After the identification and correction of data quality issues the analysis presented confirmed the localised and sporadic nature of high by-catch events.

5.10 The Working Group noted the comprehensive analysis done by the Secretariat, as well as the changes made since last year, and supported the suggestion for future iterations of the

paper to include extrapolated by-catch estimates using methods outlined in WG-IMAF-2023/03. The Working Group requested future iterations of this paper include colourblind-friendly plots as the use of cyan and bright green together on a white background can be difficult to interpret.

5.11 The Working Group noted that these analyses were valuable to the understanding of total removal of fish species, as well as from an ecological perspective. It also noted that the analysis indicated that by-catch rates are relatively similar between fishing methods, and that the by-catch of fish in the krill fishery is characterised by the occurrence of sporadic and localized large by-catch events.

5.12 The Working Group recommended the Secretariat include relevant report figures in the krill fishery report.

5.13 The Working Group noted the cohort progression of *C. gunnari* in Subarea 48.2, and that the short life span of this species may result in periodic pulses of high by-catch rates for this species until the next large recruitment event in this area. It also suggested that the detection of a large cohort of young fish may predict large catches of older fish in subsequent seasons.

5.14 The Working Group also noted the potential for different gear selectivity of by-catch species between vessels depending on gear configuration and that future research towards the correction for the effect of gear selectivity on length frequency distributions would be beneficial.

By-catch management in toothfish fisheries

Macrourus spp.

5.15 WG-FSA-2023/27 reported on three bottom trawl surveys carried out by New Zealand in the Ross Sea region in SSRUs 881HIK and 882A in 2008, 2015, and 2019. Catches from these three surveys contained a mixture of three species: *M. whitsoni*, *M. caml*, and *Cynomacrurus piriei*, and were combined across years and scaled to the slope area to give a composite biomass estimate.

5.16 The Working Group recommended that work on estimating biomass of macrourids using different data sources continues, including additional work to determine appropriate approaches for setting catch limits in the different management areas. The Working Group also noted that the timing of these biomass surveys could provide a good opportunity to assess the impact of the RSRMPA on macrourids.

5.17 Noting the three different methods of biomass estimation outlined in WG-FSA-2023/27, the Working Group recommended using the constant density biomass estimate to develop future management advice.

5.18 The Working Group recalled that the decision rules previously used in 2003 to assess γ for *M. whitsoni* were based on a median spawning stock biomass of 50% B_0 at the end of a 55-year projection, and that the probability of depletion below 20% of B_0 being no greater than 0.1 over the projection period (WG-FSA-2003, paragraph 5.238). The Working Group noted that the probability of depletion below 20% of B_0 was the rule that determined the value of γ selected in 2003 (WG-FSA-2003, paragraph 5.241).

5.19 The Working Group noted that the paper WG-FSA-2023/27 had calculated γ based upon a median escapement of 75%. This resulted in a γ for *M. whitsoni* of 0.0214 and for *M. caml* of 0.021. During the meeting, models were also run to calculate γ based on 50% escapement, and for the probability of depletion below 20% of the median pre-exploitation spawning biomass being 0.1. The 50% escapement resulted in a γ of 0.56 for *M. whitsoni* and 0.59 for *M. caml*, whilst the depletion rule resulted in a γ of 0.14 *M. whitsoni* and 0.08 for *M. caml*.

5.20 The Working Group recommended further work to evaluate the decision rules used for these species to provide guidance on an appropriate level of escapement that should be applied, noting that there were differing views on the appropriate choice of either 50% or 75% escapement for calculating the γ for macrourids.

5.21 The Working Group noted that the current levels of macrourid by-catch in the Ross Sea fishery were substantially lower than the estimated catch limits, and that the revised catch limits using 75% escapement were similar and slightly higher than the current limits.

5.22 The Working Group recommended that the current catch limits for macrourids in Subarea 88.1 remain unchanged.

5.23 SC-CAMLR-42/BG/37 provided a summary from the Secretariat on how by-catch move-on rules are implemented for *Macrourus* spp. by-catch within Paragraph 6 of CM 41-09 and how this interacts with Paragraph 5 and 6 of CM 33-03. Paragraphs 5 and 6 require two move-on rules; a 5 n mile move-on rule for individual catches exceeding 1 t, and a cessation rule that requires cessation of fishing for a vessel where catches within two 10-day periods exceed 1 500 kg and 16% of the catch of toothfish spp. The paper noted an absence of compliance issues with Paragraph 6 of CM 41-09 indicating that the by-catch thresholds in place have been effective in preventing high catches of *Macrourus* spp.

5.24 The Working Group noted that Paragraph 6 of CM 41-09 (2022) specifies the catch limits of by-catch species for Management Areas in Subarea 88.1. While CM 33-03 does not apply to Subarea 88.1, the fishing cessation rule in Paragraph 6 of CM 33-03 is also specified within Paragraph 6 of CM 41-09. However, it is applied at the SSRU level for Subarea 88.1 and at the area to which a catch limit applies in CM 33-03.

5.25 The Working Group noted that the implementation of the fishing cessation rule outlined in CM 41-09 (paragraph 6) was from the decision by the Commission to apply the cessation of fishing at the SSRU level in Subarea 88.1 following the implementation of the RSRMPA. The Working Group recommended maintaining the current fishing cessation rule for Subarea 88.1 at the scale of SSRU, as specified in CM 41-09 Paragraph 6.

5.26 The Working Group further discussed the application of the fishing cessation rule to areas outside of the Ross Sea, noting that toothfish fishing in all new and exploratory fisheries outside of the Ross Sea takes place in research blocks, aside from SSRU 88.2 H. The Working Group noted that the application of the current move-on rule may hinder toothfish research in research blocks (SC-CAMLR-2017, paragraphs 3.143 to 3.146) and that the second 1-tonne move-on rule (CM 33-03, paragraph 5) would provide adequate protection from depletion within a research block and would be consistent with article IX, 2 (h).

5.27 The Working Group recommended the removal of CM 33-03 paragraph 6.

5.28 The Working Group noted that the macrourid biomass estimates presented in WG-FSA-23/27 for the Ross Sea and suggested that catch limits for macrourids in research blocks and other exploratory areas could be calculated using the CPUE-by-seabed area analogy method currently used for toothfish. This approach would allow catch limits to better reflect the density of macrourids in each research block rather than using a constant proportion of the toothfish catch limit. The Working Group requested the Secretariat provide progress on this to WG-SAM-2024 and WG-FSA-2024.

5.29 The Working Group suggested that for the next iteration of research plan proposals in these areas, proponents provide details on how they will generate area-specific gamma values for macrourids.

5.30 WG-FSA-2023/32 Rev. 1 reported on a study of molecular and morphological traits of 338 individual macrourids collected in Subareas 88.1 and 88.3 between 2021 and 2022. The samples were classified as *M. caml* and *M. whitsoni* based on the morphological identification keys. Comparisons between morphological identification and mtDNA COI sequences of 49 individuals suggested that the pelvic fin rays and the rows of lower jaw teeth should be jointly examined for accurate identification of the two species. When samples examined by observers were compared with subsequent morphological identification conducted in the laboratory, there were differences in species identification which may be due to the overwhelming dominance of *M. caml* in the catches in Subarea 88.3, making it challenging for observers to differentiate between the two species. Molecular analysis is still underway to further differentiate between the two species.

5.31 The Working Group thanked the authors for the progress made on the identification of macrourids and looked forward to the outcomes of the molecular analysis. The Working Group recommended that a likelihood or Bayesian approach could be considered to progress the molecular analysis. As there is currently no phylogeny based on nuclear markers for Antarctic macrourids to assist in the analysis of mitochondrial marker datasets, the Working Group recommended that this could be an important avenue for future research. The Working Group noted that variation in the species identifications made aboard and subsequently ashore were possibly due to differences in individual experience and noted that South African colleagues had published a paper in 2021 (Gon et al., 2021) for the four species of *Macrourus* in the CCAMLR area that could be useful in this research. The Working Group also suggested that otolith shape morphology might assist with refining the differentiation between these two species.

5.32 The Working Group welcomed the provision of training materials or identification guides for macrourids such as those in WG-FSA-2023/32 Rev. 1, and the offer to have these initially translated into English for subsequent translation into other CCAMLR languages and being made available by the Secretariat.

5.33 WG-FSA-2023/33 reported progress made since WG-FSA-2022 to estimate the abundance trends of grenadiers caught as by-catch in the longline fisheries in CCAMLR Subarea 48.6. This work used spatio-temporal delta generalised linear mixed models (GLMMs) implemented with R package “VAST”. A single model covering all research blocks and all fishing gears (trotlines and Spanish lines) was developed, with gear types incorporated as a catchability covariate, and an index of abundance was estimated separately for each block. The paper recommended more studies to progressively improve the use of VAST modelling to estimate the abundance of by-catch species in Subarea 48.6. Future work could include abundance models for other by-catch species.

5.34 The Working Group recommended that observer data could further assist in species identification when linked to the C2 data. The Working Group welcomed the progression and suggested that further studies contrasting conventional GLMMs with the more complex VAST model might be informative.

Skates and sharks

5.35 WG-FSA-2023/40 reported on a project to inform post-release survival rates of skates using pop-up satellite tags and to investigate capture-related stress through blood biomarkers. The survival and activity patterns of 24 Kerguelen sandpaper skates was evaluated using MiniPat pop-up archival satellite tags.

5.36 The Working Group welcomed the development of the tagging method and encouraged further studies and publication on post-release survival and collaborative research into this topic. The Working Group also noted that future work could include environmental conditions, mortality factors such as depth range, soak time, and skate size with the potential to use recorded injury codes to assist in this evaluation.

5.37 The Working Group noted that the estimation of the post-release survival estimates using pop-up tags would allow for more realistic estimates of stock status from skate assessments.

5.38 WG-FSA-2023/11 described results from an aging study using the centrum of 285 vertebrae for the three skate species caught as by-catch in the Kerguelen and Crozet Patagonian toothfish (*D. eleginoides*) fisheries in Division 58.5.1 and 58.6. While the ages are not yet validated, the results using this method indicated that the three skate species display faster growth compared with the conventional method based on the corpus calcareum, suggesting a relatively productive life-history. However, the paper noted that there was potential to underestimate the ages of older individuals.

5.39 WG-FSA-2023/35 further presented research on maturity of the three species of skates mainly caught as by-catch in the Kerguelen and Crozet Patagonian toothfish fisheries. The paper presented length-at-maturity estimates for *B. eatonii* and *B. irrasa* in Kerguelen and *A. taaf* in Crozet. The length at 50% maturity for *B. irrasa* males and females were both >100 cm TL, while *B. eatonii* and *A. taaf* showed length at 50% maturity near 80 cm TL, except for female *A. taaf* which had a highly uncertain estimate of length of 50% maturity of 98 cm TL.

5.40 The Working Group thanked the authors for both papers and suggested some future work which included investigating the use of additional anatomical structures for aging as well as vertebrae, the potential to use chemical marking in tagged skates, and increasing data collection during the skate spawning seasons to obtain more information on size at maturity.

5.41 WG-FSA-2023/41 examined recent trends in shark by-catch from longline fisheries in the CAMLR Convention Area using information reported by vessels (C2) and scientific observers from 2017 to the start of 2023 fishing seasons. The paper noted substantial gaps in reported shark by-catch and suggests that shark by-catch may have increased during this period. The paper highlighted differences in trends between vessel and scientific observer records

relating to shark by-catch in total numbers, and in categories of retained, discarded, and released sharks. The paper highlight instances where observer data indicated retained sharks and the vessel data recorded none.

5.42 The Working Group noted that differences between the amount of line observed and by-catch recorded by observers was generally much less than values reported in the vessel report for the entire line, and that shark catches were generally patchy and unevenly distributed along a longline, which could explain some of the differences. The Working Group also noted that vessels may initially retain by-catch (as required when south of 60°S latitude), but then discard them north of 60°S, which may then explain part of the difference with observer records.

5.43 The Working Group suggested that the methodology on extrapolation in paper WG-IMAF-2023/03 could provide additional guidance in how the shark data might be analysed and noted that there was potential bias between the recording of small commonly caught shark species such as *Etmopterus* spp. and large sharks such as porbeagle sharks (*Lamna nasus*) and sleeper sharks (*Somniosidae*) which are rarely caught but recorded.

5.44 WG-FSA-2023/50 presented updated biomass estimates and exploitation rates consistent with the CCAMLR decision rules for *A. georgiana* in the Ross Sea, providing a range of estimates of biomass and exploitation estimates depending on values chosen for life history parameters. Model uncertainties were presented, particularly concerning survivorship. Biomass and exploitation estimates were highly reliant on mortality and recruitment steepness assumptions. Regardless of assumptions on tagging cohort treatment and assuming plausible extremes of natural mortality, the current exploitation rate was considered sustainable if survivorship was more than 60%. If live skates are not released, then exploitation rates would be higher and would likely be inconsistent with CCAMLR decision rules.

5.45 The Working Group recalled the skate survival tank experiment by Endicott and Agnew (2004) and used the estimates by depth category to estimate discard survival of *A. georgiana* in the Ross Sea region. The weighted average survivorship for all skates released in the Ross Sea region was estimated to average 0.70 ranging between 0.66 and 0.74 between 2003-2023 (Table 12).

5.46 The Working Group noted that sustainability results were dependent on a number of parameters for which there is currently little information, and encouraged more work to better inform these, such as recording of skate injury condition at capture and release (Table 1), research to improve post-release mortality estimates; welcoming the planned skate tagging in the 2027/28 season. The Working Group suggested that the use of PSAT tags may provide an alternative source of information to improve our understanding of the release mortality.

5.47 WG-FSA-2023/65 Rev. 1 recalled the 2-year programme during the 2019/20 and 2020/21 fishing seasons in the Ross Sea region to tag and release skates for abundance estimation and to validate the thorn ageing method for Antarctic starry skate (*A. georgiana*). A total of 10 218 skates have been tagged and released since the 2019/20 fishing season in the Ross Sea, Amundsen Sea, and Bellingshausen Sea region. Recaptures from these initial releases will be used to monitor trends in population size through time with additional tagging occurring periodically. Since the 2019/20 fishing season, a total of 127 skates tagged have been returned to NIWA (New Zealand) for sampling. Results from the age validation experiments are ongoing.

5.48 The Working Group noted that CM 41-01, Annex 41-01/C, paragraph 2 should remain in place to ensure skates are sampled and thorns retained. The Working Group also encouraged Members to collect thorns for analysis, and noted that CM 41-09 would need to be modified in the future to allow tagging and release of skates that are unlikely to survive.

5.49 The Working Group noted that CM 41-09 would need to be modified in the future for the next 'Year of the Skate' to allow for the tagging and release of skates with injuries, as was undertaken in previous 'Year of the Skate' programmes.

5.50 The Working Group recommended that logbook fields to record skate injury codes be reinstated to allow routine recording of injuries for tagged skates and that the form be modified to allow more than one injury type to be recorded for an individual skate (paragraph 2.21).

VME management

5.51 WG-FSA-2023/29 presented an update on the work of WG-EMM-2023 on a potential protection mechanism for notothenioid fish nest areas in the Convention Area. The authors proposed definitions for:

(i) a fish nest with a distinction between active and potential status

(ii) fish nest areas including methods, criteria (e.g., minimum density) and a review process for re-assessing fish nest areas every five years if applicable.

5.52 The Working Group recommended that the *Neopagetopsis ionah* fish nest area in the southern Weddell Sea be protected, and that a five-year review process as defined in WG-FSA-2023/29 is suitable.

5.53 The Working Group noted that the monitoring related to the procedure for five-year review enables the evidence on the continued presence of fish nest areas as defined in WG-FSA-2023/29 to be provided.

5.54 The Working Group noted that other fish species use hard substrates where evidence of a depression delineating a nest would not be apparent. The Working Group also noted that the nest density for other fish species might be lower than for *N. ionah*. Therefore, definitions and indicators developed in the paper WG-FSA-2023/29 may not be applicable to all nesting fish species.

5.55 The Working Group requested that the Scientific Committee develop mechanisms to provide protection for unusual phenomena associated with Antarctic Marine Living Resources that are vulnerable to human activities when they are discovered. It suggested that Conservations Measures such as those used for VMEs, or areas uncovered by icesheet retreat or other fishery regulations, could be developed to ensure immediate protection until such time as their importance is evaluated by the Scientific Committee.

5.56 WG-FSA-2023/70 presented a revised VME Taxa Classification Guide for the toothfish fishery and the authors recommended it replace the existing guide (https://www.ccamlr.org/node/74322) to realign the guide with recent taxonomic changes.

5.57 The Working Group welcomed the paper and noted the revised guide is an important update that will help observers aboard fishing vessels throughout the Convention Area. The Working Group further noted that analytical tools such as artificial intelligence could be developed to aid observers in classifying VME indicator taxa with more precision.

5.58 The Working Group noted that two codes were still to be created when the paper was submitted and recommended that the revised version of the guide provided in Appendix H be used throughout the Convention Area from season 2024/2025 onwards.

5.59 The Working Group noted that the revised guide could be used for season 2023/2024 by vessels operating in the Ross Sea Region and requested the Secretariat to provide observers on these vessels intending to use the revised guide with an updated observer longline form including the revised VME taxon codes.

5.60 The Working Group recommended that the 2009 version of the CCAMLR VME Taxa Classification Guide remain in use outside of the Ross Sea Region until the revised version is made available in 2024.

5.61 The Working Group noted that the 536 taxon codes provided on the forms represent a subset of the 13,615 codes maintained by FAO-ASFIS (http://www.fao.org/fishery/en/collection/asfis). The Working Group noted that all ASFIS codes can be used currently in the forms and that additional codes for taxa for which no ASFIS code exist can be requested. The Working Group requested the Secretariat update the logbook forms to clarify the procedure to report taxa not listed on the forms and add a link to the ASFIS taxon list.

5.62 WG-FSA-2023/75 presented a new interface for the VME registry which will replace the current Excel file approach. The authors further noted differences between the data reported by observers and vessels and requested the Working Group to consider how to integrate VME data reported by observers.

5.63 The Working Group welcomed the paper and noted that the visualisation tool could be used to identify areas of overlap between research plan activities and known areas where VME indicator thresholds have been notified. The Working Group requested the Secretariat continue to develop, document and maintain single sources of spatial data.

5.64 The Working Group noted that VME risk area notifications are a vessel responsibility and noted that discrepancies between vessel and observer data require further investigation as they may be the result of data quality issues.

Scheme of International Scientific Observation

6.1 WG-FSA-2023/01 presented the 'SAGO Extreme' fish collection and de-hooking system used onboard the Uruguayan fishing vessel Ocean Azul during November and December 2022 in the Patagonian toothfish fishery in CCAMLR subarea 58.7. The paper reviewed the effectiveness of the SAGO system in reducing depredation by comparing the catch per unit effort for fishing lines retrieved in the presence of marine mammals between sets with and without the system. Out of 165 sets, marine mammals were directly observed on 34 occasions, with the SAGO system being used during 14 hauls. *D. eleginoides* were collected

from the SAGO capsules on 11 occasions, which were assessed to be in good condition and therefore tagged and released.

6.2 WG-FSA-2023/02 described a new launching procedure for the 'SAGO Extreme' system to eliminate SAGO capsule contact with the seafloor.

6.3 The Working Group thanked the authors for the papers, noting that more information would be required to better enable CCAMLR Working Groups to assess the effects of the SAGO on items such as toothfish tagging programmes, the potential escapement of small by-catch species and skates, the effects of the de-hooking process on toothfish, potential for bottom impacts, and comparability of VME indicator taxon retention with the SAGO system.

6.4 The Working Group recommended that details on the methodology and sampling protocols for the SAGO system should be submitted to WG-FSA to better inform the Working Groups on the effects of this fishing method on catch, by-catch and the environment.

6.5 The Working Group noted that further research should include underwater video cameras attached to the SAGO capsule to determine the interactions with fish and marine mammals. The Working Group encouraged Uruguay to consider the experimental design and potential for attaching the CTD sensors to the SAGO capsule to collect the oceanographic data.

6.6 The Working Group recalled that a bottom fishing impact assessment, submitted for a vessel fishing in an area, needs to include information for any new fishing gear configuration notified, if that gear could be in contact with the sea floor.

6.7 The Working Group noted that the vessel Ocean Azul has been notified for the Ross Sea (Subarea 88.1 and Subarea 88.2 A and B) (CCAMLR-42/BG/08 Rev 1) and the Amundsen Sea (88.2) and noted that marine mammal depredation is not an issue when fishing in these areas. Therefore, the Working Group recommended the SAGO system should not be used in these areas.

6.8 WG-FSA-2023/07 Rev. 2 provided details of the CCAMLR Scheme of International Scientific Observation (SISO) deployments including deployment information for all observers placed onboard vessels in the CCAMLR Convention Area during the 2022/2023 season. There were 27 longline trips and 18 trawl trips observed up to 9 October 2023. The paper noted small updates to commercial and observer forms and manuals.

6.9 The Working Group welcomed an update to the taxonomic database for species codes and the implementation of minor changes in the krill observer logbook to include warp strike severity fields.

Future work

7.1 SC-CAMLR-42/BG/04 presented an application for GCBF funds to support an in-person training workshop on the development of integrated stock assessments for CCAMLR data-limited toothfish research fisheries, with Subarea 48.6 used as a pilot study. The workshop will provisionally be held in Cape Town, South Africa in 2024, organised by Mr Somhlaba, Dr T. Okuda (Japan) and Mr R. Sarralde (Spain), and supported by Mr A. Dunn (New Zealand). The total funds applied for are A$30 000.

7.2 The Working Group welcomed the initiative and recommended the Scientific Committee endorse it.

7.3 The Working Group noted that Subarea 48.6 was the focus of the training workshop and noted that consideration of sex-specific biological processes in an assessment would be beneficial in this Subarea. It noted that any interested Members were welcome to attend the workshop and that its outcomes, including training materials which could be used as templates for other areas, will be made available to all Members at WG-FSA-2024.

7.4 The Working Group reviewed its workplan (SC-CAMLR-41, Table 8) and adjusted the priority status, timing and contributors associated with the current tasks (Table 13). It also added several new tasks generated from discussions during the meeting such as those pertaining to stock assessments.

Other business

8.1 WG-FSA-2023/52 Rev. 1 presented results from a satellite tagging experiment, where fifty Popup Satellite Archival Tags (PSATs) were deployed off Davis Bank on North Scotia Ridge (FAO Area 41), during the austral summers of 2019 and 2020 on *D. eleginoides* individuals ranging from 97 to 139 cm in total length. For PSATs that reported more than 300 km away from the release site, the authors corrected for the distance that a tag had drifted prior to its first successful satellite link using particle backtracking modelling. The analysis included estimates of least-cost paths between release and recapture locations using a 450 to 2 000 m bathymetric constraint.

8.2 The Working Group welcomed the valuable results generated by this successful collaboration between scientists and the fishing industry. It noted that similar experiments were ongoing in Division 58.5.2 on skates, as well as other areas and species, and recalled past studies (e.g., WG-FSA-14/64). The Working Group noted that PSATs provided information such as indications of swimming speed, site fidelity, possible location in the water column as well as post-release mortality. It discussed the possibility of future PSATs technological advancements which may include additional sensors such as accelerometers and conductivity. Noting the lack of post-release mortality reported in the study, the Working Group noted that this was helpful to confirm that toothfish were tolerant to tagging procedures. It encouraged Members to collaborate on PSAT studies by sharing data and protocols.

8.3 Dr Devine presented work funded by Fisheries New Zealand of relevance to the Working Group on the estimation of release survival for pelagic sharks and fish. Among the objectives of the project, collating available scientific literature on the release mortality of *D. eleginoides* and convening a workshop of relevant experts to estimate the release survival, according to gear type and configuration, handling behaviour, and environmental conditions were tasks highlighted to the Working Group. Dr Devine encouraged meeting participants with expertise in tagging to collaborate on the project.

8.4 The Working Group welcomed the work and noted the importance of the consideration of post-release mortality to its work, and that it could depend on many factors including tag type, fish size and sex, depth, and fish handling procedures. It encouraged all to participate in the project, including observers and scientists not present at the meeting.

8.5 Dr P. Ziegler informed the Working Group that the annual Heard Island random stratified trawl survey was planned for March 2024.

8.6 Dr Devine informed the Working Group that the Italian research vessel Laura Bassi will be conducting a survey in the Ross Sea region in January-February 2024 and will be deploying moored instrumentation and Argo floats along with under-way and vessel-based sampling, sampling to study the hydrography, zooplankton, pelagic, and benthic communities, and for palaeoecological ocean and sea ice reconstruction.

Advice to the Scientific Committee

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

(i) Fisheries and observer forms updates

  (a) Catch and Effort (CE) for longlines (paragraph 2.11)

  (b) Separate C1 form for krill and finfish (paragraph 2.12)

  (c) Workshop to discuss trawl forms (paragraph 2.13)

  (d) B2 removal, noting proposal to retire CM 23-05 (paragraph 2.15)

  (e) C4 form review (paragraph 2.16)

  (f) Skate injury codes in observer logbook (paragraphs 2.21 and 5.50)

  (g) Marine debris reporting (paragraph 2.37)

  (h) krill observer form, by-catch sampling (paragraph 3.41)

  (i) Additional fields in C2 and observer forms for tagging (paragraph 4.192)

(ii) Geospatial rules (paragraph 3.18)

(iii) Krill fishery management

  (a) Catch limits in Divisions 58.4.1 and 58.4.2 (paragraphs 3.27 and 3.28)

  (b) Priority questions and data requirements (paragraphs 3.49 and 3.50)

  (c) Krill length sampling (paragraphs 3.44 and 3.45)

(iv) Icefish fisheries management

  (a) Catch limits in Subarea 48.3 (paragraph 4.73)

  (b) Catch limits in Division 58.5.2 (paragraph 4.135)

(v) Toothfish fisheries management

(a) Catch limits for data-limited toothfish fisheries (paragraph 4.7)

(b) Age determination (paragraphs 4.18, 4.20, 4.21)

(c) Tag overlap statistic (paragraph 4.34)

(d) Tagging protocols (paragraphs 4.36 and 4.37)

(e) Independent review panel conclusion (paragraph 4.51)

(f) Integrated stock assessments work programme (paragraphs 4.57 and 4.58)

(g) *D. eleginoides* in Subarea 48.3 (paragraphs 4.96 and 4.97)

(h) *D. eleginoides* in Subarea 48.4 (paragraph 4.106)

(i) *D. mawsoni* in Subarea 48.4 (paragraph 4.112)

(j) *D. mawsoni* in Subarea 48.6 (paragraph 4.129 and 4.130)

(k) *D. eleginoides* in Division 58.5.1 outside of EEZ (paragraph 4.144)

(l) *D. eleginoides* in Division 58.5.2 (paragraph 4.159 - 4.161)

(m) *D. eleginoides* in Subarea 58.6 outside of EEZ (p. 4.168)

(n) *D. mawsoni* exploratory fishery in Divisions 58.4.1 and 58.4.2 (paragraphs 4.174 and 4.175)

(o) *D. mawsoni* in Ross Sea region (paragraphs 4.201 and 4.202)

(p) *D. mawsoni* in Subarea 88.2 (paragraphs 4.205 and 4.206)

(q) *D. mawsoni* in Subarea 88.3 (paragraphs 4.210 and 4.206)

(r) by-catch of macrourids in Subarea 88.1 (paragraph 5.22)

(s) by-catch move-on rules (paragraphs 5.25 and 5.27)

(t) GCBF funds application (paragraph 7.2)

(u) Use of SAGO Extreme (paragraph 6.7)

(vi) VMEs

(a) fish nests (paragraph 5.52)
(b) protection for unusual phenomena (paragraph 5.55)

Adoption of the report and close of meeting

10.1 The report of the meeting was adopted requiring 7 h and 50 min of discussion.

10.2 At the close of the meeting, Mr Somhlaba thanked all members of the Working Group for the hard work and positive contributions. He also thanked the Secretariat for their support and coordination in progressing the work of the group.

10.3 On behalf of the Working Group, Dr M. Collins (United Kingdom) thanked Mr Somhlaba for his leadership, skill, patience and tremendous spirit in guiding the discussions of the Working Group.

10.4 On behalf of the Working Group, Mr Dunn (New Zealand) thanked the Secretariat team for their work, responsiveness, and high-quality work in support of the meeting.

10.5 The meeting was closed.

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Table 1. Proposed skate injury codes for skate injury assessment.

Category	Description
0	No visible injuries
J	Jaw cartilage break or significant tearing of tissue around the mouth
G	Gills bleeding on either dorsal or ventral surface
L	Lice damage on/around the peritoneal cavity
I	Intestinal prolapse exceeding 3 cm, including if bleeding
P	Penetrating injury of the peritoneal cavity
E	Eye or spiracle injury
W	Wounds that are minor or superficial skin trauma to any region
B	Bruising on the dorsal or ventral side of disc or tail
S	Scar tissue around mouth/jaw that has healed from previous injury

Table 2. Precautionary catch limits for *Euphausia superba* in Division 58.4.1.

Division	Subregion	Longitude Range	Biomass (million tonnes)[1]	Precautionary Harvest Rate	Catch Limit (t)
58.4.1	West	80-103°E	1.567	0.0847	132 725
58.4.1	Middle	103-123°E	0.643	0.0847	54 462
58.4.1	East	123-150°E	2.114	0.0847	179 056
58.4.1	Total	80-150°E			366 243

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

Table 3. Precautionary catch limits for *Euphausia superba* in Division 58.4.2.

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

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

Table 4: Research Blocks biomasses (B, tonnes) and catch limits (CL, tonnes) estimated using the trend analysis*. Greyed cells indicate research blocks that require catch advice for the upcoming season. PCL: previous catch limit; ISU: increasing, stable or unclear; D: declining; Y: yes; N: no; -: no fishing in the last Season; x: no fishing in the last 5 Seasons. Recommended catch limits are subject to approval by the Commission.

Area	Subarea or Division	Research Block	Species	PCL	Trend decision	Adequate recaptures	CPUE Trend Decline	B	B×0.04	PCL×0.8	PCL×1.2	Recommended CL for 2024
48	48.1	481_1	*D. mawsoni*	43	-	-	-	-	-	-	-	
		481_2	*D. mawsoni*	43	-	-	-	-	-	-	-	
		481_3	*D. mawsoni*	0	x	x	x	x	x	x	x	
	48.2	482_N	*D. mawsoni*	75	-	-	-	-	-	-	-	
		482_S	*D. mawsoni*	75	-	-	-	-	-	-	-	
	48.6	486_2	*D. mawsoni*	123	ISU	Y	N	3 741	150	98	148	148
		486_3	*D. mawsoni*	37	ISU	N	N	1 045	42	30	44	42
		486_4	*D. mawsoni*	157	D	Y	Y	6 136	245	126	188	126
		486_5	*D. mawsoni*	168	ISU	Y	Y	20 621	825	134	202	202
58	58.4.1	5841_1	*D. mawsoni*	138	x	x	x	x	x	x	x	112*
		5841_2	*D. mawsoni*	139	x	x	x	x	x	x	x	80*
		5841_3	*D. mawsoni*	79	x	x	x	x	x	x	x	79*
		5841_4	*D. mawsoni*	46	x	x	x	x	x	x	x	46*
		5841_5	*D. mawsoni*	60	x	x	x	x	x	x	x	116*
		5841_6	*D. mawsoni*	104	x	x	x	x	x	x	x	50*
	58.4.2	5842_1	*D. mawsoni*	86	ISU	Y	N	13 769	551	69	103	103
		5842_2	*D. mawsoni*	258	ISU	N	Y	5 934	237	206	310	206
	58.4.3	5843a_1	*D. eleginoides*	0	x	x	x	x	x	x	x	
	58.4.4	5844b_1	*D. eleginoides*	18	-	-	-	-	-	-	-	
		5844b_2	*D. eleginoides*	14	-	-	-	-	-	-	-	

(continued)

Table 4 (continued)

Area	Subarea or Division	Research Block	Species	PCL	Trend decision	Adequate recaptures	CPUE Trend Decline	B	B×0.04	PCL×0.8	PCL×1.2	Recommended CL for 2024
88	88.2	882_1	*D. mawsoni*	230	ISU	Y	N	4 356	174	184	276	184
		882_2	*D. mawsoni*	268	ISU	Y	N	28 853	1154	214	322	322
		882_3	*D. mawsoni*	208	ISU	N	N	6 054	242	166	250	242
		882_4	*D. mawsoni*	185	ISU	Y	N	10 302	412	148	222	222
		882H	*D. mawsoni*	122	ISU	Y	N	10 837	433	98	146	146
	88.3	883_1	*D. mawsoni*	16	ISU	N	Y	1 401	56	13	19	13
		883_2	*D. mawsoni*	20	-	-	-	-	-	-	-	20
		883_3	*D. mawsoni*	48	ISU	N	Y	5 371	215	38	58	38
		883_4	*D. mawsoni*	48	ISU	N	Y	2 078	83	38	58	38
		883_5	*D. mawsoni*	8	-	-	-	-	-	-	-	8
		883_6	*D. mawsoni*	36	ISU	N	N	2 065	83	29	43	43
		883_7	*D. mawsoni*	36	ISU	N	N	3 184	127	29	43	43
		883_8	*D. mawsoni*	10	-	-	-	-	-	-	-	10
		883_9	*D. mawsoni*	10	x	x	x	x	x	x	x	x
		883_10	*D. mawsoni*	10	x	x	x	x	x	x	x	x

*Proposed maximum catch is based on the 75th percentile of catch rates and longlines with 5000 hooks (see Table 8 in WG-SAM-2023/03).

Table 5: Preliminary example of a table summarising evidence for changes in stock assessment parameters or processes that could be due to the effects of environmental variability or climate change, based on the available information for the Antarctic toothfish stock assessment for the Ross Sea region.

Parameter or process			Evidence for trends and potential drivers
1a	Recruitment	Mean recruitment	Patterns in recruitment from the assessment model showed no evidence of trends over time (WG-FSA-2023/13).
1b		Recruitment variability (σ_R and autocorrelation)	The time series is currently not long enough to evaluate changes in variability, but the depletion rule was not a constraint in the application of the CCAMLR decision rules in the most recent assessment (WG-FSA-2023/13).
2	Age at maturity		No analyses have investigated potential changes in age or length at maturity (WG-FSA-12/40).
3	Stock-recruit relationship		Recent recruitments are consistent with the stock recruitment assumptions, but the time series of recruitment is not long enough to determine if the stock recruitment relationship was affected by climate change (WG-FSA-2023/13). Long term monitoring of mean recruitment and its relationship to spawning stock biomass may be able to be used to determine if changes in the relationship occur in future years.
4a	Natural mortality	From direct predation	Not known.
4b		Not from direct predation	Not known.
5	Growth rates		Age-length residual patterns across cohorts suggest that there have been small long-term fluctuations in mean size at age, following a roughly decadal cycle (WG-FSA-2019/11).
6	Length-weight		Patterns of length-weight relationship showed no evidence of trends or variability over time (WG-FSA-2019/11).
7	Sex ratio changes		No evidence of changes in sex ratio in the catch or the RSSS that may be explained by climate change (WG-FSA-2023/19).
8	Spatial distribution		No evidence of a change in the spatial distribution for Antarctic toothfish in the Ross Sea region from the analysis of fishing effort data (WG-FSA-2023/19). However, any changes in spatial distribution outside the historical fishing footprint are not known.
9	Stock structure		No evidence to suggest the stock structure hypothesis for Antarctic toothfish in the Ross Sea has altered from current stock structure hypotheses.
10	Locations of spawning and site fidelity		Not known.
11	Depredation mortality		No evidence for any changes in rates or occurrence of depredation from either fisher or observer observations - only rare instances of depredation mortality have been observed in the Ross Sea.

Table 6: Recommendations from the summary of the 2023 Independent Review, and the Working Group response to them including allocation of priority.

2023 Independent review panel recommendation	Priority	Response
1.1 Assessments move to a more contemporary modelling platform/s such as Casal2 as soon as practicable to allow more flexibility and robustness in running models.	High	Casal2 assessments presented and used for advice in 2023.
2.1 Where data allows, toothfish assessments should use sex-specific estimates of biological parameters.	Medium	The Ross Sea assessment is already sex disaggregated. For the other assessments work has been undertaken estimating sex-specific parameters. Sex-specific models should be investigated as a sensitivity run in future work, but importance dependent on the use of length data and sexual dimorphism.
2.2 Future analyses should investigate methods to incorporate environmental and ecosystem parameters in toothfish population models.	Medium	Consider whether assessments and management are robust to ecosystem changes using management strategy evaluations.
2.3 Sensitivity testing should be conducted to investigate the impact of freeing and covarying currently fixed parameters such as natural mortality and steepness in toothfish assessment models.	Low	Very little information is available to estimate these parameters freely, but sensitivity testing is a high priority for future work when evaluating alternative decision rules. An evaluation should be conducted when more recent information on steepness available. Work on the estimates and functional forms of natural mortality should be conducted and uncertainties in these parameters would be useful to consider in an MSE.
2.4 Post release mortality associated with tagging, natural mortality and movement estimates should be regularly reviewed and updated as new methods become available and tagging timeseries grow.	Medium	Vessel-specific relative tagging mortality estimates have been estimated for the Ross Sea, 48.3 and 58.5.2. Natural mortality was estimated in 58.5.2 and the Ross Sea (Candy, 2011; Candy et al. 2011; WG-SAM-06/08) but estimates of M should be updated.
3.1 Methods such as longline surveys and/or spatially structured fishing should continue to be developed to augment fishery-independent data on distribution and abundance of toothfish vulnerable to the fishery.	Medium	Existing survey time series contribute to the assessment in the Ross Sea (longline survey) and in 48.3 and 58.5.2 (trawl surveys). Potential for development of future structured sampling should be evaluated.
3.2 Model-based methods should be investigated to evaluate and, where necessary, adjust for, possible biases introduced by interannual variation in surveys, fishing pattern and stock distribution.	Very high	A workplan has been developed (see paragraph 4.53 to 4.60) to investigate the impact of interannual spatial variability in tag and effort distribution, with respect to the stock.
3.3 Where available, otoliths collected from across the timespan of fishing activity should be aged and included in estimating catch at age, growth.	Ongoing	Ageing programs underway in all the assessments. Ross Sea and 58.5.2 have aged otoliths across all years of the fishery.
3.4 Future analyses should investigate the extent of age, cohort and density-related effects on biological parameters for toothfish stocks.	Low	Could be investigated as part of management strategy evaluations.

(continued)

Table 6: (continued)

2023 Independent review panel recommendation	Priority	Response
4.1 A comprehensive stock annex should be developed for CCAMLR's integrated assessments for toothfish.	High	Stock annexes presented or updated for 48.3 TOP, 48.4 TOP, Ross Sea TOA.
4.2 Retrospective analyses be added to the suite of standard diagnostics for assessment models.	High	Presented for many of the assessments in 2023. The Working Group investigated retrospective trends in tag data. Stock assessors should include retrospective diagnostics in all future assessments.
5.1 CCAMLR continue to develop its suite of assessment diagnostics to include checks for trends in key biological and fishery parameters in space and time.	Medium	Table 5. Developments towards Casal2 has allowed standardised code for diagnostics. Diagnostics with analyses of key biological and fishery parameters in space and time should be developed.
6.1 Management strategy evaluation should be conducted to investigate alternative periodicity of assessments, length of projection period and alternative harvest strategies to achieve CCAMLR's objective.	Very high	A workplan has been developed (paragraph 4.53) to evaluate additional decision rules such as F-based rules and refine the operationalisation of the current decision rules.
6.2 CCAMLR continue to explore alternative methods for robustly estimating recruitment used in projections.	High	Being addressed as part of 6.1. Assumptions about future recruitment need to be evaluated as part of the MSE.
7.1 SC-CAMLR note that the 2021 integrated assessment constituted the best science available to CCAMLR upon which to base its management advice in the subarea 48.3 Patagonian toothfish fishery.	-	An updated integrated assessment was presented to the Working Group for this fishery in 2023 to provide management advice in 48.3.
7.2 SC-CAMLR continue to use assessments that integrate timeseries of fishery, survey and biological data in a statistically robust way, such as that used in 2021, to provide management advice to CCAMLR for the subarea 48.3 Patagonian toothfish fishery.	-	Future assessments for Subarea 48.3 will continue to be developed based on Casal2 integrated assessments that integrates timeseries of fishery, survey and biological data in a statistically robust way.

Table 7: Maximum posterior density (MPD) CASAL B_0 estimates (tonnes) for *D. eleginoides* reported to WG-FSA and comparison with Secretariat estimates.

Assessment/Model Run	Reported B_0	Secretariat B_0	Difference (%)	WG-FSA-2023 paper No
Division 58.5.1				
M2	225 761	225 761	0	67 Rev. 1
Subarea 58.6				
M4	51 387	51 387	0	66

Table 8: Secretariat verification of MPD results and risks for Casal2 assessments submitted to WG-FSA. Risk 1 and risk 2 refer to the CCAMLR decision rules where risk 1 refers to Rule 1 and risk 2 to Rule 2.

Assessment/Model Run	Variable	Reported value	Secretariat value	WG-FSA-2023 paper No
Subarea 48.3	B_0	110 386	110 386	15 Rev. 1
Casal2 final	Objective function	879	879	
	Risk 1	<0.01	<0.01	
	Risk 2	0.49	0.49	
Subarea 48.4	B_0	914	914	17
Run23	Objective function	14 939	14 939	18
	Risk 1		<0.01	
	Risk 2		0.19	
Division 58.5.1	B_0	203 372	203 372	67 Rev. 1
M2	Objective function	1 299	1 299	
	Risk 1		<0.01	
	Risk 2		0.33	
Division 58.5.2	B_0	66 343	66 343	26 Rev. 1
3b	Risk 1	<0.01	<0.01	
	Risk 2		0.50	
Ross Sea region	B_0	78 533	78 533	13
R3	Objective function	2 977	2 977	
	Risk 1	<0.01	<0.01	
	Risk 2	0.50	0.50	

Table 9: Template table to be included in Casal2 stock assessment reports for Secretariat verification purposes. The "Comments" column may contain justifications for expected differences with Secretariat verifications. MPD refers to the median of the posterior distribution.

Variable	Value	Comments
Proposed yield (t)	X	
B_0 (t)		
MPD	X	
MCMC median	X	
Total objective function value	X	
Risk 1	X.xx	
Risk 2	X.xx	

Table 10: Summary review schedule of proposed and ongoing research proposals under CM 21-02 and CM 24-01. New proposals submitted either under CM 21-02 or CM 24-01, paragraph 3 should be submitted by 1 June and reviewed by WG-SAM and WG-FSA. Ongoing proposals need to be notified each year by 1 June with proposals under CM 24-01 to be reviewed by WG-FSA annually and proposals under CM 21-02 to be reviewed by WG-FSA every other year. AUS – Australia, ESP – Spain, FRA – France, JPN – Japan, KOR – Korea, NZL – New Zealand, UKR – Ukraine, ZAF – South Africa, CHL – Chile.

CM	Project plan	Description	Member	Area	Fishing seasons	Years since approval	2023	2024	2025
24-01	WG-FSA-2021/34	New research plan for *Dissostichus* spp. under CM 24-01, paragraph 3 in Subarea 88.3 by Korea and Ukraine from 2021/22 to 2023/24	KOR, UKR	88.3	2021/2022-2023/2024	2	FSA		
24-01	WG-FSA-2022/41	Proposal to continue the time series of research surveys to monitor abundance of Antarctic toothfish (*Dissostichus mawsoni*) in the southern Ross Sea, 2022/23-2024/25: Research Plan under CM 24-01	NZL	88.1	2022/2023-2024/2025	1	FSA	FSA	
24-01	WG-FSA-2023/03	New Fishery Research Proposal Plan Under CM 24-01 Paragraph 3 to Continue the Acoustic-Trawl Survey *Champsocephalus gunnari* in the Statistical Subarea 48.2	UKR	48.2	2023/2024-2024/2025	Resubmitting in 2024	SAM FSA	To be determined	
24-01	WG-FSA-2023/36	New Fishery Research Proposal Plan for *Dissostichus* spp. under CM 24-01, paragraph 3, Subarea 48.2 during season 23/24 — 25/26	CHL	48.2	2023/2024-2025/2026	WG-FSA Suggested submit to WG-SAM 2024	SAM FSA	To be determined	To be determined
21-02	WG-SAM-2023/03	Continuing research in the *Dissostichus mawsoni* exploratory fishery in East Antarctica (Divisions 58.4.1 and 58.4.2) from 2022/23 to 2025/26; Research plan under CM21-02, paragraph 6(iii)	AUS, FRA, JPN, KOR, ESP	58.4.1	2022/2023-2025/2026	New	SAM FSA		FSA
21-02	WG-SAM-2023/03	Continuing research in the *Dissostichus mawsoni* exploratory fishery in East Antarctica (Divisions 58.4.1 and 58.4.2) from 2022/23 to 2025/26; Research plan under CM21-02, paragraph 6(iii)	AUS, FRA, JPN, KOR, ESP	58.4.2	2022/2023-2025/2026	1		FSA	
21-02	WG-FSA-2021/38	Revised proposal for continuing research on Antarctic toothfish (*Dissostichus mawsoni*) in Statistical Subarea 48.6 in 2021/22 from a multiyear plan (2021/22–2023/24): Research Plan under CM 21-02, paragraph 6(iii)	JPN, ZAF, ESP	48.6	2021/2022-2023/2024	2	FSA		

Table 11: Summary of the assessment of proposed and ongoing research plans and proposals under CM 21-02 and CM 24-01. AUS – Australia, ESP – Spain, FRA – France, JPN – Japan, KOR – Korea, NZL – New Zealand, UKR – Ukraine, ZAF – South Africa, TOA – *Dissostichus mawsoni*; n/a – not applicable. Section references refer to sections of the proposal listed in row 1 of the table.

Subarea/division:	48.6	58.4.1	88.1	88.3
Proposal:	WG-SAM-2023/01 Rev. 1	WG-SAM-2023/03 ** The research activity at Division 58.4.2 has been conducted in 2022/23 fishing season. So, this is the second year of an ongoing four-year plan with no significant change proposed for Division 58.4.2. Therefore, it is not required to be reviewed by WG-SAM and WG-FSA in 2023. This review table focuses on only Division 58.4.1.	WG-SAM-22/01 Rev. 1 WG-FSA-2022/41 Rev. 1 WG-SAM-2023/02	WG-SAM-2023/04 WG-FSA-2023/20 Rev. 1
Members:	JPN, ESP, ZAF	AUS, ESP, FRA, JPN, KOR	NZL	KOR, UKR
Conservation measure under which the proposal is submitted:	CM21-02	CM21-02	CM24-01	CM24-01
Time period:	2021/22–2023/24	2022/23–2025/26	2022/23–2024/25	2021/22–2023/24
Main species of interest:	TOA	TOA	TOA	TOA
Main purpose of the research (e.g. abundance, population structure, movement, …)	Abundance, population structure and distribution	Abundance, population structure and distribution	Population structure and distribution, monitoring of recruitment	Abundance, Stock structure, etc.
Is the purpose of the research linked to Commission or Scientific Committee priorities?	Y: section 1.a	Y: Section 1a	Y: sections 1a, 1b	Y: 1. Objective of the research plan (a)
1. Quality of the proposal				
1.1 Is there enough information to evaluate the likelihood of success of the research objectives?	Y: all of this proposal	Y: Sections 3a, 3b & 3c	Y: sections 3a-3d	Y: 1. Objective of the research plan (b)

(continued)

Table 11 (continued)

Subarea/division:	48.6	58.4.1	88.1	88.3
2. Research design				
2.1 Is the proposed catch limit in accordance with research objectives?	Y: section 3.d, 4.a, and 4.b	Y: Sections 4a and 4b	Y: sections 4a and 4b	Y: 3. Survey design, data collection and analysis (Proposed number of stations/hauls) 4. Proposed catch limits
2.2 Is the sampling design appropriate to achieve research objectives?	Y: section 3.b	Y: Section 3b (e.g., Report WG-SAM-2019 para. 6.6-6.7 and 6.11-6.13, and Table 1)	Y: section 3a	Y: 3. Survey design, data collection and analysis
2.3 Have the environmental conditions been thoroughly accounted for?	Y: section 3.b	Y: Appendix 2 Section b	Y: section 3a	Y: 3. Survey design, data collection and analysis (updated sea ice analysis)
3. Research capacity				
3.1 Have the research platforms demonstrated experience in:				
3.1.1 Conducting research/exploratory fishing following a research plan?	Y: section 5	Y	Y WG-SAM-11/16, WG-FSA-12/41, WG-SAM-13/32, WG-SAM-14/25, WG-FSA-14/51, WG-SAM-15/44, WG-SAM-16/14, WG-SAM-17/39, WG-FSA-17/57, WG-SAM-17/01, WG-SAM-18/10, WG-FSA-17/41, WG-SAM-19/03, SC-CAMLR-39/BG/28, WG-FSA-21/23, WGFSA-2022/40	Y: Research fishing by the *Greenstar* has occurred annually since 2016. *Marigold* joined in this research from 2020.
3.1.2 Collecting scientific data?	Y: section 5	Y: Section 5	Y: section 5, reference in Appendix 1, section 3.1.1	Y: 3. Survey design, data collection and analysis (b)

(continued)

Table 11 (continued)

Subarea/division:	48.6	58.4.1	88.1	88.3
3.2 Do the research platforms have acceptable tag detection and survival rates?	Y: WG-FSA-17/36 and WG-FSA-2019 report (Figure 7). *Shinsei-maru No. 8* is a new vessel, same gear and crew that the withdrawn *Shinsei-maru No.3*.	The vessels *Antarctic Discovery* and *Tronio* have good tagging performance (WG-FSA-17/36). The vessel *Kingstar* had a tag detection of 1 and no tag survival performance estimated (WG-FSA-17/36), however this vessel released 22 recaptures of a total 56 recaptures in Divisions 58.4.1 and 58.4.2 between 2015-2020. The vessel *Antarctic Aurora* has not had their tagging performances calculated but recaptured tagged fish before in this area, and the *Shinsei-Maru No. 8* started fishing in 2021 in Subareas 88.1 and 48.6 with the same crew and fishing gear as the *Shinsei-Maru No.3*. The vessel *Southern Ocean* started toothfish fishing in the Ross Sea in 2021/22 and has not had the tagging performances calculated. The vessels *Cap Kersaint* and *Sainte Rose* have tagging experience from fishing in Division 58.5.1 and not had the tagging performances calculated.	Y: WG-FSA-17/36 (*San Aotea II*: survival =0.83, detection =1.0; *Janas*: survival=0.76, detection =1.0; *San Aspiring*: survival=1.0, detection = 1.0) *Janas* and *San Aotea II* have been active in the Ross Sea fishery since 1999 and the *San Aspiring* since 2005.	Y: WG-FSA-17/36 *Greenstar* which do not have their tagging performances calculated but have had tag recaptures before in this area.
3.3 Have the research teams sufficient resources and capacity for:				
3.3.1 Sample processing?	Y: section 1.c	Y: section 3b	Y: section 3b	Y: 3. Survey design, data collection and analysis

(continued)

Table 11 (continued)

Subarea/division:	48.6	58.4.1	88.1	88.3
3.3.2 Data analyses?	Y: section 1.c	Y: table 5	Y: Sections 3c, 3d WG-SAM-11/16, WG-FSA-12/41, WG-SAM-13/32, WG-SAM-14/25, WG-FSA-14/51, WG-SAM-15/44, WG-SAM-16/14, WG-SAM-17/39, WG-FSA-17/57, WG-SAM-17/01, WG-SAM-18/10, WG-FSA-17/41, WG-SAM-19/03, SC-CAMLR-39/BG/28, WG-SAM-2021/23, WG-FSA-2022/40	Y: 3. Survey design, data collection and analysis
4. Data analyses to address the research questions				
4.1 Are the proposed methods appropriate?	Y: section 1.a and 3.c	Y: section 3c	Y: section 3c	Y
5. Impact on ecosystem and harvest species				
5.1 Is the catch limit proposed consistent with Article II of the Convention?	Y: section 3.d, 4.a, and 4.b	Y: section 4a and 4b	Y: sections 4a and 4b	The proposed catch limits are planned to be updated during WG-FSA-23, reflecting the data collected in 2021/22 season.
5.2 Are the impacts on dependent and related species accounted for and consistent with Article II of the Convention?	Requires more analysis on by-catch populations, see WG-SAM-2019/09 (WG-FSA-2019 report Table 8): section 3.b	Y: Figure 1, Section 4c	Y: Sections 4b, 4c, Appendix 3 SC-CAMLR-39-BG- 03, SC-CAMLR-39-BG-28	Y

(continued)

Table 11 (continued)

Subarea/division:	48.6	58.4.1	88.1	88.3
6. Progress towards objectives for ongoing proposals				
6.1 Have the past and current milestones been completed?	Y: Section 1.c, and WG-FSA-2019/23 Rev. 1 Appendix 1	Y: Table 5, Section 1c	Y WG-SAM-11/16, WG-FSA-12/41, WG-SAM-13/32, WG-SAM-14/25, WG-FSA-14/51, WG-SAM-15/44, WG-SAM-16/14, WG-SAM-17/39, WG-FSA-17/57, WG-SAM-17/01, WG-SAM-18/10, WG-FSA-17/41, WG-SAM-19/03, SC-CAMLR-39/BG/28, WG-FSA-21/23, WG-SAM-2022/13, WG-FSA-2022/40, see Appendix 2.	Y: Appendix 1 (Vessel calibration still outstanding)
6.2 Has previous advice from the Scientific Committee and its working groups been addressed?	Y: WG-FSA-2019 report, para 4.58	Y: Report WG-FSA-2019 para. 4.91	Y	Y
6.3 Are all the objectives likely to be completed by the end of the research plan?	Y: Table 1	Completion of research objectives is conditional on the continuation of the exploratory fishing activities in Division 58.4.1.	Y	Y
6.4 Are there any other concerns?	N	N	N	N

Table 12. Annual percentage of skates released by depth range (m) in the Ross Sea region, using the survivorship estimates from Endicott & Agnew (2004) shown as bolded percentages for those depths.

Season	< 1300	1300–1500	> 1500	No. released	Estimated survivorship
Survivorship	**75%**	**46%**	**24%**		
2003	81	16	3	966	0.69
2004	92	8		1 852	0.73
2005	78	22		5 057	0.69
2006	74	25	1	14 698	0.67
2007	75	22	3	7 336	0.67
2008	82	17	1	7 190	0.70
2009	87	11	1	7 088	0.71
2010	87	11	2	6 796	0.71
2011	91	9	0	5 440	0.72
2012	80	20		2 238	0.69
2013	86	13	1	5 675	0.71
2014	96	4		5 534	0.74
2015	90	8	2	12 978	0.72
2016	72	26	2	6 016	0.66
2017	81	19	0	3 857	0.69
2018	74	25	1	5 924	0.67
2019	83	16	1	8 870	0.70
2020	86	13	1	15 620	0.71
2021	71	27	2	9 490	0.66
2022	83	16	1	15 654	0.70
2023	91	9	0	8 461	0.72

Table 13: Intersessional work plan for WG-FSA. Items tasked to WG-FSA from the Scientific Committee Strategic Plan (SC-CAMLR-41, Table 8). Numbers refer to the numbering in the original tables. DSAG – Data Services Advisory Group, SISO – Scheme of International Scientific Observation, AUS – Australia, CHN – People's Republic of China, ESP – Spain; FRA – France, JPN – Japan, KOR – Republic of Korea, NZ – New Zealand, ZAF – South Africa, UK – United Kingdom, USA – United States.

Theme	Priority research topic	Priority research topic task	Timeframe	Contributors	Secretariat participation
1. Target species	(a) Develop methods to estimate total fish by-catch for the krill fishery	(iii) Data collection – SISO, vessels Priority: High	2024-2025	Secretariat	Yes
	(b) Develop stock assessments to implement decision rules for krill	(i) Krill management approach (synthesis of krill recruitment, spatial scale, biomass estimates, predator risk) Priority: High (1) Subarea 48.1 (2023) Priority: High (2) Other areas (48.2 and 48.3) Priority: High	2024-2025	WG-ASAM-2024/ WG-EMM-2024	Yes
		(ii) Methods to account for uncertainty in stock status Priority: Low			
		(iii) Develop krill management approach as a multiannual cycle Priority: Medium	Upon completion of (i)		
		(iv) Krill management strategies that are robust to climate change Priority: Low	2027	WG-SAM-2027/ WG-EMM-2027	Yes
	(c) Develop methods to estimate biomass for finfish	(i) Data collection – SISO and vessels Priority: High			
		(1) Conversion factors Priority: mostly done	2024	Secretariat, FRA and NZ	Yes
		(2) Tagging protocols Priority: done	2023	Dr Jones/Mr Arangio	Yes
		(3) Ross Sea data collection program Priority: Medium	2024–2028	All involved Members (NZ Lead)	Yes

(continued)

Table 13 (continued)

Theme	Priority research topic	Priority research topic task	Timeframe	Contributors	Secretariat participation
		(ii) Accounting for potential spatial bias in assessments. Priority: Urgent	2024–2025	WG-SAM 2024 and Members	
	(d) Develop stock assessments to implement decision rules for finfish	(i) Research to develop new assessments Priority: Low		WG-SAM	
		(1) Research plan evaluations Priority: Required	Annual	WG-SAM/WG-FSA	Yes
		(2) Subarea 88.2 fishery structure Priority: Low	2027 2023–2027	(NZ lead) All involved Members	Yes
		(3) Stock structure and connectivity (cross ref modelling of spatial structure, done in Areas 48, 58 and Subareas 88.1 and 88.2) Priority: Low		JPN/NZ/CHN/KOR/USA Members	Yes
		(ii) Develop new assessment tools			
		(1) Casal2 development Priority: done	2023–2025	NZ/All involved Members	
		(2) Casal2 data limited assessment. Priority: high	2024	ZAF, ESP, JPN and other Members	Yes
		(iii) Provide precautionary catch limits Priority: Required	Annual	WG-FSA regular updates	Yes
		(iv) Developing sex disaggregated assessment models for areas with combined sex assessments Priority: Medium	2026	Members	

(continued)

Table 13 (continued)

Theme	Priority research topic	Priority research topic task	Timeframe	Contributors	Secretariat participation
	(e) Management strategy evaluations for target species (Second Performance Review, Recommendation 8 independent review)	(ii) Development and testing of data-limited fishery decision rules Priority: Medium	2024–2025	Interested Members (WG-FSA-2024, paragraph 4.67)	Yes
		(iii) Finfish management strategies that are robust to climate change Priority: Urgent	2024	AUS/NZ/UK Interested Members	Yes
		(iv) Analysis of current and alternative decision rules Priority: High (see also WG-SAM-2023 Table 1, theme 1, task (e)(i))	2024	Members and WG-SAM-2024	Yes
	(f) Refine stock assessment procedures	i) Improve methods for inclusion of ageing data, e.g.: • Determining the CVs on the age compositions and effective sample sizes Priority: Medium • Determining the effect of different target levels of precision for age determination, Priority: Medium	2024-2025	Members	
		ii) Incorporating environmental and ecosystem parameters in toothfish population models Priority: Medium	2024-2025		
		iii) Investigate the impact of covarying productivity parameters. Priority: Medium	2026-2027		

(continued)

Table 13 (continued)

Theme	Priority research topic	Priority research topic task	Timeframe	Contributors	Secretariat participation
		iv) Continuing development of stock assessment diagnostics Priority: ongoing	2026-2027		
		v) Developing methods to validate and pool multimember age data Priority: ongoing	2026-2027		
2. Ecosystem impacts	(a) Ecosystem monitoring (Second Performance Review, Recommendation 5)	(i) Structured ecosystem monitoring programs (CEMP, fishery) (2) Fishery via SISO Priority: Medium (3) Research surveys Priority: Low (iii) Invasive species Priority: Low		Regular monitoring Members fishing under CM-24-01 Surveys	Yes
	(c) By-catch risk assessment for krill and finfish fisheries	(i) Monitoring status and trends Priority: High	Annual	Secretariat	
		(ii) By-catch species catch limits Priority: High	2026	Members	
		(iii) Review of by-catch decision rules Priority: Medium	2027		
		(iv) By-catch mitigation methods Priority: Low	2026	Members	
	(d) Habitat protection from fishing impacts	(i) Habitat classification, bio-regionalisation and monitoring Priority: Low			
		(ii) VME identification and management Priority: Low	2025	Members	Yes

(continued)

Table 13 (continued)

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

(continued)

Table 13 (continued)

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

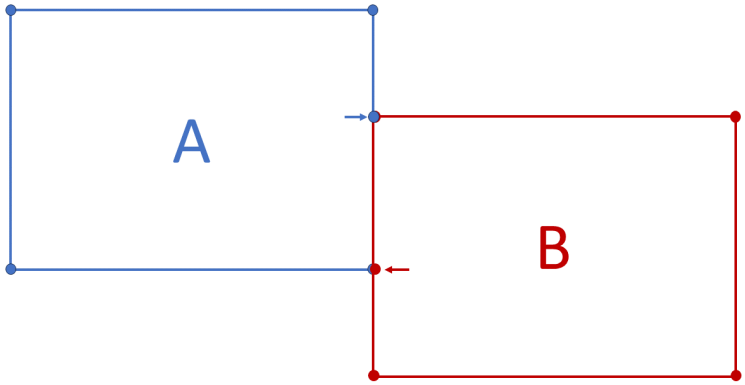


Figure 1. Polygons A and B are each defined by four vertices and an additional vertex at the extremity of their shared edge (arrow).

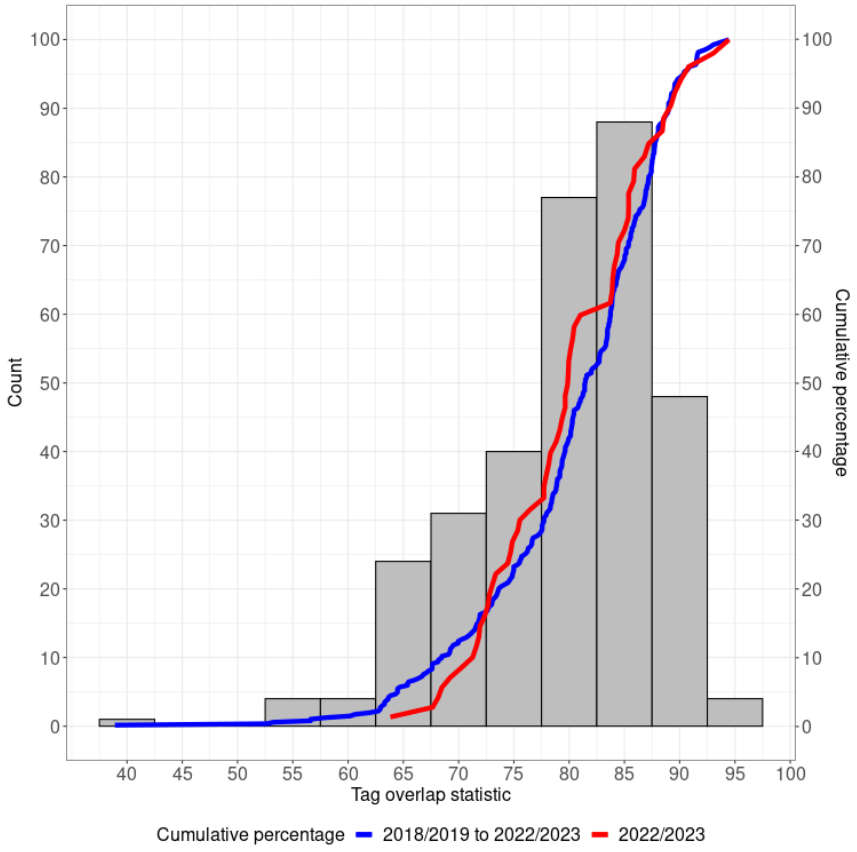


Figure 2: Histogram of the tag overlap statistics calculated as specified in CM 41-01 (2022) for CCAMLR seasons 2018/2019 to 2022/2023. The overlap statistic was calculated when more than 30 TOP or 30 TOA were tagged for all areas for which a catch limit is assigned. An overlap statistic below 60 does not necessarily imply a compliance issue, as the spatial distribution to which the tag overlap should to be applied was modified in CM 41-01 during 2022. The figure also shows cumulative percentage of the fishing trips which achieved a given value for the tag overlap statistic (blue – seasons 2018/2019 to 2022/2023 and red – season 2022/2023 only).

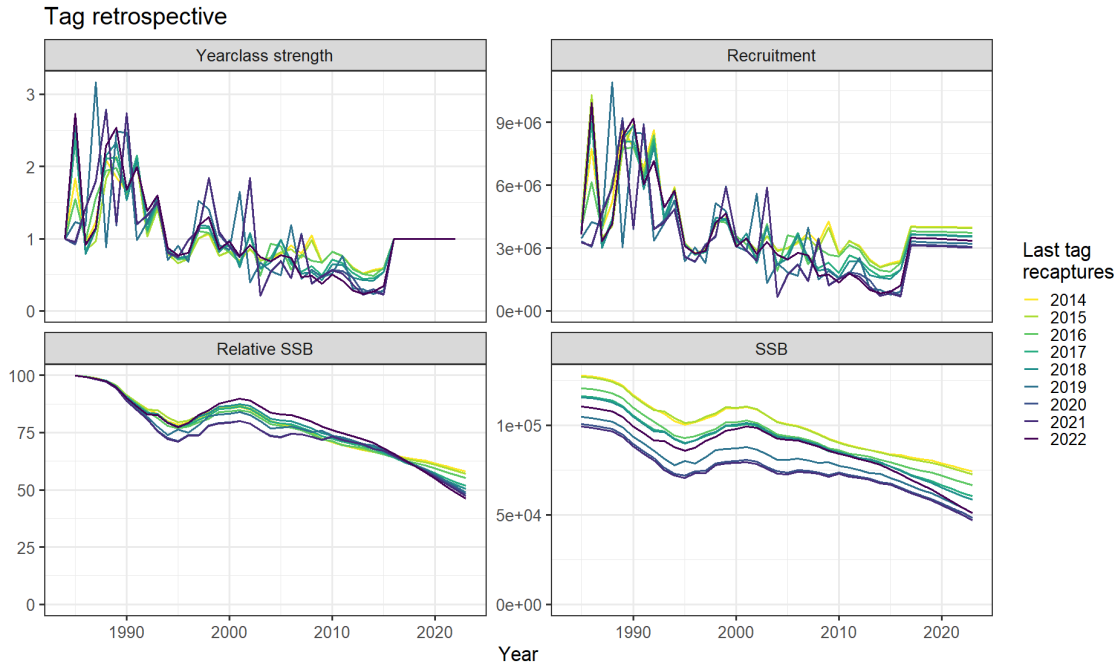


Figure 3: Estimated year class strength, recruitment, relative spawning stock biomass and spawning stock biomass, from the tagging retrospective analysis for the *D. eleginoides* stock assessment in Subarea 48.3 where tagging data were removed year-by-year from the 2023 stock assessment. Note that the 2023 stock assessment used tag recapture data up to 2022.

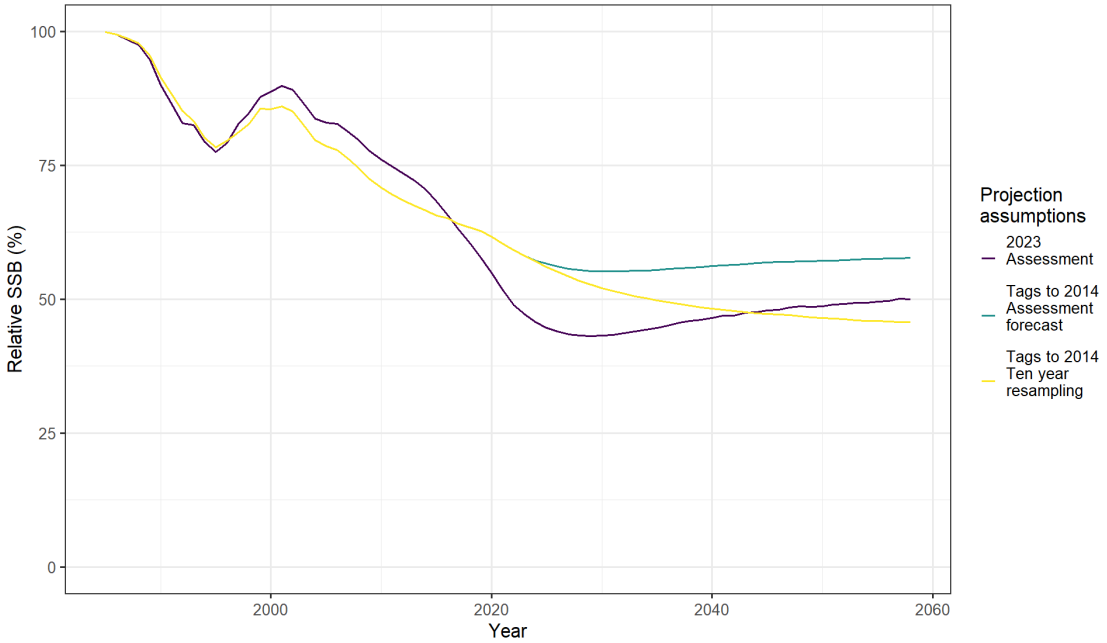


Figure 4: Maximum of the posterior distribution (MPD) from the toothfish stock assessment in WG-FSA-2023/15 Rev. 1 and median projection forward applying a 0.85 multiplier to the lognormal-empirical distribution from 1993-2016 estimated year class strength time series (purple line) for *D. eleginoides* in Subarea 48.3, and the retrospective run with tagging data up to 2014 and median projection forward with the same recruitment assumption as in WG-FSA-2023/15 Rev. 1 (green line) and resampling the last ten years of estimated recruitment (yellow line). All projections assume the proposed catch limit of 2 000 tonnes and 98 tonnes of depredation from WG-FSA-2023/15 Rev.1.

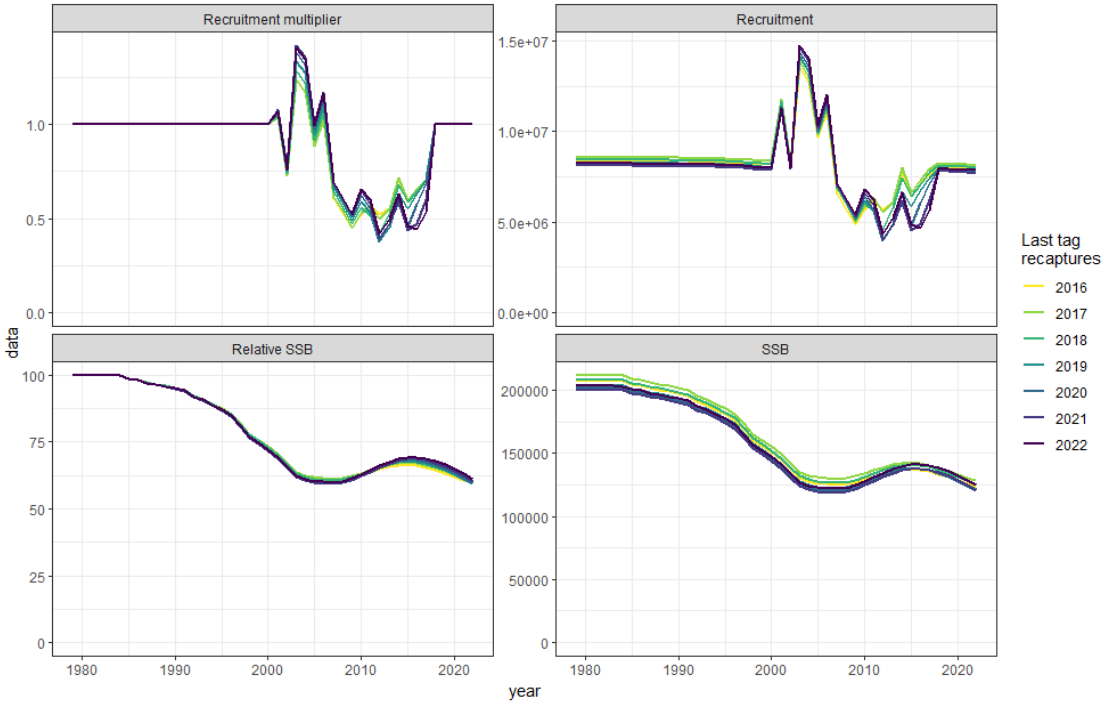


Figure 5: Estimated recruitment multiplier, recruitment, relative spawning stock biomass and spawning stock biomass from the tagging retrospective analysis for *D. eleginoides* in Division 58.5.1 where tagging data were removed year-by-year from the 2023 stock assessment. Note that the 2023 assessment used tag recapture data up to 2022.

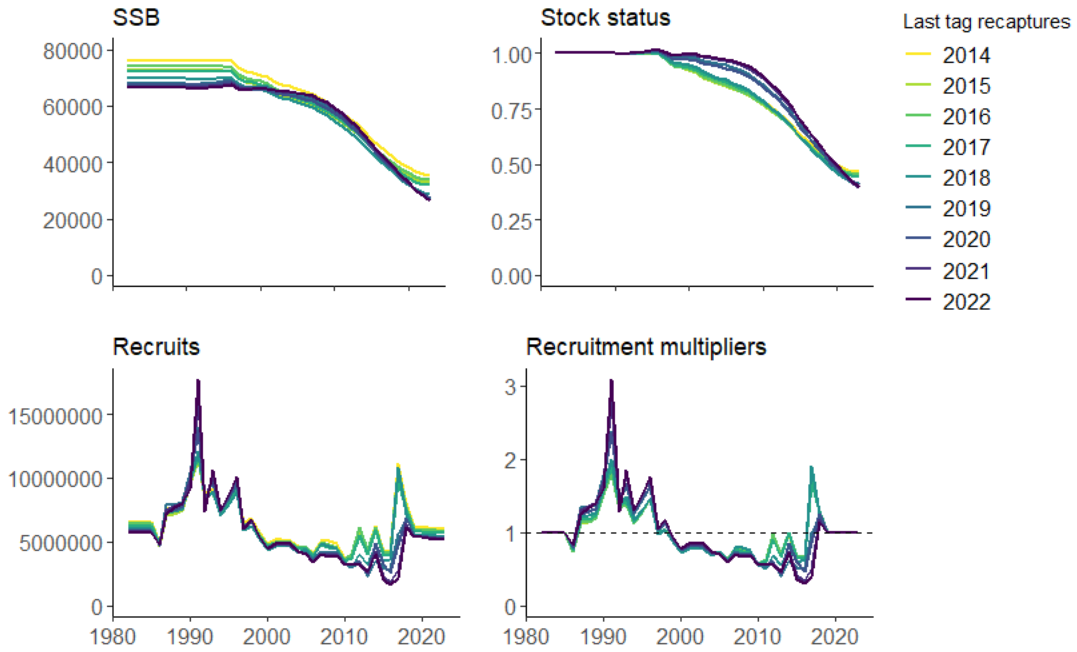


Figure 6: Estimated spawning stock biomass, relative spawning stock biomass (stock status), recruitment and recruitment multipliers from the tagging retrospective analysis for the *D. eleginoides* stock assessment in Division 58.5.2 where tagging data were removed year-by-year from the 2023 stock assessment. Note that the 2023 stock assessment used tag recapture data up to 2022.

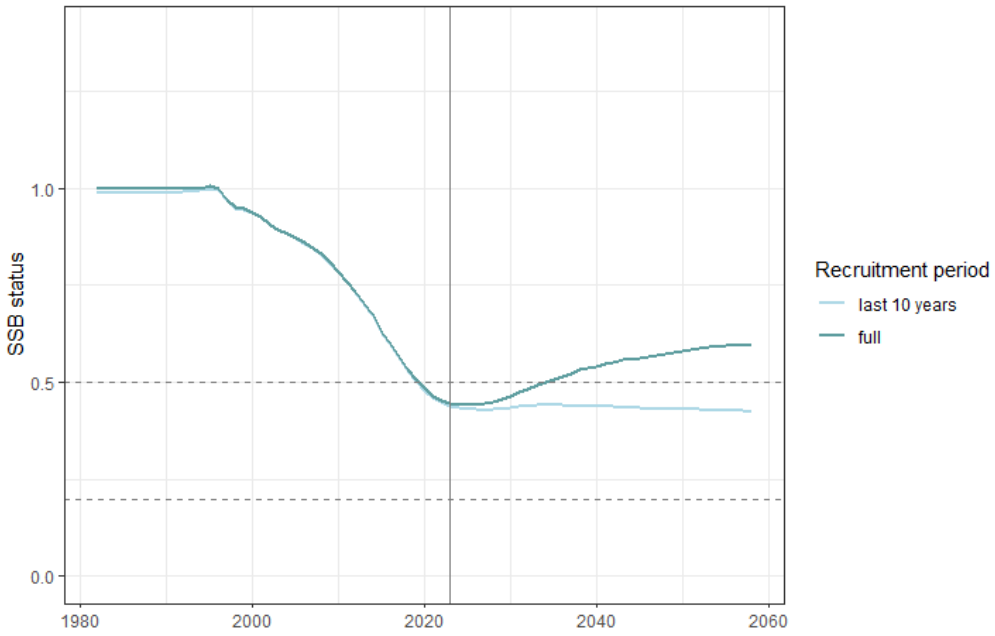


Figure 7: Maximum of the posterior distribution (MPD) of the retrospective run with tagging data up to 2018 and median projection forward with the catch limit of 2 660 tonnes proposed by WG-FSA-2023/26 Rev. 1 and recruitment sampled from either the full estimated recruitment time series (1986-2017) or from only the last 10 years of estimated recruitment (2008-2017) for *D. eleginoides* in Division 58.5.2.

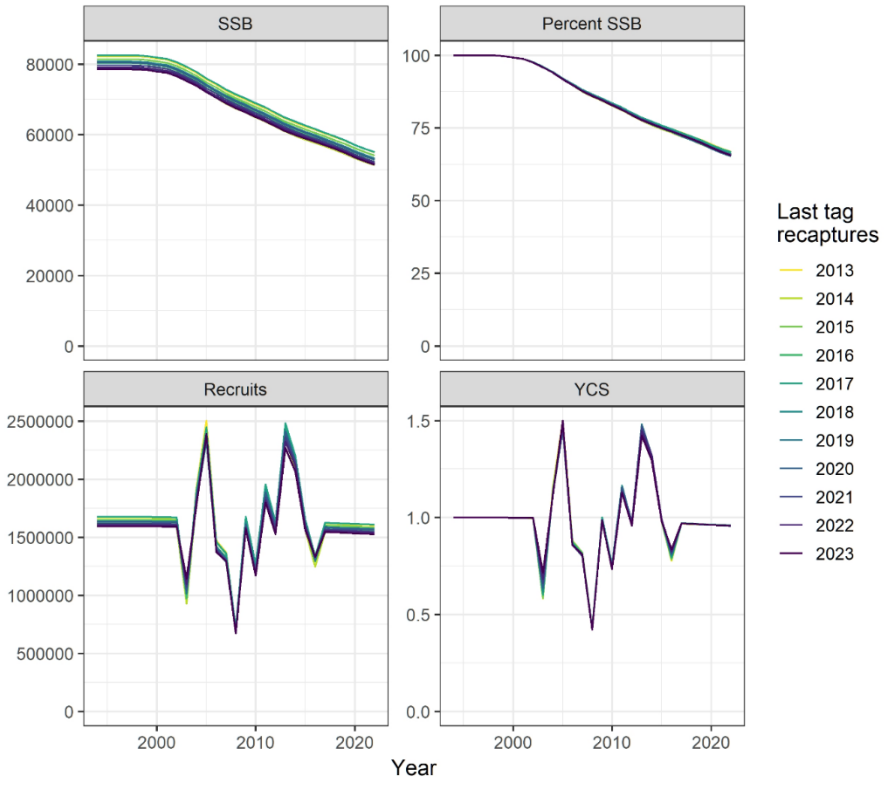


Figure 8: Estimated spawning stock biomass, percent spawning stock biomass, recruitment, and relative year class strength from the tagging retrospective analysis for *D. mawsoni* in Subareas 88.1 and 88.2AB where tagging data were removed year-by-year from the 2023 stock assessment.

Appendix A

List of Participants

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

Convener	Mr Sobahle Somhlaba Department of Agriculture, Forestry and Fisheries
Argentina	Dr Marco Favero National Research Council (CONICET, Argentina)
	Dr Germán Lukaszewicz Instituto Nacional de Investigación y Desarrollo Pesquero (INIDEP)
	Dr María Inés Militelli CONICET-INIDEP
	Dr Eugenia Moreira Instituto Antártico Argentino / CONICET
	Dr Emilce Florencia Rombolá Instituto Antártico Argentino
	Dr María Mercedes Santos Instituto Antártico Argentino
Australia	Dr Jaimie Cleeland Institute for Marine and Antarctic Studies (IMAS), University of Tasmania
	Ms Danait Ghebrezgabhier Australian Fisheries Management Authority
	Dr So Kawaguchi Australian Antarctic Division, Department of Climate Change, Energy, the Environment and Water
	Mr Dale Maschette Institute for Marine and Antarctic Studies (IMAS), University of Tasmania
	Dr Cara Masere Australian Antarctic Division, Department of Climate Change, Energy, the Environment and Water

	Dr Dirk Welsford Department of Climate Change, Energy, the Environment and Water
	Dr Philippe Ziegler Australian Antarctic Division, Department of Climate Change, Energy, the Environment and Water
Belgium	Ms Zephyr Sylvester University of Colorado Boulder
Chile	Dr César Cárdenas Instituto Antártico Chileno (INACH)
	Mr Mauricio Mardones Instituto de Fomento Pesquero | Universidad de Magallanes
	Dr Juan Carlos Quiroz Espinosa AOBAC - Asociación Gremial de Operadores de Bacalao de Profundidad de Magallanes
China, People's Republic of	Mr Hongliang Huang East China Sea Fisheries Research Institute, Chinese Academy of Fishery Science
	Dr Yi-Ping Ying Yellow Sea Fisheries Research Institute
	Ms Haiting Zhang Shanghai Ocean University, IMAS, University of Tasmania
	Mr Jiancheng Zhu Yellow Sea Fisheries Research Institute, Chinese Academy of Fishery Science
	Professor Guoping Zhu Shanghai Ocean University
European Union	Dr Sebastián Rodríguez Alfaro European Union
France	Dr Marc Eléaume Muséum national d'Histoire naturelle
	Dr Pierre Feutry CSIRO

	Ms Maude Jolly Ministère de la Transition Ecologique
	Dr Félix Massiot-Granier Muséum national d'Histoire naturelle
	Ms Fanny Ouzoulias Muséum national d'Histoire naturelle
Germany	Professor Bettina Meyer Alfred Wegener Institute for Polar and Marine Research
Japan	Dr Takehiro Okuda Fisheries Resources Institute, Japan Fisheries Research and Education Agency
	Dr Kota Sawada Fisheries Resources Institute, Japan Fisheries Research and Education Agency
Korea, Republic of	Mr Hyun Joong Choi TNS Industries Inc.
	Dr Sangdeok Chung National Institute of Fisheries Science (NIFS)
	Mr Taebin Jung TNS Industries
	Professor Hyun-Woo Kim Pukyoung National University
	Dr Eunjung Kim National Institute of Fisheries Science
	Dr Chi Hin Lam Large Pelagics Research Center
	Professor Hyuk Je Lee Sangji University
	Mr Jeongseok Park National Institute of Fisheries Science
	Mr Sang Gyu Shin National Institute of Fisheries Science (NIFS)
New Zealand	Dr Clare Adams Ministry for Primary Industries

	Dr Jennifer Devine National Institute of Water and Atmospheric Research Ltd. (NIWA)
	Mr Alistair Dunn Ocean Environmental
	Mr Jack Fenaughty Silvifish Resources Ltd
	Mr Nathan Walker Ministry for Primary Industries
Norway	Mr James Clark MRAG
	Dr Ulf Lindstrøm Institute of Marine Research
South Africa	Mrs Melanie Williamson Capricorn Marine Environmental (CapMarine)
Spain	Dr Takaya Namba Pesquerias Georgia, S.L
	Mr Joost Pompert Pesquerias Georgia, S.L
	Mr Roberto Sarralde Vizuete Instituto Español de Oceanografía
Ukraine	Dr Kostiantyn Demianenko Institute of Fisheries and Marine Ecology (IFME) of the State Agency of Melioration and Fisheries of Ukraine
	Dr Leonid Pshenichnov Institute of Fisheries and Marine Ecology (IFME) of the State Agency of Melioration and Fisheries of Ukraine
	Mr Illia Slypko Institute of Fisheries and Marine Ecology (IFME) of the State Agency of Fisheries of Ukraine
United Kingdom	Dr Mark Belchier British Antarctic Survey
	Dr Martin Collins British Antarctic Survey

	Dr Timothy Earl Centre for Environment, Fisheries and Aquaculture Science (Cefas)
	Dr Phil Hollyman British Antarctic Survey
	Dr Jessica Marsh Centre for Environment, Fisheries and Aquaculture Science (Cefas)
	Ms Lisa Readdy Centre for Environment, Fisheries and Aquaculture Sciences (Cefas)
	Ms Georgia Robson Centre for Environment, Fisheries and Aquaculture Science (Cefas)
United States of America	Dr Jefferson Hinke National Marine Fisheries Service, Southwest Fisheries Science Center
	Dr Christopher Jones National Oceanographic and Atmospheric Administration (NOAA)
	Dr George Watters National Marine Fisheries Service, Southwest Fisheries Science Center
CCAMLR Secretariat	Dr Steve Parker Science Manager
	Isaac Forster Fisheries and Observer Reporting Coordinator
	Dr Stéphane Thanassekos Fisheries and Ecosystem Analyst
	Daphnis De Pooter Science Data Officer

Appendix B

Agenda

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

1. Opening of the meeting
    1.1 Introduction
    1.2. Adoption of the agenda
    1.3 Review of terms of reference and the work plan
2. Review of CCAMLR fisheries in 2022/2023 and notifications for 2023/2024
3. Krill
4. Fish
    4.1 Area 48
        4.1.1 *Champsocephalus gunnari* in Subarea 48.3
        4.1.2 Icefish research survey proposal in Subarea 48.2
        4.1.3 *Dissostichus eleginoides* in Subarea 48.3
        4.1.4 *Dissostichus eleginoides* in Subarea 48.4
        4.1.5 *Dissostichus mawsoni* in Subarea 48.4
        4.1.6 Research plans targeting *D. mawsoni* in area 48 notified under CM 21-02 or CM 24-01
    4.2 Area 58
        4.2.1 *Champsocephalus gunnari* in Division 58.5.2
        4.2.2 *Dissostichus eleginoides* in Division 58.5.1
        4.2.3 *Dissostichus eleginoides* in Division 58.5.2
        4.2.4 *Dissostichus eleginoides* in Division 58.6
        4.2.5 Research plans in area 58 notified under CM 21-02

4.3 Area 88

4.3.1 Subarea 88.1 and SSRUs 882AB - *D. mawsoni* in the Ross Sea region

4.3.2 Subarea 88.2

4.3.3 Subarea 88.3

5. By-catch

5.1 By-catch management in krill fisheries

5.2 By-catch management in toothfish fisheries

5.3 VME management

6. Scheme of International Scientific Observation

7. Future work

8. Other business

9. Advice to the Scientific Committee

10. Adoption of the report and close of meeting

Appendix C

List of Documents

Working Group on Fish Stock Assessment
(Hobart, Australia, 2 to 13 October 2023)

WG-FSA-2023/01	Advances in reducing the interaction with Killer whales and Sperm whales, in the Patagonian Toothfish fishery in CCAMLR subarea 58.7: application of the SAGO Extreme capture system Delegation of Uruguay
WG-FSA-2023/02	Update of the ´SAGO EXTREME` fishing system on the ´Patagonian toothfish` *Dissostichus* eleginoides fishery Delegation of Uruguay
WG-FSA-2023/03	New Fishery Research Proposal Plan Under CM 24-01 Paragraph 3 to Continue the Acoustic-Trawl Survey *Champsocephalus gunnari* in the Statistical Subarea 48.2 Delegation of Ukraine
WG-FSA-2023/04	Improving identification of fish bycatch in the Antarctic krill fishery Delegation of the United Kingdom
WG-FSA-2023/05	2023 trend analysis: Estimates of toothfish biomass in Research Blocks CCAMLR Secretariat
WG-FSA-2023/06	CCAMLR fishery data forms and manuals development status CCAMLR Secretariat
WG-FSA-2023/07 Rev. 2	Implementation of the CCAMLR Scheme of International Scientific Observation during 2022/23 CCAMLR Secretariat
WG-FSA-2023/08	Core processes illustrations in support of the proposed Agent-Based Modelling framework (WG-SAM-2023/17) CCAMLR Secretariat
WG-FSA-2023/09	2023 Ross Sea shelf survey results Devine, J. and C. Péron
WG-FSA-2023/10	A preliminary assessment for mackerel icefish (Champsocephalus gunnari) in Division 58.5.2, based on results from the 2023 random stratified trawl survey Maschette, D.

WG-FSA-2023/11	Age and growth of the subantarctic skates *Bathyraja eatonii* and B. irrasa in Kerguelen and Amblyraja taaf in Crozet through the use of the vertebrae centrum Faure, J. and C. Péron
WG-FSA-2023/12	Antarctic toothfish (*D. Mawsoni*) age determination Misar, N.
WG-FSA-2023/13	Assessment model for Antarctic toothfish (*Dissostichus mawsoni*) in the Ross Sea region to 2022/23 Mormede, S., A. Grüss, A. Dunn and J. Devine
WG-FSA-2023/14	Casal2 Stock Assessment for Antarctic krill in CCAMLR Subarea 48.1 Kinzey, D. and G.M. Watters
WG-FSA-2023/15 Rev. 1	Assessment of Patagonian Toothfish (*Dissostichus eleginoides*) in Subarea 48.3 Earl, T. and L. Readdy
WG-FSA-2023/16	Assessment of Patagonian Toothfish (*Dissostichus eleginoides*) in Subarea 48.3: Assessment Diagnostics Earl, T. and L. Readdy
WG-FSA-2023/17	Assessment of Patagonian Toothfish (*Dissostichus eleginoides*) in Subarea 48.4 Readdy, L. and T Earl
WG-FSA-2023/18	Assessment of Patagonian Toothfish (*Dissostichus eleginoides*) in Subarea 48.4: Assessment Diagnostics Readdy, L. and T. Earl
WG-FSA-2023/19	Characterisation of the toothfish fishery in the Ross Sea region (Subarea 88.1 and SSRUs 882A–B) through 2022/23 Devine, J.A. and S. Mormede
WG-FSA-2023/20	Continuing research plan for *Dissostichus* spp. under CM 24-01, paragraph 3 in Subarea 88.3 by Korea and Ukraine from 2021/22 to 2023/24 Delegations of the Republic of Korea and Ukraine
WG-FSA-2023/21 Rev. 1	Detection by an albatross sentinel of a vessel probably engaged in IUU activity in 2019 over Banzare Bank, subarea 58.4.3b Collet, J., K. Delord, B. Guilloux, A.-S. Bonnet-Lebrun, C. Péron, A. Corbeau, A. Pajot, C. Barbraud and H. Weimerskirch

WG-FSA-2023/22	Diagnostic plots for the 2023 assessment for Ross Sea region Antarctic toothfish (*Dissostichus mawsoni*) Mormede, S., A. Grüss, A. Dunn and J.A. Devine
WG-FSA-2023/23	Diagnostic plots for the 2023 assessment model for the Crozet Islands EEZ Patagonian toothfish (*Dissostichus eleginoides*) fishery in Division 58.6 Massiot-Granier, F., F. Ouzoulias and C. Péron
WG-FSA-2023/24 Rev. 1	Diagnostic plots for the 2023 assessment model for the Kerguelen Island EEZ Patagonian toothfish (*Dissostichus eleginoides*) fishery in Division 58.5.1 Massiot-Granier, F., F. Ouzoulias and C. Péron
WG-FSA-2023/25	Diet composition and feeding strategy of Antarctic toothfish, Dissostichus mawsoni in Subareas 88.1 and 88.3 in the 2022/23 fishing season Baeck, G.W., S. Chung and J. Park
WG-FSA-2023/26 Rev. 1	Draft integrated stock assessment for the Heard Island and McDonald Islands Patagonian toothfish (*Dissostichus eleginoides*) fishery in Division 58.5.2 Masere, C. and P. Ziegler
WG-FSA-2023/27	Estimates of biomass and catch limits for macrourids on the continental slope of the Ross Sea region (Subarea 88.1 and SSRUs 88.2AB) Devine, J., S. Parker, A. Dunn, R. O'Driscoll, and M. Pinkerton
WG-FSA-2023/28	Exploring SSBs responses to different recruitment scenarios and SSB0 calculations in a context of regime shift: a Kerguelen Patagonian toothfish fishery case study Ouzoulias, F., C. Péron and F. Massiot-Granier
WG-FSA-2023/29	Fish nest area in the southern Weddell Sea. Discussions and recommendations from WG-EMM-2023 Teschke, K., R. Konijnenberg, P. Brtnik, L. Ghigliotti and M. Eléaume
WG-FSA-2023/30	Fishery characterisation for Antarctic toothfish (*Dissostichus mawsoni*) and Patagonian toothfish (*D. eleginoides*) around the South Sandwich Islands (Subarea 48.4) Marsh, J., T. Earl, A. Riley and L. Readdy
WG-FSA-2023/31	Fishery characterisation for Patagonian toothfish (*Dissostichus eleginoides*) around South Georgia (Subarea 48.3): 2023 update Marsh, J. and T. Earl

WG-FSA-2023/32 Rev. 1	Identification traits for the grenadiers *Macrourus caml* and *M. whitsoni* for onboard observer's use with preliminary attempt in Subarea 88.3 Chung, S., M-J. Seo and J-K. Kim
WG-FSA-2023/33	Improved VAST (vector autoregressive spatio-temporal) modelling of grenadier relative abundance in Subarea 48.6 Sawada, K. and T. Okuda
WG-FSA-2023/34	Intra- and Inter-annual Variability in Seasonal Sea Ice and Krill Fishery in Subareas 48.1 and 48.2 Shnar V. and S. Kasatkina
WG-FSA-2023/35	Length at maturity of the subantarctic skates *Bathyraja eatonii* and *B. irrasa* in Kerguelen and *Amblyraja taaf* in Crozet Faure, J. and C. Péron
WG-FSA-2023/36	New Fishery Research Proposal Plan for Dissostichus spp. under CM 24-01, paragraph 3, Subarea 48.2 during season 23/24 — 25/26 Delegation of Chile
WG-FSA-2023/37 Rev. 1	Population structure of Antarctic toothfish, *Dissostichus mawsoni* from Areas 58 and 88 in the Antarctic Ocean using microsatellites and genome-wide SNPs Choi, H., H. Park, S. Chung, J. Park, D. Maschette and H.J. Lee
WG-FSA-2023/38	Preliminary assessment of mackerel icefish (*Champsocephalus gunnari*) in Subarea 48.3 based on the 2023 Groundfish Survey Marsh, J. and T. Earl
WG-FSA-2023/39	Preliminary tag-recapture based population assessment of Antarctic toothfish (*Dissostichus mawsoni*) in Subarea 48.4 - 2023 fishing season Marsh, J., L. Readdy, A. Riley and T. Earl
WG-FSA-2023/40	Quantifying post-release survival of skate bycatch in the HIMI Patagonian Toothfish longline fishery Appert, C., S. Tracey, C. Peron, C. Masere, P. Ziegler and J.B. Cleeland
WG-FSA-2023/41	Recent indicative trends in by-catch of sharks in the CAMLR Convention Area C.D. Jones
WG-FSA-2023/42	Report of research fishing operations at Subarea 48.6 between the 2012/13 and 2022/23 fishing seasons Delegations of Japan, Spain, and South Africa

WG-FSA-2023/43 Rev. 1	Report of the co-conveners of the Age Determination Workshop Hollyman, P. and J. Devine
WG-FSA-2023/44	Report of the Groundfish Survey at South Georgias Islands (CCAMLR- Subarea 48.3) in 2023 Delegation of Argentina
WG-FSA-2023/45 Rev. 1	Report of the UK Groundfish Survey at South Georgia (CCAMLR Subarea 48.3) in February 2023 Hollyman, P., S.L. Hill, C. Gunn, P. Keith, B. Rodriguez and M.A. Collins
WG-FSA-2023/46	Report on Argentina´s CCAMLR Subarea 48.3 survey: fish Ruocco, N.L., G. Lukaszewicz, E. Aguilar, B. Fusaro, S. Barbini, D. Figueroa and G.A. Colombo
WG-FSA-2023/47	Report on exploratory fishing in Divisions 58.4.1 and 58.4.2 between the 2011/12 and 2022/23 fishing seasons Cleeland, J., C. Masere, T. Lamb and P. Ziegler
WG-FSA-2023/48	Report on the Acoustic-Trawl Survey of *Champsocephalus gunnari* in Statistical Subarea 48.2 in 2023 Delegation of Ukraine
WG-FSA-2023/49	Results from the 2023 Random Stratified Trawl Survey in the Waters Surrounding Heard Island in Division 58.5.2 Maschette, D., T. Lamb, J. Cleeland, C. Appert, C. Masere and P. Ziegler
WG-FSA-2023/50	Risk assessment for the Antarctic starry skate (*Amblyraja georgiana*) in the Ross Sea Holmes, S.J., B. Finucci, J.A. Devine, and M.H. Pinkerton
WG-FSA-2023/51	Ross Sea region Data Collection Protocols Delegation of New Zealand
WG-FSA-2023/52 Rev. 1	Satellite Tagging of Adult Patagonian Toothfish (*Dissostichus eleginoides*) Provides First Evidence for Unexpected Movement Patterns Kim, E. and C.H. Lam
WG-FSA-2023/53	Searching Spatial-Temporal Changes in Intrinsic Productivity of Antarctic Krill (*Euphausia superba*) in a Climate Change and Fishery Management Context Mardones, M., G. Watters and C. Cárdenas
WG-FSA-2023/54	Spatial Mismatch in Krill Management Approach Warwick-Evans, V., M.A. Collins and S. Hill

WG-FSA-2023/55	Stock Annex for the 2023 assessment of Ross Sea region Antarctic toothfish (*Dissostichus mawsoni*) Mormede, S., J. Devine, A. Grüss and A. Dunn
WG-FSA-2023/56	Stock Annex for the 2023 assessment of Subarea 48.3 (South Georgia) Patagonian toothfish (*Dissostichus eleginoides*) Earl, T., L. Readdy and J. Marsh
WG-FSA-2023/57	Stock Annex for the 2023 assessment of Subarea 48.4 (South Sandwich Islands) Patagonian toothfish (*Dissostichus eleginoides*) Readdy, L., T. Earl and J. Marsh
WG-FSA-2023/58	Stock Annex for the 2023 assessment of the Patagonian toothfish (*Dissostichus eleginoides)* population of the Crozet Islands EEZ in Division 58.6. Massiot-Granier, F., F. Ouzoulias and C. Péron
WG-FSA-2023/59	Stock Annex for the 2023 assessment of the Patagonian toothfish (*Dissostichus eleginoides*) population of the Kerguelen Island EEZ in Division 58.5.1. Massiot-Granier, F., F. Ouzoulias and C. Péron
WG-FSA-2023/60	Stock Annex for the mackerel icefish (*Champsocephalus gunnari*) fishery in Subarea 48.3 Marsh, J. and T. Earl
WG-FSA-2023/61	Study on reproductive potential of *Champsocephalus gunnari, Chaenocephalus aceratus, Pseudochaenichthys georgianus and Notothenia rossii* from South Georgias Islands, March 2023 Militelli, M.I., N. Ruocco and G. Lukaszewicz
WG-FSA-2023/62	Summary of the Toothfish Fishery and Tagging Programme in the Amundsen Sea Region (Small-Scale Research Units 882C-H) to 2021/22 Devine J.A. and S. Mormede
WG-FSA-2023/63	Summary Report from Australia's Heard Island and McDonald Islands Fishery Climate Adaptation Workshop McDonald, A., M. Gold and Philippe Ziegler
WG-FSA-2023/64	The Need to Revise the Approach to Assessing Gear Selectivity in Relation to the Krill Fishery in the Current CCAMLR Topics Sergeev S. and S. Kasatkina
WG-FSA-2023/65 Rev. 1	Update of Skate Tagging Programme in the Ross and Amundsen Sea Regions B. Finucci

WG-FSA-2023/66	Updated Stock Assessment Model for the Crozet Islands EEZ Patagonian Toothfish (*Dissostichus eleginoides*) Fishery in Sub-Area 58.6 Massiot-Granier, F., F. Ouzoulias and C. Péron
WG-FSA-2023/67 Rev. 1	Updated Stock Assessment Model for the Kerguelen Island EEZ Patagonian Toothfish (*Dissostichus eleginoides*) Fishery in Division 58.5.1 for 2023 Massiot-Granier, F., F. Ouzoulias and C. Péron
WG-FSA-2023/68	Updated Stock Assessments for *Euphausia superba* in Divisions 58.4.1 and 58.4.2 Maschette, D., H. Murase, N. Kelly, P. Ziegler and S. Kawaguchi
WG-FSA-2023/69	Using a novel machine learning approach to alleviate the allometric effect in otolith shape-based species discrimination Zhu, G.P. and Y.W. Chen
WG-FSA-2023/70	Revised VME Taxa Classification Guide Ross Sea region – version 2 Devine, J., D. Tracey, S. Mills, D. Macpherson, D. Gordon and E. Mackay
WG-FSA-2023/71	Tag linking - 2023 report CCAMLR Secretariat
WG-FSA-2023/72	Progress on the CCAMLR gear library CCAMLR Secretariat
WG-FSA-2023/73	Fish by-catch in the krill fishery - 2023 update. CCAMLR Secretariat
WG-FSA-2023/74	*Dissostichus* spp. Catch Documentation Scheme (CDS), and monthly fine-scale catch and effort data decision rule review CCAMLR Secretariat
WG-FSA-2023/75 Rev. 1	Vulnerable Marine Ecosystems (VME) in CCAMLR CCAMLR Secretariat
Other documents	
WG-FSA-2023/P01	Fatty acid composition and energy allocation in muscle and gonad tissues indicates that the female mackerel icefish *Champsocephalus gunnari* is an income breeder Zhu, G.P. and K. Huang. 2023. *J. Fish Biol.*, 103(3): 460-471, doi: https://doi.org/10.1111/jfb.15461.
WG-EMM-2023/14	CCAMLR Marine Debris Monitoring Program, 2023 CCAMLR Secretariat

Appendix D

Report of the co-conveners of the Ageing Workshop
(Virtual meeting, 9 to 11 May 2023)

Welcome and introductions

1.1 The CCAMLR Ageing Workshop was held online from 9 to 11 May 2023. The Workshop was convened by Dr Philip Hollyman (United Kingdom) and Dr Jennifer Devine (New Zealand) and supported by the CCAMLR Secretariat. Scientists and technical experts from 12 Member nations attended the Workshop.

1.2 At the start of the workshop, Drs Hollyman and Devine welcomed the 36 participants (Attachment I) and thanked those that had uploaded information to the e-Group on practices and procedures in their ageing laboratories. The Workshop was noted as being an informal meeting with the aim to bring together technical experts involved with age estimation of toothfish, skates, macrourids, and other species and those who analyse age data to discuss specific aspects of the age estimation process. The goal was to develop documentation and guidelines on ageing, provide recommendations on the structure and implementation of an age reading database to be maintained by the Secretariat for toothfish, and recommend standard guidelines to improve and validate ages between readers and Members.

1.3 Accordingly, this report is not an adopted report, but is a summary by the Co-conveners for the consideration of the Scientific Committee and its working groups. The intent is that the requests and recommendations outlined below will be reported to WG-SAM-2023 and WG-FSA-2023 for further discussion and agreed at SC-CAMLR-42 according to the Scientific Committee Rules of Procedure.

1.4 The names of participants are in Attachment I, the terms of reference for the Workshop are given in Attachment II, and the agenda in Attachment III.

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

ToR 1(a)

2.1 Participants from Australia, China, New Zealand, Japan, Korea, Spain, the United Kingdom, and the United States presented on the preparation and protocols used for production ageing within their labs, and some of the issues encountered while preparing and reading otoliths. Information for ToR 1a(i-v) from each Member can be found in Table 1.

2.3 Participants from Australia noted some difficulties with newer versions of the imaging software (Leica K2C/LAS), but that the imaging clarity was vastly improved.

2.2 Participants from China presented a comparison of baked and unbaked otoliths, noting that the primordium and first 5 zones can be identified using unbaked otoliths, and that accurate ageing can be done without baking otoliths, allowing for alternate uses after ageing, such as stable isotope or otolith microchemistry. No systematic differences were found in the ages between the baked and unbaked otoliths, but it was noted that a comparison of grinding versus thin section is still needed.

2.3 New Zealand presented some preliminary comparisons of thin sections versus bake and embed methods, noting that some differences were also because an inexperienced reader was being trained and that more work was needed to determine if systematic differences existed between the two preparation methods. New Zealand also noted issues with cracking when preparing thin sections and advice from other participants included creating slightly thicker sections that are fixed to slides and polished thinner or by using two blades separated by a spacer for stabilisation.

2.4 Participants from Spain noted that they have worked with other Members on ageing, and that direct counting using a microscope tended to have better results, but that images were easier to exchange, compare, and discuss.

2.5 The UK presented on a large resampling project being conducted to add ages to the historical data for Patagonian toothfish and on new studies with geochemical analyses. Images were noted as being difficult to age from static images and that older fish sometimes had crystalised edges with no banding or structure. Several labs discussed that they had encountered this, if not in toothfish, in other species, and that it might be related to a metabolic shift occurring in older fish, possibly with senescence.

2.6 The UK presented on their ageing of Antarctic toothfish and the progress they have made with practical issues and data cleaning but noted that they have limited material and were interested if other Members might share otoliths if fishing in the same areas.

2.7 Participants from the US presented on their connectivity work using, in part, otolith microchemistry to determine pathways and movement and how this might be impacted by the environment or climate change, and on developments using artificial intelligence to age toothfish.

2.7.1 Participants from Australia, China, and New Zealand also discussed developments in their labs for various species for ageing and morphological studies. Other methods, such as genomic approaches and use of methylation for ageing were also discussed.

2.8 The possibility of using otoliths as a source of DNA for other studies was discussed, but it was noted that biosecurity protocols for some Members may prevent this and otoliths with adhered dried tissue creates problems during preparation for ageing. Participants agreed that dedicated tissue collection programs may be better for this data collection and that this information could be part of the metadata that is stored within the otolith library.

2.9 Workshop participants discussed different types of resin or epoxy used for otolith preparation and if environmentally-friendly options were available. Some labs had success with less environmentally-bad epoxies (e.g., exopoxy), while others mentioned several plant-based brands that should be avoided because of poor quality.

2.10 Other species were discussed briefly by the Workshop participants, but many experts could not take part in the Workshop.

2.10.1 The use of skate caudal thorns versus vertebrae was discussed and it was noted that caudal thorns had promise for species in cold water environments, freezing and thawing did not seem to affect the thorns, and there may be sexual dimorphism for some species, where the caudal thorns are more robust for males because they use them when competing; this may affect the reading. Vertebra were discussed as not having the same calcification in deep, cold water as in shallower/warmer-living skate species and that they are likely not a suitable structure for ageing in the Southern Ocean. Workshop participants discussed age validation for skates and that only one individual was needed to validate ages from the pulsed strontium/OTC chemical marking of skates in the Ross Sea region.

2.10.2 Many Member laboratories are ageing other species and were happy to share protocols and comparing age readings.

2.11 Participants noted that several labs are restricted to one reader because of budgetary constraints and that this was not an ideal situation.

2.12 Readability scores were discussed as being useful when comparing between readers (or multiple reads with one reader) to determine where discrepancies in ageing might occur, to determine which otoliths should be used for imaging, and for creating an ageing matrix as described in WG-FSA-2014/46. Each lab tended to have its own set of scores for readability (Appendix IV) and it was discussed that should information be stored at the Secretariat or nations pool their ages for an assessment, a common scale may be needed.

2.12.1 The workshop requested WG-SAM or WG-FSA to determine if the assessments are affected by the number of unreadable otoliths and how that effect is spread across the age classes.

2.12.2 Participants discussed that protocols for pooling ageing data between different laboratories will need to be developed as well as the process for determining when data becomes valid for use in stock assessments.

2.12.3 The workshop requested WG-SAM to develop a mechanism for interlaboratory comparison of ages when pooling data (e.g., CV, IAPE, readability scores).

2.12.4 Participants suggested that if ageing data is used in a stock assessment, then the distribution of readability scores should be included in the report to determine if pooling created issues and where biases may occur.

2.12.5 The workshop requested WG-FSA to recommend to Scientific Committee that all papers that use production ageing data include the distribution of the readability scores, add readability scores to inter-reader comparison plots to indicate where potential biases may arise, and standardise reporting methods, such as by creating common scripts to be added to the CCAMLR github or to the eGroup for the Workshop on Age Determination.

2.12.6 Participants agreed a mechanism or protocol for interlaboratory comparison of age compositions are needed when pooling age data and that this information would need to be included in the ageing database. The Workshop noted that early reports from the CCAMLR Otolith Network (CON) included interlaboratory comparisons in a report to WG-FSA (WG-FSA-02/51) and that this should be considered.

2.13 Participants agreed that otolith reference sets for the two preparation methods: bake and embed and thin sectioning, will need to be developed, that sister otoliths will need to be used for the two methods, and that criteria for developing the reference set need to be defined. It was agreed that pooling resources and otoliths could be less onerous than each lab building its own reference sets, and that sharing of images would be easier and cheaper. Participants also agreed that switching preparation or ageing methods will be difficult for labs to do because it may require extra tools and equipment, which might not be possible.

2.13.1 Concerns were raised that there may be differences between counts from images and via a microscope, therefore the working group participants recommended that Members with the capability to use both methods investigate this further.

2.13.2 The Workshop discussed that the size of the reference set may differ between species because of differences in longevity, but that this may not be problematic because reference sets should continuously evolve (e.g., should be updated with otoliths from more recent seasons), and may need to be larger for species that are aged for assessments. The Workshop discussed that using the age distribution might resolve how large the sample size should be for the reference set. It would need multiple fish in each age category to estimate a variance, may need to be area-specific, and would need to be stratified by sex, readability, or other metadata.

2.13.3 The Workshop discussed the potential use of different types of reference sets. With some (potentially larger sets) being used to train new readers and others for returning readers to read before resuming ageing after an extended break, or to recalibrate their reading at certain intervals to check for drift.

2.13.4 A workshop with ageing experts from each lab would be needed to ensure everyone agreed on interpretation and to generate a single count for each otolith in the reference set. Cassandra Brooks (University of Colorado) offered to host the workshop in the intersessional period (early 2024).

2.13.4.1 The Workshop drafted ToRs (Attachment IV) for the proposed workshop and recommended that SC endorse the proposal for the workshop and ToRs. requested WG-FSA recommend to the Scientific Committee to recommend the draft ToRs for this workshop

2.13.5 The workshop requested WG-FSA to recommend that Scientific Committee recommend an in-person (or online) meeting before 2024 mid-year meetings for the different laboratories to generate a single count for each otolith in the reference set.

2.14 Participants discussed the need for comparative studies on ageing using the two preparation methods and comparing direct counting using microscopes versus images. The US discussed current work their lab is conducting, comparing counts using direct microscope reading versus images and offered to share their results, when available, while experts from Spain discussed discrepancies they found when comparing preparation methods.

2.15 The Workshop discussed what a reasonable sample size should be for inter-reader comparison and that guidance on the optimal amount of coverage is needed. Some labs read 20-30% of the samples, while others have found that 120 otoliths were enough to allow for variance among all the ages.

2.15.1 The workshop requested that WG-SAM help determine the reasonable amount of coverage needed when a second reader ages a subset of the otoliths for production ageing.

2.16 Workshop discussed whether the current thresholds for CV and Index of Average Percent Error (IAPE, 10% and 5%) were adequate and whether thresholds should be different if using only one reader. If the CV is too high, the age-length matrix would become highly variable, and the assessment would not be able to track cohorts well. Participants agreed that including the standard set of precision and bias checks should be added to characterisations or assessment reports, where these data were used.

2.16.1 The workshop requested that WG-SAM and WG-FSA determine the effect of a range of CVs on the age-length matrix and assessments.

2.16.2 The workshop requested that WG-SAM and WG-FSA develop target levels of precision (CV, IAPE) for age determination among readers or counts between a single reader and for reference sets to monitor and maintain consistency in age interpretation.

2.17 The Workshop discussed that a network, such as the CCAMLR Otolith Network (CON) or joining an existing one that meets (online or in-person) to exchange knowledge on new methods and technology, for interlaboratory training, would be beneficial.

2.17.1 The Workshop requested WG-FSA to recommend to Scientific Committee to recommend the resurrection of the CCAMLR Otolith Network for Members to exchange knowledge and work together for ageing purposes, and that the Age Determination eGroup might form the basis for the reinstated network

ToR 1(b)

3.1 Participants discussed lead-radium (Brooks et al. 2011), strontium-chloride, and oxytetracycline marking (Horn et al. 2003) were validation methods used previously for toothfish, and strontium and oxytetracycline were used for skates, but that ethics rules for many Members have changed since these studies which may prevent the use of strontium and tetracycline in the future. Toothfish may be a good candidate for genomic methods, and magnesium mapping, magnesium trace elemental methods, Fourier transform near-infrared spectroscopy (FT-NIRS; Passerotti et al., 2022), or otolith microchemistry approaches may be possibilities.

3.1.1 The workshop requested that WG-FSA recommend Scientific Committee recommend that members work should continue on age validation methods, particularly on non-toothfish species.

3.1.2 Cassandra Brooks offered to make available a dataset that had been age validated.

ToR 1(c)

4.1 The Workshop noted that time and money constraints seemed to dictate what can be accomplished among labs when developing age compositions and catch-age structure, but that if Members pooled ages, less otoliths may need to be read by each lab in the future.

4.1.1 The workshop requested guidance on ToR 1c from WG-SAM to determine the minimum number of samples required and methods to estimate age compositions and catch age structure.

ToR 1(d)

5.1 The Workshop participants noted that there were large differences in the preparation of otoliths and processing of samples between the different laboratories and that a document library, hosted on the Secretariat's website, might be the best approach. Members that may want to contribute can then do so.

5.1.1 The workshop participants recommend Members submit documentation on their ageing protocols and manuals to a document library held by the Secretariat.

ToR 1(e)

6.1 Participants discussed whether the metadata within the otolith reference library should be allowed to link to observer or C2 data and agreed some fields could be useful, but that not all would be needed. The Secretariat noted that linking data to new samples (more recent data) would be possible, but that data quality issues mean linking to historical data could be problematic and require manual confirmation of links.

6.1.1 The workshop recommend Members consider submitting data for inclusion in the age database and otolith library.

6.1.2 The workshop recommended that the Secretariat include a data field indicating whether otolith is part of the reference collection (in both individual member and CCAMLR otolith databases).

6.1.3 The Workshop further recommended that the database would need to include when a change occurred to the database, otolith preparation, ageing approach or readability scoring.

6.2 The Workshop discussed that some suggested database fields were only collected as standard by very few members due to time constraints (e.g., otolith length and weight) but that this data is useful in morphometric studies when available.

6.2.1 The workshop recommended that Members record lengths and weights of otoliths to aid morphometric and AI studies, where possible, but with a particular focus on non-toothfish species as these data are quite sparse.

ToR 1(f)

7.1 The workshop concluded that more images are needed in the CCAMLR otolith reference library before a comparison of age estimates can take place. The workshop discussed a range of variables that would ideally be covered with new imagery, including images from: both toothfish species, a range of geographical areas, both sexes, and a range of lengths and readabilities.

7.1.1 The workshop requested WG-FSA to recommended to Scientific Committee to recommend Members submit a set of up to 60 high quality images, including notations (where currently available), for each species they age, beginning with toothfish, which will then be used to build the reference otolith set.

7.1.2 The workshop requested FSA to recommend to Scientific Committee that Members submit otolith images for Antarctic and Patagonian toothfish by March 1st 2024.

7.1.3 The workshop recommended that those interested in participating in the potential in-person workshop in 2024 should read 150 of the available otolith images before the workshop.

ToR 1(g)

8.1 The workshop had several discussions regarding the use and building of otolith reference collections (2.13 – 2.13.3) but no decisions were reached on a minimum number of otoliths for a reference collection, or how the samples for a reference collection should be chosen. Members currently use reference sets of differing size ranging from 100 – 240 (Attachment 1).

8.2 Recommendations are needed for several aspects on the construction and use of reference sets. The discussion of which should be continued via the eGroup and / or the proposed in-person workshop in 2024.

8.2.1 The workshop requested the assistance of WG-SAM to determine the total number and the selection of specific variables (e.g., sex, area, lengths, years, season, readability score) needed when building the reference set.

8.2.2 The workshop requested Members to work together in the eGroup to determine the number of otoliths to age when reading the reference set for training or for experienced readers prior to production ageing.

8.2.3 The workshop requested Members work together in the eGroup to determine how often readers should use the reference set once qualified, to check for drift.

References

Brooks, C.M.; Andrews, A.H.; Ashford, J.R.; et al. (2011). Age estimation and lead–radium dating of Antarctic toothfish (*Dissostichus mawsoni*) in the Ross Sea. Polar Biology 34: 329–338.

Horn, P.L. Sutton, C.P.; DeVries, A.L. 2003. Evidence to support the annual formation of growth zones in otoliths of Antarctic toothfish (*Dissostichus mawsoni*). CCAMLR Science 10: 125–138.

Passerotti, M.S.; Reichert, M.J.M.; Robertory, B.A.; Marsh, Z.; Morgan, S.; Quattro, J.M. (2022). Physicochemical mechanisms of FT-NIRS age prediction in fish otoliths. Marine and Freshwater Research 73: 846–865.

Appendix D Table 1. Summary of Member ageing programs, including the species aged, method of selection, preparation method, measures of quality control, whether a reference set is used and how it is constructed, and the age arbitration method.

Member	Species	Method of selection	Otolith preparation	Quality control	Use of a reference set	Age arbitration method
Australia	TOP and TOA (also Macrourids, grey rockcod and unicorn Icefish)	2 fish per 1 cm length bin. 1:1 sex ratio	thin section method	Independent readings by 2 different readers. Otoliths for which discrepancies are large are re-read by both readers and the reconciled ages are used. Readers are tested using reference collections for each species prior to production readings.	TOP reference set of 200 otoliths and TOA reference set of 200 otoliths	
China	TOA and TOP (also Icefish, Myctophids, and other several species from Nototheniidae)	Left and right otoliths are randomly selected	bake and embed method / unbaked and embed method (for comparison)	Independent readings by different readers. Precision is assessed by calculating the APE and CV.	No reference set available yet.	
Japan	TOP and TOA	10 random per set and additional fish to ensure 10 males and 10 females for each 5cm length bin	thin section method	A second reading by either different readers or by the same reader at least 2 weeks after the original reading. Precision is assessed by calculating the APE and CV. Annotated images with annuli are created during each reading.	Uses CCAMLR reference dataset	
New Zealand	TOA (also Skates, Macrourids)	all recaptured fish 10 fish per set per species 10 fish per sex per 5cm length bin	bake and embed intent to move to thin section method	Only 1 reader experienced with bake and embed method. Use reference set to test the reader if longer than 4 weeks have passed since the reader had aged the species. Precision is assessed by calculating the APE and CV of the reference set readings.	TOA reference set of 240 otoliths make up, subset in 4 discrete sets of 60 otoliths. These reference sets have been made available to CCAMLR	
Korea	TOA	5 fish per 1 cm length bin in 883. 10 fish per set in other area's	bake and embed method	Only 1 reader whose estimations have been previously demonstrated to be comparable to expert readers.	No reference set available yet.	

(continued)

Appendix D Table 1. (continued)

Spain	TOA	10 random per set and additional fish to ensure 10 males and 10 females for each 5cm length bin	bake and embed method	Consensus by 2 readers is needed.	Uses CCAMLR reference set	
UK	TOP	4 fish per 1cm size class for M and F. also juvenile TOP for groundfish survey	thin section method	The main reader will re-read a random selection of otoliths to assess within-reader variation. A second reader will read between 10 and 20% of the subset. Precision is assessed by calculating the APE and CV.	Two reference sets of 100 otoliths exists and a new reference set is being created using more recent samples.	
USA	TOP and TOA	Random selection of otoliths	bake and grind method	Independent readings by different readers. Precision is assessed by age bias plots and calculating the APE and CV.	Reference set of sectioned otoliths which have been read repeatedly.	

Appendix D Table 2. Otolith clarity rankings used by different members.

Rank	Australia	Japan	Republic of Korea
1	Sections where the opaque and translucent zones are extremely unclear or discontinuous and/or the section does not go through the primordium, where the count is not possible or would be highly unreliable, should be marked unreadable.	very easy to see	Otolith very easy to read; excellent contrast between successive opaque and translucent zones.
2	The section is through the primordium, but the opaque zones are unclear and not continuous for very long sections, or there are large areas where opaque banding is not distinguishable (often in the centre), leaving the count with a high degree of uncertainty.	easy to see	Otolith easy to read; excellent contrast between successive opaque and translucent zones.
3	Opaque zones are visible around most of the section and fairly distinguishable, but some uncertainty still exists in differentiation and interpretation of the banding.	normal	Otolith readable; less contrast between successive opaque and translucent zones than in 2, but alternating zones still apparent; potential error 2 opaque zones.
4	Opaque zones are clear over almost all of the otolith section, but there is perhaps one area that has some ambiguity e.g., towards the outer edge.	hard to see	Otolith readable with difficulty; poor contrast between successive opaque and translucent zones; potential error 3 opaque zones.
5	Opaque zones are clearly visible around the proximal half of the otolith enabling an accurate count of the bands and confidence in repeatability of the count.	unreadable	Otolith unreadable.

(continued)

Table 2. (continued).

Rank	New Zealand	Spain	UK
1	Otolith very easy to read; excellent contrast between successive opaque and translucent zones.	Otolith unreadable	Otolith is very clear and easily readable. Contrast between growth zones is very good.
2	Otolith very easy to read; excellent contrast between successive opaque and translucent zones.	Otolith readable with difficulty; poor contrast between successive opaque and translucent zones	Otolith is clear and readable. Contrast between growth zones is good. One growth zone may be unclear.
3	Otolith readable; less contrast between successive opaque and translucent zones than in 2, but alternating zones still apparent; potential error 2 opaque zones.	Otolith readable; less contrast between successive opaque and translucent zones than in 2, but alternating zones still apparent	Otolith is readable but contrast between zones is lower than 1 & 2. Two growth zones may be unclear.
4	Otolith readable with difficulty; poor contrast between successive opaque and translucent zones; potential error 3 opaque zones.	Otolith very easy to read; excellent contrast between successive opaque and translucent zones	Otolith is difficult to read. Contrast between zones is poor and three growth zones may be unclear.
5	Otolith unreadable		Otolith unreadable

Appendix D Table 3. Requests and recommendations from the Age Determination Workshop.

No.	Request/Recommendation	To whom	Report paragraph	Priority	If actioned and where
1	Submit documentation on their ageing protocols and manuals to a document library held by the Secretariat	Members' ageing laboratories	5.1.1	High	
2	Submit data for inclusion in the age database and otolith library	Members	6.1.1	High	
3	Submit a set of up to 60 high quality images, including notations, to the reference set library before the next Ageing Workshop (March 2024)	Members	7.1.1–7.1.2	High	
4	Read 150 of the available otolith images in the reference set held by the Secretariat before the next Ageing Workshop.	Members / technical experts on toothfish ageing	7.13	High	
5	To work together in the eGroup to determine how often qualified readers should use the reference collection to check for drift, and to determine how many otoliths to age from the reference set for training or for experienced readers prior to production ageing.	Members / technical ageing experts	8.2.2–8.2.3	High	
6	Recommend those with capability to investigate the potential differences in counts from images and from a microscope.	Members' ageing laboratories	2.13.1	Medium	
7	Record lengths and weights of otoliths to aid morphometric and AI studies, where possible, but with a particular focus on non-toothfish species as these data are quite sparse.	Members	6.2.1	Low	
8	Include in the age database a field indicating whether otolith is part of the reference collection (in both individual member and CCAMLR otolith databases).	Secretariat	6.1.2	Medium	
9	Include a field in the age database to indicate when a change occurred to the database, otolith preparation, ageing approach or readability scoring.	Secretariat	6.1.3	Medium	
10	Recommend that all papers that use production ageing data include the distribution of the readability scores, add readability scores to the 1:1 plot to indicate where potential biases may arise, and standardise reporting methods, such as by creating common scripts to be added to the CCAMLR github or to the eGroup for the Workshop on Age Determination.	Scientific Committee	2.12.5	High	

(continued)

Appendix D Table 3. (continued)

11	Develop a mechanism for inter-laboratory comparison of ages when pooling data (e.g., CV, IAPE, readability scores).	WG-SAM	2.12.3	High	
12	Determine the effect of a range of CVs on the age-length matrix and on the stock assessments for toothfish.	WG-SAM, WG-FSA	2.16.2	High	
13	Recommend ToRs for the 2nd Ageing Workshop, to be held before the 2024 mid-year meetings.	WG-FSA, Scientific Committee	Draft ToRs are included in Attachment IV	High	
14	Resurrect the CCAMLR Otolith Network for Members to exchange knowledge and work together for ageing purposes.	Scientific Committee	2.17.1	Medium	
15	Work should continue on age validation methods, particularly on non-toothfish species.	Scientific Committee	3.1.1	Medium	
16	Determine the minimum level of double reading necessary to ensure consistency in age readings	WG-SAM	2.15	High	SAM workplan – Theme 1, Task 11
17	Develop target levels of precision for age determination among readers or compared to reference sets (e.g., mean weighted coefficient of variation (CV)) to monitor and maintain consistency in age interpretation.	WG-SAM, WG-FSA	2.16.1	High	SAM workplan – Theme 1, Task 10
18	Determine the minimum number of samples required and methods to estimate age compositions and catch age structure.	WG-SAM	4.1.1(a)	High	SAM workplan – Theme 1, Task 12
19	Recommend the building of an otolith reference collection	WG-SAM, Secretariat	7.1.1	High	SAM workplan – Theme 1, Task 13
20	Determine the total number and the selection of specific variables (e.g., sex, area, lengths, years, season, readability score) needed for the reference otolith collection	WG-SAM	8.2.1	Medium	SAM workplan – Theme 1, Task 13

Attachment I. List of Participants

Tom Barnes
Avumile Bawuli
Cassandra brooks
Jilda Caccavo
Kevin Caoimhgin
Sangdeok Chung
Daphnis De Pooter
Jennifer Devine
Brit Finucci
Clare Gallagher
Laura Ghigliotti
Alan Hart
Philip Hollyman
Kai Huang
Christopher Jones
Sibusisile Kheswa
Evan Leonard
Alfonsina Macias
Jessica Marsh
Dale Maschette
Andy Nichols
Takehiro Okuda
Kenichiro Omote
Steve Parker
Yuli Rivadeneira
Georgia Robson
Roberto Sarralde
Sanggyu Shin
Sobahle Somhlaba
Colin Sutton
Mio Tanaka
Marino Vacchi
Jose Velez Tacuri
Melanie Williams
Zhen Zhao
Guoping Zhu
Mpumalanga

Attachment II. Workshop TORs

Virtual Workshop on Age Determination Methods – Terms of Reference

1) Identify ageing protocols and methods used to age Antarctic and Patagonian toothfish (and common by-catch taxa such as *Macrourus* spp. and Rajiformes if time and resources allow) by Members, including:
   a) Processes to:
      i) Collect otoliths at sea;
      ii) Select otoliths for ageing;
      iii) Prepare and read otoliths;
      iv) Conduct quality control and readability measurement methods, including reader agreement metrics and thresholds for using the read ages in analyses; and
      v) Construct and use reference sets.
   b) Mechanism of ageing validation across laboratories/Members.
   c) The minimum number of samples required and methods to estimate age compositions and catch age structure.
   d) Develop updated documentation and guidelines on ageing, considering documentation used by Members laboratories, recommendations from the 2012 Workshop on Techniques and Procedures for Ageing of Otoliths from D. eleginoides and D. mawsoni (WG-FSA-2012, paragraphs 10.1 to 10.19) and relevant documentation from other organisations recognised for best practise in fish ageing.
   e) Provide recommendations on the structure and implementation of an age reading database to be maintained by the Secretariat for toothfish otolith readings.
   f) Undertake a comparison of age estimates and subsequent evaluation metrics by Members from a standard reference set of otoliths using images of otoliths from the CCAMLR otolith image library WG-FSA-2022 Report – Preliminary version.
   g) Recommend standard guidelines for ageing and future work needed to improve and validate ages between readers and Members.

Attachment III. Workshop Agenda

Virtual Workshop on Age Determination Methods, 9–11 May 2023

Dear Colleagues,

We are looking forward to welcoming all interested parties to the virtual workshop on age determination, taking place on the 9th – 11th of May (SC CIRC 23/19).
The aim of the workshop is to bring together technical experts involved with age estimation of toothfish, skates, macrourids, and other species and those who analyse age data to discuss specific aspects of the age estimation process. The goal is to develop documentation and guidelines on ageing, provide recommendations on the structure and implementation of an age reading database to be maintained by the Secretariat for toothfish, and recommend standard guidelines to improve and validate ages between readers and Members. We would like encourage all delegations with interests in age determination to join the workshop and sign up to the e-group as soon as possible **(**Workshop on age determination**)**.

The workshop will run from 19:00 UTC until 23:15 UTC each day, be broken into two 2-hour sessions each day with a short break between sessions, and will cover the following topics:

9th of May: Antarctic Toothfish & Patagonian toothfish ageing
10th of May: Toothfish ageing (continued) & Skate ageing
11th of May: All other species (e.g. Macrourids) & wrap up

We are seeking input from members on the following aspects of their ageing programs, no later than the 3rd of May 2023, to be submitted to the CCAMLR e-group (Workshop on age determination**).**

1) Which species are aged;
2) How the ageing structures are
    a. collected at sea,
    b. selected for ageing,
    c. prepared for reading,
    d. read;
3) What methods are used for quality control;
4) What readability measurements are used; and
5) Are references sets used – if so, please provide details on how they are constructed and used.

We would also encourage members to prepare short presentations on their ageing programs to cover the following:

1) An overview of their ageing program (methods, species, current and future work)
2) Any queries or issues they would like to raise or discuss during the workshop

We will share all materials on an e-group prior to the workshop and a summary of the workshop outcomes will be presented to WG-FSA.

Kind regards,
Dr Philip Hollyman & Dr Jennifer Devine, Co-conveners
Material can also be emailed to:
Philip Heath Philip.Heath@mpi.govt.nz; Jennifer Devine Jennifer.Devine@niwa.co.nz

Attachment IV. 2nd Age Determination Workshop Terms of Reference

1) Develop otolith reference sets for both Patagonian and Antarctic toothfish for each stock that is currently production aged, where reference sets will be housed at the Secretariat, including
    a. Annotate images
    b. Agree upon ages
    c. Agree upon metadata to be included in the reference set database, held by the Secretariat
2) Document the standard practices for ageing depending on the preparation method
3) Conduct a comparison of age reading from static images and physical samples to determine if there are any differences in age readings and/or biases from a particular method.

Appendix E

Proposal for a second CCAMLR workshop on age determination methods

Title: 2nd CCAMLR Age Determination Workshop (WS-ADM2-2024)
Host: University of Colorado, Boulder
Objectives:

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

Terms of Reference:

1. Develop otolith reference sets for both Patagonian and Antarctic toothfish for each stock that is currently aged for stock assessments, where reference sets images and associated ageing data will be held by the Secretariat. Reference sets will be developed using annotated images submitted by members in advance of the workshop (WG-FSA-2023/43 rev 1, Table 3).
2. Document the best practise standards for ageing depending on the age preparation method including:
    a. Annotate images.
    b. Agree upon reference set ages.
    c. Agree upon metadata to be included in the reference set database, held by the Secretariat.
3. Conduct comparisons of age reading from static images and physical samples to determine if there are any differences in age readings and/or biases from a particular method.
4. Develop protocols, diagnostics, and procedures for 'blind' reads of otoliths to be used in future inter-reader and inter-lab comparisons

Convener(s): Dr J. Devine (New Zealand), Dr. C. Brooks (SCAR), Dr. P. Hollyman (United Kingdom)
Venue: University of Colorado, Boulder
Date: 22–26 April 2024
Duration: 5 days
Invited experts: TBA
Observers or external organisations: None
Funding required by CCAMLR: A$50 000 to cover invited experts travel related costs.
Secretariat Support required: Yes – Data Officer and Science Manager
Ability to submit papers: Not required
Outputs: Conveners report to WG-SAM-2024 and WG-FSA-2024 summarising the data, outcomes, and recommendations from the ToRs of the workshop.
Reported to: WG-SAM-2024 and WG-FSA-2024

Appendix F

Skate Tagging Poster

Tag deployment

1. Use handling procedures outlined in the training manual, minimise time out of water

2. Use more than one person for large skates, transport skate using a transport aide.

3. Carefully remove the hook. Assess suitability for tagging. Do not tag the skate if any of the 'retain' conditions listed below are present.

4. Double tag the skate using tags with sequential numbers if possible.

5. Confirm that tags are anchored with a gentle tug.

6. Record data as required in the observer longline logbook and the C2 logbook. Make sure to include all leading characters, tag type, colour and inscription.

7. Check that tag numbers are recorded correctly.

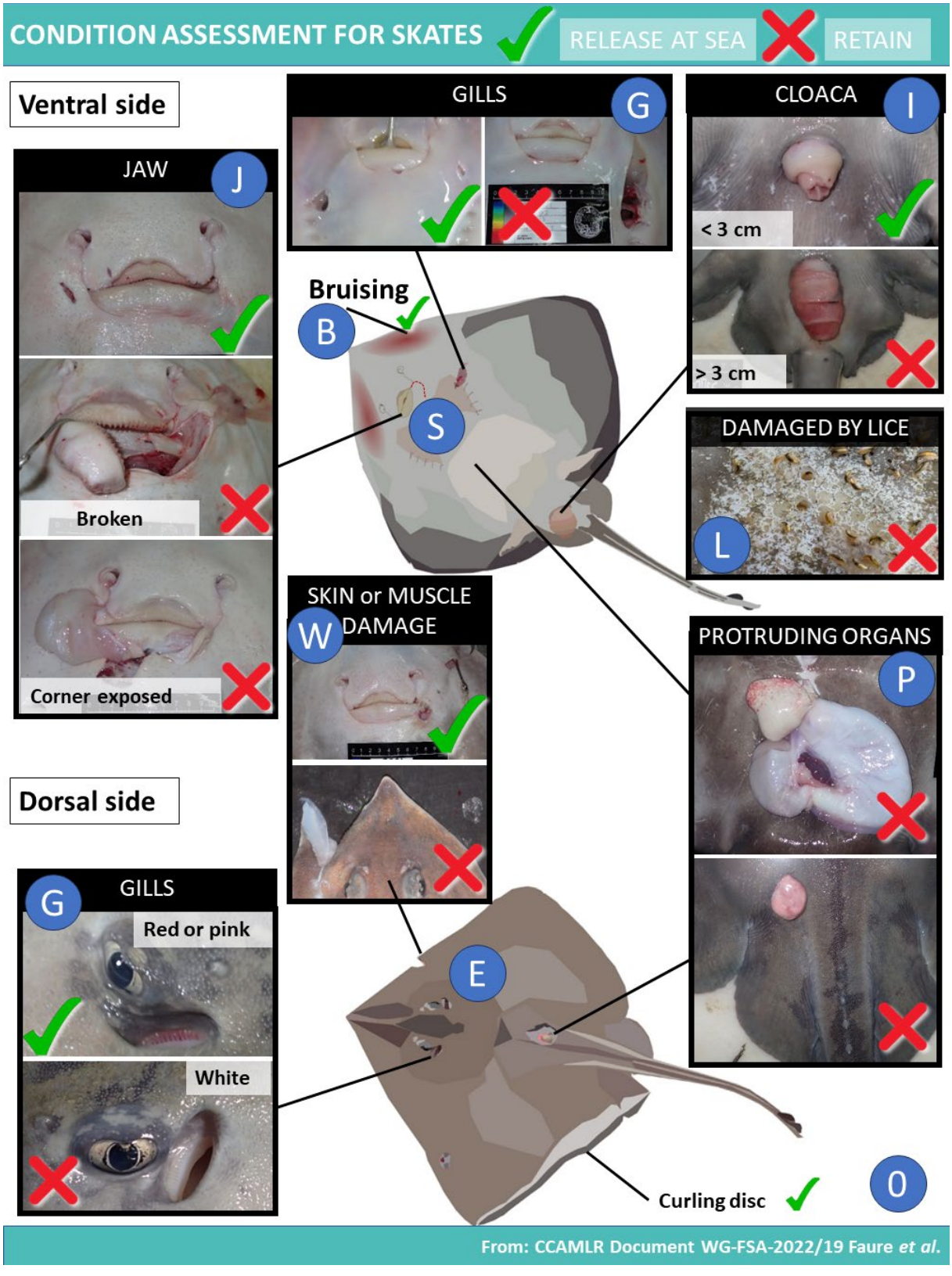
8. Release skate dorsal side up into water where release conditions are appropriate.

9. Observe and record fate of the skate in the logbook.

If a tagged skate is recaptured, retain it for the observer.

Suitability assessment injury codes to use for skates.

Category	Description
0	No visible injuries
J	Jaw cartilage break or significant tearing of tissue around the mouth.
G	Gills bleeding on either dorsal or ventral surface
L	Lice damage around the peritoneal cavity
I	Intestinal prolapse exceeding 3 cm, including if bleeding
P	Penetrating injury of the peritoneal cavity
E	Eye or spiracle injury
W	Wounds that are minor or superficial skin trauma to any region
B	Bruising on the dorsal or ventral side of disc or tail
S	Scar tissue around mouth/jaw that has healed from previous injury


CONDITION ASSESSMENT FOR SKATES
RELEASE AT SEA
RETAIN
Ventral side
JAW
J
Broken
Corner exposed
GILLS
G
Bruising
B
S
CLOACA
I
< 3 cm
> 3 cm
DAMAGED BY LICE
L
SKIN or MUSCLE DAMAGE
W
PROTRUDING ORGANS
P
Dorsal side
GILLS
G
Red or pink
White
E
Curling disc
0
From: CCAMLR Document WG-FSA-2022/19 Faure et al.

Best Practice Tagging Protocol

1. All tagging procedures and provision of equipment, including the sourcing of tags for vessels, is the responsibility of the Flag State of the vessel.

2. Observers and crew should work together in an efficient and effective way to achieve the best possible survival of the tagged fish.

3. Use a lifting aide such as a cradle, stretcher, dip net, or sling to support the weight of large fish selected for tagging from underneath to avoid injury.

4. Don't lift fish to be tagged using a gaff or any other method that may injure the fish.

5. Only select fish that are in good condition for tagging using the condition assessment criteria.

6. Keep the distance between the hauling bay, the tagging station, and the release point as short as practicable and minimise obstacles that may increase time onboard and the potential for injury to the fish.

7. Use a tagging station which is protected from the weather, both for the safety of the fish handlers and the health of the fish.

8. Minimise the total time fish to be tagged are out of any water, aim for less than three minutes.

9. Minimise the time fish are held in holding tanks, if used.

10. Don't overcrowd holding tanks or have both skates and toothfish in the tank at the same time. Recommendations on holding tank design can be found in the Commercial Data Collection Manual – Longline Fisheries. The percentage of fish volume relative to volume of water in the holding tank should not exceed 10%.

11. Release tagged toothfish headfirst into the sea and keep the distance between the release point and the sea surface as short as practicable.

12. Release tagged skates dorsal side up and keep the distance between the release point and the sea surface as short as practicable.

**Additional information is listed in the Commercial Data Collection Manual – Longline Fisheries.*

Note that FAO codes = CCAMLR codes

CCAMLR VME Taxa Classification Guide 2023 Version 2

These groups are not included: Snails, Starfish, Crabs

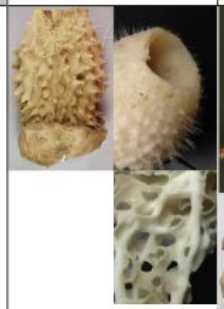
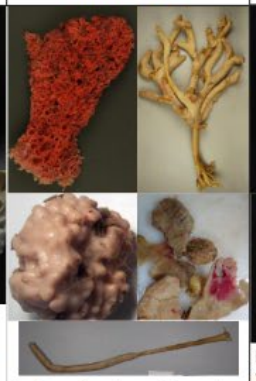
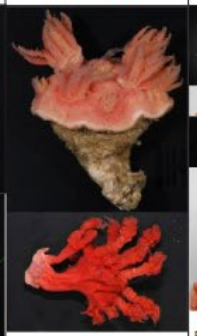
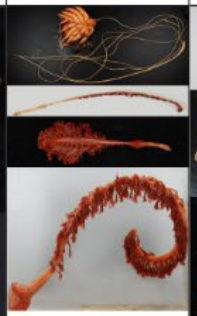
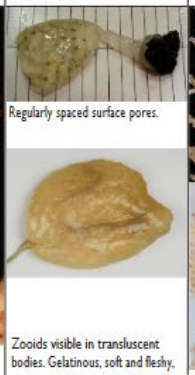
Phylum	Cnidaria (CNI)									
Code	DWR					HQZ		CSS	AQZ	ZOT
Level	Gorgonian octocorals: Scleralcyonacea (Order)					Leptothecata ZUD (Order)	Anthoathecata AZN (Order)	Scleractinia (Order)	Antipatharia (Order)	Zoantharia (Order)
Taxon	Keratoisididae and Mopseidae (Bamboo)	Coralliidae (Red / precious)	Primnoidae (Bottle brush, sea fans)	*Paragorgia* (Genus) (Bubblegum)	Chrysogorgiidae (Golden)	Hydroids	Stylasteridae AXT (Hydrocorals)	Stony corals	Black corals	Zoanthids
Form, size	Solid calcified trunk with brown joints (nodes), rings in x-section, branching 2D or 3D, fine tips, tree like branch tips	Calcified skeleton, no spines. Thick, stubby stems with fine side branches	Dark or metallic tree-like branches, flexible	Large (up to 2 m), red, thick stems, breaks when flexed	Gold, black or green metallic lustre. Semi-rigid, single, main axis with semi-soft tissue cortex. Small specimens can be feathery like hydroids or bushy like black coral	Entire organism small, <30 cm, flexible and plant-like, often feathery, no soft tissue covering	Calcified, no rings in X-section, often pink or white. Often uniplanar, side branches lattice from obviously thicker main stems	Cups: usually small (<20cm), solitary or in small clusters Branching matrix-forming stony corals have not been observed south of 56°S	Semi-rigid, woody, not very dense, dark brown or black skeleton, can be large (>2 m). Branch tips can look like hydroids or small gorgonian	Erect "coral-like" colonies. Often grow on, or colonise, other living corals.
Detail (texture, colour, polyps)	Can scrape off surface tissue, skeleton surface smooth between nodes	Can scrape off surface tissue. Smooth (not sandpapery) with knobbly ends. No pores on skeleton	Usually no spines, some metallic lustre on skeleton, 3D bushy branches, obvious polyps	Chalky material, not hard. No spines, can scrape off surface. Bulbous ends with polyps	Can be non-branching and whip-like. Usually no spines, metallic lustre. Fine or sparse 3D branching	Indistinct polyps, feathery tips	Coarse sandpaper texture, can't scrape off surface tissue. Has minute pores. Can be white or red	Calcified, very hard or brittle Cups: Can be ridged Branching: Often smooth stems. Can form a 3D matrix. Polyp calyces well formed with ridged edges, large, hard polyps	Slimy flesh on branches. Surface with minute spines, may appear smooth. 3D, fine or bushy tips	5 mm Large roundish polyps; often bright orange.
Commonly mistaken for other groups, such as:	Other gorgonians if in small pieces, but won't break easily	Soft corals, that have soft stems. Stylasterids, but Corallidae have nodules	Hydroids if small pieces, but have distinct polyps	Pieces of Corallium	Antipatharia, but tips are not slimy	Small specimens of Gorgonacea, Antipatharia, or carnivorous sponges	Small, hard bryozoans or pieces of Corallidae	Pieces of hydrocorals and *Corallium* can be confused with branching stony corals	Hydroid if small, or small pieces of dead Gorgonacea	Large brooding gorgonian coral polyps; branching soft corals

CCAMLR VME Taxa Classification Guide 2023. Commission for the Conservation of Antarctic Marine Living Resources, Hobart, Tasmania, 4p.

Note that FAO codes = CCAMLR codes

CCAMLR VME Taxa Classification Guide 2023 Version 2

These groups are not included: Snails, Starfish, Crabs

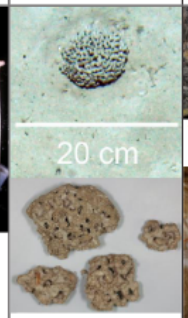
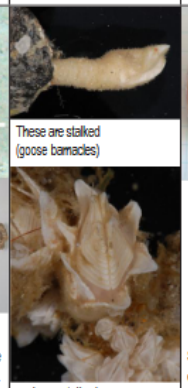
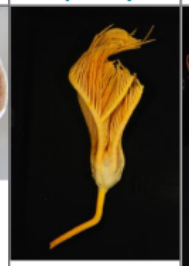
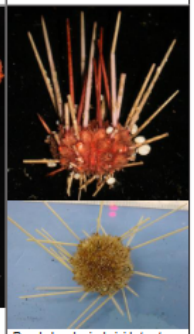
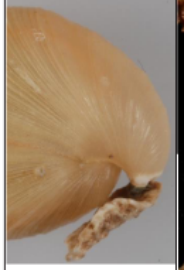
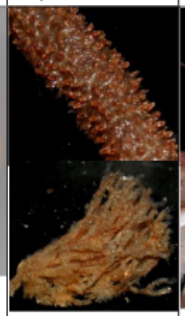
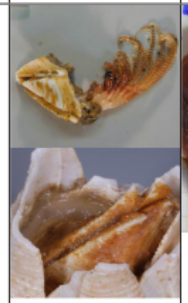
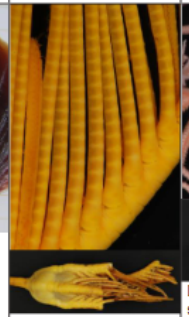
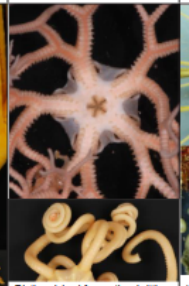
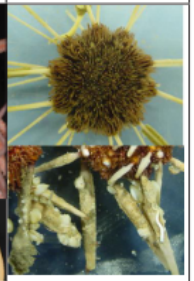
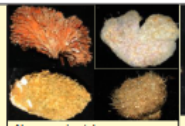
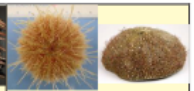
Phylum	Porifera (PFR)		Cnidaria (CNI)			Chordata (CZ1)	Bryozoa	Chemosynthetic
Code	HXY	DMO	ATX	DWQ	NTW	SSX	BZN	CX1
Level	Hexactinellida (Class)	Demospongiae (Class)	Actiniaria (Order)	Malacalcyonacea (Order)	Pennatuloidea (Superfamily)	Ascidiacea (Class)	Bryozoa (Phylum)	Various groups
Taxon	Glass sponges	Siliceous sponges	Anemones	True soft corals	Sea pens	Sea squirts	Lacy bryozoans	Chemosynthetic communities
Form, size	 Diverse shapes: hollow central chamber spiky & vase-like, egg-shaped with hairy mass at base, honeycombed tubular crystalline forms	 Much variety: fans, spheres, solid masses, tubes, and encrusting	 Rubbery bottom with single polyp with lots of tentacles. Usually in retracted hardened cylinder form when captured	 Can be mushroom shaped. Floppy or soft, leather-like surface texture. Usually multiple large polyps, body not symmetrical, no foot or stalk	 Feather-shaped with fleshy polyps. Non-branching to whip-like cartilaginous stalk. Fleshy foot or anchor present, body symmetrical. Can be tall, >1 m	 No tentacles or polyps. Stalked solitary or colonial. No skeleton, stalk-like or encrusting over substrate	 Typically small, (<30 cm). Variable forms. Can be hard or soft (most commonly hard) branching, lace-like, or cornflake shaped, calcified, and brittle, surface cannot be scraped off	Chemosynthetic habitat sites, including cold seeps, vents, whale falls and sunken wood include some of the following associated biota: 
Detail (texture, colour, polyps)	 Surface frequently spiny, always very siliceous or like fibre-glass, ice-like, delicate, crunchy	 Varied textures: fleshy, rubbery, fibrous, woody, flexible, elastic, stony, hairy	 Tentacles sometimes look like worms when detached	 Similar polyps to seapens, but soft corals are not stalked	 Fleshy polyps. Flower or feather like polyp mass	 Zooids visible in translucent bodies. Gelatinous, soft and fleshy, leathery, flexible	 No polyps	 Sediment or organisms may smell of rotten eggs - sulphurous
Commonly mistaken for other indicator groups, such as:	 Bryozoans or scleractinians that are small and of a hard matrix	 Some Alcyonaceans, Ascidians, which are not spongy but fleshy and have polyps or siphons, and Bryozoans.	 Alcyonaceans, which usually have several polyps	 Small pieces of Corallidae or some sea pens	 Alcyonaceans or some gorgonians due to large polyps and size	 Spherical demosponges or piece of sea pen	 Stylasterids if hard, hydroids if soft, carnivorous demosponge	Species belonging to the same taxa – to date only the white squat lobsters have been recorded in the Antarctic region. Because these communities are little known, **retain samples to be identified by experts**

CCAMLR VME Taxa Classification Guide 2023. Commission for the Conservation of Antarctic Marine Living Resources, Hobart, Tasmania, Australia, 4p.

Note that FAO codes = CCAMLR codes

CCAMLR VME Taxa Classification Guide 2023 Version 2

These groups are not included: Snails, Starfish, Crabs

Phylum	Brachiopoda	Hemichordata	Annelida (NHE)	Xenophyophoroidea within order Astrorhizida	Arthropoda	Mollusca (MOL)	Echinodermata (ECH)		
Code	BVH	PBQ	SZS	XEF	AX1	DMK	CWD	OEQ	DWL
Level	Brachiopoda (Phylum)	Pterobranchia (Class)	Serpulidae (Family)	Xenophyophoroidea (Suborder)	Cirripedia (Subclass) Bathylasmatidae BWY (Family) Scalpellomorpha DWI (Order)	*Adamussium colbecki* (Species)	Crinoidea (Class)	Euryalida (Order)	Cidaroida (Order)
Taxon	Lamp shells	Pterobranchs *Cephalodiscus* (genus)	Serpulid tube worms	Xenophyophores	Acorn & goose/stalked barnacles	Antarctic scallop	Stalked crinoids (Sea lilies)	Basket stars and snake stars	Pencil spine urchins
Form, size	 Valves enclose the body dorsally and ventrally rather than laterally. Ventral valve typically larger than the dorsal. Attached species have a short stalk emerging from the hinge area of the valves	 Tubes conjoined into colonies. Usually gelatinous, often semi-transparent	 Tube dwelling marine worms. Each tube flange is about 3.5 mm diameter. Forms large clumps, somewhat coral-like, typically Subantarctic distribution	 A specialised group, is among the largest single-celled protozoans. Colony size can be 10-20 cm in diameter	 These are stalked (goose barnacles) and non-stalked (acorn barnacles)	 Scallop shaped bivalve. Laterally compressed with two shells, hinged dorsally, that completely enclose the body in most species	 Stalked. Small tulip-like body. Arms usually branched. Crinoids are generally fragile, often only fragments. A long stalk, some bearing whorls of hooklike cirri. Body length up to 20 cm	 *Gorgonocephalus* spp (QCX) Gorgons head basket-stars. Large disc with 5 arms splitting at the disc into many coiled branches	 Regularly spherical, rigid structure, typically 2–10 cm in diameter. Covered with small spines and 10 distinct columns of large pencil-like spines
Detail (texture, colour, polyps)	 Delicate shell; clam like. Each valve is bilaterally symmetrical and may be ornamented with concentric growth lines and a fluted or spiny surface	 Red-orange to brown. Tubes closely or loosely bound	 Serpulid worms in hard calcareous tubes	Varied appearance ranging from spherical to flat. Many species have a rounded, lumpy form and irregular netlike surface structure. Most are fragile but one group is felt-like & robust. Found >500 m	 The mantle surface of any barnacle bears at least 5 major plates, which are pulled together for protection. Heavily armoured	 Ribbed scallop-like shell	 Fragile, not flexible. Brittle and segmented	 Distinguished from other brittle stars by branched or highly coiled arms and from sea stars by lack of ventral groove on underside of arms	 Usually shades of beige, burgundy or purple. Spines paler, they can be a substrate for other organisms. Large spines can be cylindrical or flattened
Commonly mistaken for other indicator groups, such as:	Resemble bivalve molluscs but one valve is much larger, and overhangs the smaller valve	 Algae, marine tube worms, tunicates or demosponges	 Other worm like forms in sediment tubes	 Fragments of demosponges sponges (see image), colonial ascidians, bryozoans, or 'inorganic concretions'	 Cup corals or clusters of tube worm casings	 Other bivalves or lamp shells	 Arm fragments can look like other animals such as basketstars, or feather stars if stalk not present	 Seastars with multiple non-coiled arms, and more common sea and brittle stars (in other Orders) with non-branching arms.	 Urchins that lack the large pencil-like spines

CCAMLR VME Taxa Classification Guide 2023. Commission for the Conservation of Antarctic Marine Living Resources, Hobart, Tasmania, Australia, 4p.

CCAMLR VME Taxa Classification Guide

Conservation Measure 22-07 requires vessels to monitor bycatch for the presence of vulnerable marine ecosystem (VME) taxa as defined by the Commission.
The level of classification required is relatively coarse for most taxa, where phylum, class or order is sufficient. However, some groups may require classification to family or even species. In addition, several groups can be confused at first sight. Therefore, a classification guide is needed to assist in the rapid and efficient classification of VME taxa.

Instructions

This CCAMLR VME Taxa Classification Guide provides observers, fishers, and biologists at sea with a taxon-specific, quick, on-deck guide to aid in the classification of macroscopic marine invertebrate bycatch into the required VME groupings. VME taxa are a subset of the total invertebrate taxa encountered as fishery bycatch, and therefore additional processes are still required to collect information on non-VME taxonomic groups. Typically, invertebrate identification is not done at sea because it requires specialised tools. The format of the VME guide is a "compare and contrast table", using photographs and key characteristics to correctly assign VME taxa to the appropriate grouping. It also highlights commonly confused groups. Symbols representing non-VME groups are listed in the top right-hand margin.

The guide is organised into columns, each describing a taxonomic group and colour coded by phylum. Those groups that appear similar have been placed next to each other where possible. The top row for each column is a parent column that identifies the phylum for the vulnerable groups below. The FAO 3-letter taxonomic code for each group is provided at the top of each column and for the parent group. Below the codes are the scientific and common names for each group. The first row contains photographs and brief descriptions of the overall size and shape of specimens for each group. The next row then provides details of the specimen's appearance, such as texture, colour, or polyp characteristics, and also includes close-up images as examples. A final row (with a yellow background) has images and descriptions of specimens representing other phyla. This row shows how these specimens can be commonly mistaken for other taxa and flags details on what to look out for during classification. Text in this row should be read beginning with the phrase in the row heading to aid in clarity.

Photographs of Antarctic specimens have been used where possible to aid in the identification of VME groups. The guide has been linked through colour coding to phyla in the "Guide to common deepsea invertebrates in New Zealand waters" (Tracey et al. 2011), the SPRFMO VME taxa guide (Tracey et al. 2008), and the Field identification guide to Heard Island and McDonald Island (HIMI) benthic invertebrates (Hibberd and Moore 2009). Invertebrate specimens that cannot be identified with confidence need to be identified to the lowest taxonomic level possible, retained on board, and returned frozen as biological specimens for formal identification.

Acknowledgments

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Corresponding author: j.devine@niwa.co.nz

National Institute of Water & Atmospheric Research Ltd (NIWA)
Private Bag 14901, Wellington, New Zealand

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Tracey, D.M.; Anderson, O.F.; Naylor, J. R. (Comps.) (2011). A guide to common deepsea invertebrates in New Zealand waters. New Zealand Aquatic Environment and Biodiversity Report No. 86. 317 p.

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Tracey D.M.; Parker, S.J.; Mackay, E.; Anderson, O.; Ramm, K. (2008). Classification guide for potentially vulnerable invertebrate taxa in the SPRFMO Area. New Zealand Ministry of Fisheries, Wellington, New Zealand.

Hibberd, T.; Moore, K. (2009). Field identification guide to Heard Island and McDonald Island (HIMI) benthic invertebrates: a guide for scientific observers aboard fishing vessels. The Department of Environment, Water, Heritage, and the Arts, Australian Antarctic Division and the Fisheries Research and Development Corporation. 158 p.