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# Report of the Working Group on Statistics, Assessment and Modelling (WG-SAM-2024)

(Leeuwarden, The Netherlands, 24 to 28 June 2024)

This is a preliminary[1] version of the WG-SAM-2024 Report as adopted on Friday 28 June 2024.

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

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# Report of the Working Group on Statistics, Assessments and Modelling – WG-SAM-2024

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## Introduction

1.1 The 2024 meeting of the Working Group on Statistics, Assessments and Modelling (WG-SAM-2024) was held in the Z Leeuwarden meeting centre in Leeuwarden, the Kingdom of the Netherlands, from 24 to 28 June 2024. The meeting was hosted by Wageningen Marine Research, the Arctic Centre of the University of Groningen and the Dutch Ministry of Foreign Affairs.

Opening of the meeting

1.2 The meeting convener, Dr T. Okuda (Japan) welcomed participants (Appendix A) to the meeting and expressed his goals. The participants were welcomed to Leeuwarden by Dr F. Schaafsma (the Scientific Committee representative for the Netherlands and previous CCAMLR Scientific Scholar). She also acknowledged the support of the Dutch Ministry of Foreign Affairs and wished participants a pleasant and productive meeting.

Adoption of the agenda

1.3 The agenda was adopted without change (Appendix B).

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

1.5 In this report, paragraphs that provide advice to the Scientific Committee and its other working groups have been indicated in grey. A summary of these paragraphs is provided under 'Advice to the Scientific Committee'.

1.6 The report was prepared by S. Chung (Republic of Korea), A. Dunn (New Zealand), T. Earl (United Kingdom), M. Eleaume (France), C. Jones (United States of America), C. Masere (Australia), F. Massiot-Granier (France), S. Parker (Secretariat), L. Readdy (United Kingdom), S. Shin (Republic of Korea), S. Thanassekos (Secretariat) and P. Ziegler (Australia).

1.7 A glossary of acronyms and abbreviations used in CCAMLR reports is available online at https://www.ccamlr.org/node/78120.

1.8 The Working Group noted the terms of reference agreed by the Scientific Committee in 2022 and set out in SC CIRC 23/52.

1.9 The Working Group noted the workplan set out in SC-CAMLR-42, Annex 15. The Working Group further agreed to discuss additional modifications to the workplan under 'Future Work'.

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**Development of methods to estimate biomass for krill**

2.1 WG-SAM-2024/26 presented an age-based integrated stock assessment model for Antarctic krill in the Western Antarctic Peninsula developed using Stock Synthesis (SS3; Methot and Wetzel, 2013). The model integrated fishing, environmental and ecological variables while considering the spatial heterogeneity of the krill population structure. The impact of biological and population structure assumptions on the performance of the model was evaluated.

2.2 The Working Group welcomed the large amount of work conducted by Mr M. Mardones (Chile), a CCAMLR scholarship recipient, and noted it represented valuable progress towards progressing Task 2 of its intersessional work plan (development of integrated stock assessment for krill; WG-SAM-2023, Table 1). It noted that the proposed stock assessment framework may provide an approach to understanding the complex dynamics of Antarctic krill populations in Subarea 48.1, but that the model parameterisation and its underlying hypotheses required further discussion.

2.3 Noting that the authors recalled a previous independent review of an age-based integrated stock assessment for Antarctic krill which encouraged the development of such assessments (Thomson, 2016), the Working Group highlighted that the other reviewer on that panel noted that a length-based model could be considered due to the sparsity of direct age data (de Lestang, 2016). It also noted that this would avoid the approximations required when converting length data to age data. The Working Group further recalled that a similar comment had been made (WG-SAM-2023, paragraph 4.3) in relation to a pilot Casal2 age-based assessment (WG-SAM-2023/25). It encouraged the authors to provide standard model diagnostics, similar to those presented for toothfish assessments, to facilitate understanding of model performance (e.g., WG-SAM-2023, paragraphs 6.33 and 6.34).

2.4 While noting that this study constituted interesting and important work, the Working Group noted that some issues needed further consideration including the change of trawl designs over the course of the collection of the data used as inputs to the model (e.g. changes in mesh sizes and the presence of fine-mesh codend inserts) and the likely invalid assumption of the Peninsula as being a closed system. It further highlighted the need to discuss the development of a standardised data collection plan to support the ongoing revision of the krill fishery management approach.

2.5 Dr S. Kasatkina (Russian Federation) noted that data on krill length and biological composition from catches of fishing vessels will be not suitable for such a modelling approach, and recalled that comparisons of krill length composition from catches of fishing trawls and catches of scientific trawls within the same fishing ground revealed significant differences (WG-ASAM-2021/03). Moreover, Dr Kasatkina noted that there were significant differences in the length composition of catches between fishing vessels and these differences are random in nature, which may be due to both the selective properties of commercial trawls, different fishing methods (continuous and traditional fishing) as well as the efficiency of krill sampling by observers at-sea (WG-ASAM-2021/03; WG-EMM-2024/37). Dr Kasatkina noted that this modelling effort required clarity regarding the interaction between the fishery and krill-dependent predators, which requires regular observations to study the spatial overlap of fishing zones and predator foraging zones and could be accompanied by krill distribution patterns (for example, such complex ecosystem observations were provided on RV *Atlantida* in 2020; SC-CAMLR-42/07). Dr Kasatkina recalled that the spatial and temporal dynamics of

krill biomass and its length structure in Subarea 48.1 are determined by the transport of krill groups from the Bellingshausen and Weddell Seas (Fach et al, 2002; Murphy et al, 2004; WG-EMM-2024/43; WG-EMM-2024/39) and noted that without data on krill transport and standardised acoustic surveys of krill, it is impossible to assess the influence of factors such as spatial heterogeneity and life history parameters on key krill population variables.

2.6 The Working Group encouraged the authors to provide a progression of model implementations from simple to more complex to facilitate understanding and evaluate the evidence for the model assumptions. It further noted the presence of patterns in the residuals shown in the paper (Figures 5 and 6) which warranted further investigation, as well as the need to assess the realism of some parameter values used in the model. The Working Group also indicated that this work would benefit from taking into consideration recent findings by SKEG regarding the krill stock hypothesis (e.g. WG-EMM-2024/39).

2.7 WG-SAM-2024/27 presented an analysis using a range of methods to determine growth (von Bertalanffy $L_\infty$ and $k$) and mortality ($M$) parameter values at the scale of management strata within Subarea 48.1. Using methods such as Modal Progression Analysis with Electronic Length Frequency ANalysis (ELEFAN) and empirical models of mortality, results indicated differences in parameter estimates between strata, highlighting the need for spatial consideration of parameter values in krill population dynamics models within Subarea 48.1.

2.8 The Working Group welcomed these efforts as the estimation of key parameter values was an important task to ensure model realism. It noted that such effort would benefit from using more recent approaches such as those described in Thorson et al. (2017) and those given here: http://barefootecologist.com.au/shiny_m.html. The Working Group further noted that the von Bertalanffy parameter $t_0$ would also deserve attention and that its influence could be tested through a sensitivity analysis. It also highlighted the importance of considering a seasonally-adjusted von Bertalanffy formulation as per the one used in the Grym.

2.9 The Working Group recommended that future krill assessment papers be accompanied by standard descriptive analysis reports that underpin the assessment, so that alternative models can be easily compared with the same observational data and assumptions. This would (i) describe the observational data and the methods used for their derivation, including providing tables within documents where appropriate, and (ii) describe the biological parameters used, including comparison with previous values assumed and estimates of uncertainty. The Working Group noted that the stock annexes used for the integrated toothfish models would be useful templates for the development of such documentation.

2.10 The Working Group discussed Task 1 of its intersessional work plan (effective sampling to estimate length frequencies; WG-SAM-2023, Table 1) and recalled previous efforts (WG-SAM-16/39; WG-SAM-2023, paragraph 3.4). It identified that some of the potential uses of such data include acoustic surveys, estimating growth and other life-history parameters, and providing catch length frequencies for use in length-based stock assessments (Figure 1), noting that each use may have different sample size requirements.

2.11 The Working Group noted that as well as considering sample size, sampling frequency should be considered, as length frequencies, in addition to being affected by gear type, design and operation, may be affected by time of day (i.e. day vs night) and may vary within a haul and within a small area, therefore sampling more frequently may be important to ensure representativeness. The current protocols require length data collection every 3 or 5 days

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depending on the month, whereas the Working Group discussed sampling being triggered by catch amount, number of hauls or 2h trawling periods, or movement between areas. It noted that WG-ASAM-2024 identified that sampling every 20 to 60 n miles along transects would be appropriate for the purpose of acoustic surveys (WG-ASAM-2024, paragraph 3.32).

2.12 Recalling the outcomes of WS-KFO-2023, The Working Group noted that the workload placed on the observers needed to be considered (also noting the estimated observation durations provided in WS-KFO-2023/03, Figure 3a). Differing views were expressed regarding the possibility of increasing the number of observers instead of prioritising the workload of existing observers. The Working Group acknowledged that image recognition technology may provide future opportunities to collect more length data more frequently.

2.13 Dr Kasatkina noted that the level of sampling by observers at-sea needed evaluation and recalled that the current levels of sampling in the krill fishery in Bransfield Strait are 6.6% of hauls sampled, that the current mean catch per sample collected is up to 714 tonnes and that this sampling level has no appropriate justification (WG-EMM-2022/28).

2.14 The Working Group discussed the potential to use the net configuration descriptions provided in fishery notifications to support analyses of length frequency data, and that such idea deserved further consideration.

**Development of stock assessments to implement decision rules for krill**

3.1 The Working Group recalled recent and noted continuing efforts towards the development of integrated stock assessments for krill (e.g. WG-SAM-2023, paragraphs 4.1–4.3, including ongoing efforts from American, Chilean and Chinese scientists). The Working Group welcomed these efforts and noted that more coordination was required between model development teams to:

(i) maximise efficiency

(ii) allow shared resources

(iii) ensure data that are used in multiple analyses are high-quality and

(iv) inform data collection needs which could, at least partially, be addressed through the SISO program.

3.2 In addition, communication with finfish integrated stock assessment modellers would be helpful.

**Develop methods to estimate biomass for finfish**

Survey design

4.1 The Working Group considered the high-priority tasks for finfish biomass estimation from the workplan (SC-CAMLR-42, Annex 15, Task 3 to Task 8). The Working Group noted

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that progress on these tasks was delayed due to the work needed to progress the stock assessment workplan this year.

4.2 The Working Group discussed Task 6 of its intersessional workplan (develop protocol for conversion factors; WG-SAM-2023, Table 1). It recalled previous work related to this issue (WS-CF-2022/01, WG-FSA-2022/12) and recent discussions on the use of French conversion factor data (WG-SAM-2023, paragraphs 5.1–5.3). It noted that the Secretariat and French scientists collaborated on this work during the intersessional period, and requested the Secretariat conduct a power analysis using Convention-Area-wide data to ensure applicability of the sampling protocol to all fisheries. The expected outcome of the analysis would be recommended sample sizes in space and time (e.g. per SSRU and per month) and the Working Group requested that the Secretariat present results at WG-SAM-2025.

Data collection – SISO and vessels

4.3 WG-SAM-2023/10 presented updates to both observer and vessel longline forms and manuals for introduction in the 2025 season as endorsed by the Scientific Committee in 2023. The changes included adding additional skate injury fields, linking tag recapture data to the corresponding biological information in the biological sampling worksheet using an individual fish serial number, and including more detailed tagging information and protocols and training information as developed during WS-TAG-2023.

4.4 The Working Group thanked the Secretariat for its efforts to maintain updated protocols for observers and supported the inclusion of specific data collection fields, and noted that the instructions will be introduced in the Observer Longline and C2 excel-based logbooks for season 2025, as well as included in the Scientific Observer – Finfish Fisheries, and Commercial Data Collection Manual – Longline Fisheries documents.

4.5 The Working Group encouraged the Secretariat to develop a more transparent mechanism to track the changes implemented across different versions of the CCAMLR data collection forms and manuals. This should include a submission of revised manuals and instructions with tracked changes as documents to the relevant meetings, and changes to workbooks detailed in a separate worksheet within each workbook.

4.6 The Working Group noted that video training materials on toothfish and skate tagging are under development, and that when finalised these will complete the updated training materials as recommended by the tagging workshop (WS-TAG-2023, paragraphs 2.27 and 2.39).

4.7 The Working Group noted that the request from WG-SAM-2023 to identify fish that were not randomly sampled was not addressed (WG-SAM-2023, paragraphs 5.5 and 5.6) and requested that this be addressed in future updates.

4.8 The Working Group noted the benefit of updating forms that are shared between vessel and observer logbooks at the same time so they maintain consistency. The Working Group noted that a tag overlap statistic calculator was available for vessels and observers on the CCAMLR website as a separate workbook and was updated following revisions to the calculation in December 2023 (see also WG-SAM-2024/20) along with the development of an R package (paragraph 11.9).

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Improve biomass estimation methods

4.9 WG-SAM-2024/08 presented an exploration of the CPUE by seabed area analogy method for estimating macrourids by-catch limits of toothfish fisheries in the Convention Area with limited macrourid data. The paper showed that the ratio of macrourid CPUE to survey density was not constant, that vessels using different gear types report CPUE values that do not show similar relationships with survey density, that the productivity parameters used to estimate precautionary exploitation rates vary among species and that species composition varies among areas.

4.10 The Working Group noted that the application of the CPUE by seabed analogy for by-catch species was unlikely to be successful, because fishermen actively attempt to avoid by-catch of macrourids while targeting toothfish.

4.11 The Working Group noted that the setting of by-catch limits for macrourids based on the 16% of the toothfish catch limits (WG-SAM-2024/08) could be improved, and encouraged Members to develop alternative methods based on direct estimates of abundance for the relevant species.

4.12 The Working Group noted that macrourid CPUE varies spatially and is likely related to environmental and ecological drivers that could be incorporated using spatial modelling methods such as VAST (e.g. WG-FSA-2022/48, WG-FSA-2023/33).

4.13 The Working Group noted that the trawl survey estimates from the Ross Sea surveys (WG-FSA-2023/27) could be used in addition to fishery by-catch data to develop models to predict the ratio of numbers of macrourids to the numbers of toothfish caught in different habitats, and that this ratio could be used to inform the derivation of by-catch limits.

4.14 The Working Group noted the development of alternative approaches would benefit from enhanced data collection on the biology of macrourid by-catch by species, and that this could be incorporated into research plans to collect data from more areas and habitats.

**Develop stock assessments to implement decision rules for finfish**

5.1 In response to the recommendation by WG-FSA-2023 (paragraph 4.58) and SC-CAMLR-42 (paragraph 2.121) on high-priority work for the toothfish stock assessments in Subarea 48.3, Divisions 58.5.1 and 58.5.2 and in the Ross Sea region, seven papers were presented to the Working Group that evaluated potential biases introduced by interannual spatial patterns in effort and tagging data, explored alternative methods for determining recruitment used in projections, investigated the implementation of dynamic $B_0$, and investigated CCAMLR decision rules with a Management Strategy Evaluation (MSE).

5.2 The Working Group thanked the authors and noted that this work represented a substantial effort to address the issues identified by the Scientific Committee. The Working Group also noted that the papers presented were the result of scientific collaboration between a large multi-Member team of scientists.

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Communication of progress, internal and external

Interannual variability in fishing patterns

5.3 WG-SAM-2024/22 and WG-SAM-2024/23 presented an exploration of the impact of tagging and recapture effort on mark-recapture abundance estimators in integrated Casal2 stock assessments for the toothfish fisheries in Subarea 48.3, Divisions 58.5.1 and 58.5.2 and in the Ross Sea region. The papers reported on simulations with a Shiny application which was developed to explore and visualise the potential effects of different types of population distributions, tagging and recapture rates, and distributions of recapture effort on abundance estimates. The papers also reported on analyses to enable the comparison of fishing and tagging effort between fishing seasons using correspondence analysis, spatial dissimilarity indices and kernel density estimation methods.

5.4 The Working Group noted that the correspondence analysis and dissimilarity indices for the toothfish fisheries in Subarea 48.3 and Division 58.5.1 provided consistent results which indicated a gradual change in the spatial distribution of fishing effort over the years. Dissimilarity in fishing effort was higher in Division 58.5.2 during 2013, 2014 and 2020 in particular, following markedly different patterns than other years. The fishery in the Ross Sea region showed a more random pattern between years with no overall trend, although there was some difference between the period before and after the introduction of the Ross Sea region MPA.

5.5 The Working Group noted that a number of factors could have contributed to the different patterns of fishing effort in the four areas, including different historical fishing operations and management arrangements, the number of vessels active in a fishery, and the size of suitable fishing grounds.

5.6 The Working Group noted that these patterns of spatial variability in fishing and tagging effort in Subarea 48.3, Division 58.5.1 and Division 58.5.2 could impact the stock assessment estimates derived from tagging data, in particular on the absolute level of SSB0 and stock status, trends in annual *SSB*, and trends in the estimates of recruitment. In the current implementations of the stock assessments, all tagged fish that have been released were assumed to have randomly mixed completely and are recaptured in proportion to the untagged population. However, most toothfish exhibit only limited movement, and therefore fish are typically recaptured in higher densities in the areas where they have been released. Fishing locations and any interannual variability in fishing patterns would therefore affect the relative number of recaptures in the catch.

5.7 The Working Group considered that the observed fishing patterns are likely to result in an overall negative bias in stock biomass estimates (i.e. an underestimate of the whole stock) similar to what has been predicted for Antarctic toothfish in the Ross Sea region where stock estimates from the stock assessment had been compared with estimates from the spatial population model (SPM, WG-FSA-2012/45, Mormede et al. 2014). The Working Group noted that while a continuous expansion of a fishery could create tag-recapture data that would result in an ongoing overestimation of stock abundance for a short time period, this was unlikely in these fisheries as suitable fishing grounds were limited and these fisheries have redistributed their effort on already fished grounds.

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5.8 While the bias in stock biomass estimates is likely to be negative overall, the Working Group noted that the degree of this bias in each year will depend on the fishery and fish population characteristics.

5.9 The Working Group noted that the values of dissimilarity indices may be difficult to interpret on their own as they depend on the underlying fishing patterns, and that, for example, spatial expansion, contraction or shifting between fishery grounds could result in a similar dissimilarity index. To account for the effects caused by interannual variability in spatial fishing effort on tagging data, the Working Group recommended the development of correction metrics for tag-recapture data. These metrics should be based on the characteristics of the fishery (such as annual spatial coverage) and characteristics of the fish populations (such as spatial density and movement).

5.10 The Working Group noted the need to separate the effects of potential underestimation of the stock, due to negative bias, from potential declines in recruitment. Therefore, for the integrated stock assessments presented to WG-FSA-2024, the Working Group recommended a general framework which consisted of sensitivities that included the following:

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

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

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

5.11 The Working Group noted that the biomass time series based on Chapman estimators should be run with at least a 1-year time lag, but that other time lags (e.g., 2–6) could also be included and evaluated. For the stock assessment model version (iii), the Working Group recommended that dissimilarity indices could be used to check that the variability of spatial fishing effort at the regional level did not display any systematic trends.

5.12 The Working Group noted that the implementation of this framework may vary in application for an individual stock assessment due to the characteristics of the different fisheries and encouraged the stock assessment scientists to continue their collaboration over the inter-sessional period in the lead-up to WG-FSA-2024.

5.13 The Working Group also recommended conducting sensitivity runs with partial or complete removal of tagging data and model retrospective analyses to WG-FSA-2024, specifically where there was evidence of a shift in spatial distribution of effort over a short period.

5.14 The Working Group requested that a version of the Shiny app presented as part of WG-SAM-2024/22 be hosted on the CCAMLR GitHub to enable others to understand and visualise the implications of spatial distributions of fishing effort and fish population, and various patterns and rates of tag release and recapture on tag-based abundance estimates.

5.15 The Working Group recommended that other approaches to address the effects of spatial variability in fishing and tagging effort in integrated stock assessments be developed and evaluated, such as:



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(i) spatial distribution models of recapture probabilities

(ii) spatially-explicit stock assessment models

(iii) structured fishing to minimise fishery-induced biases in biomass estimates from tag-recapture data.

The Working Group acknowledged that the development of such approaches may take some time due to their inherent complexity.

Recruitment in projections

5.16 WG-SAM-2024/23 presented an analysis of potential effects of alternative recruitment assumptions on the estimated spawning stock status over the 35-year projection period used to determine catch limits. Based on the 2023 toothfish stock assessments in Subarea 48.3, Divisions 58.5.1 and 58.5.2 and in the Ross Sea region, recruitment was projected forward that reflected the entire historical time series or the last 10 years of estimated recruitment or was determined by an autoregressive integrated moving average (ARIMA) time series approach. The paper also compared model estimates of recruitment to observations of recruitment from research surveys and identified differences in trends in some areas that may reflect model misspecification or observation bias.

5.17 The Working Group noted that recruitment trends differed between the four areas, and that the stock status at the end of the projection period was strongly influenced by the assumption about future recruitment for those assessments where a decrease in recent recruitment had been estimated.

5.18 The Working Group noted that the ARIMA recruitment time series used in these projections included autocorrelation such that low estimates at the end of the estimated recruitment time period continued at the start of the projection period, and that recruitment returned to the same as the mean of the historical time series in the long-term. The Working Group noted that autocorrelation is a common feature in recruitment and may need to be considered in recruitment projections. It also noted that this would increase the long-term variability in stock projections and therefore may impact the interpretation of the risk of the stock dropping below the depletion level in the application of the CCAMLR toothfish decision rules.

5.19 The Working Group noted that recruitment in the immediate future is likely to be similar to the period of recent estimated recruitment. Therefore, the Working Group recommended that where there is substantive evidence of a decrease in recent recruitment, the recent recruitment (e.g. using empirically resampling) rather than the entire estimated recruitment time series should be used in projections to determine the precautionary catch limits for the CCAMLR toothfish decision rules.

5.20 For such an approach, the Working Group noted that the recent recruitment period used for projections should be at least 10 years to include sufficient recruitment variability.

5.21 The Working Group noted that further work was needed to explore the approaches and criteria for identifying a suitable time period to use as the basis for projecting future recruitment.

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The time period is likely to be stock-specific, and factors that should be considered include, inter alia, clear changes in patterns of estimated recruitment, evidence of multi-year cycles in recruitment and environmental drivers, and the lifespan of the species.

Dynamic $B_0$

5.22 WG-SAM-2024/25 presented an evaluation of potential effects on toothfish stock projections in Subarea 48.3, Divisions 58.5.1 and 58.5.2, and in the Ross Sea region when changes in the underlying stock productivity (dynamic $B_0$) were assumed. The paper indicated that potential changes in stock productivity has implications for the management target and can result in significant changes in the current stock status.

5.23 The Working Group noted that changes in stock productivity due to environmental or ecosystem factors are an important issue for the management of fished stocks and that CCAMLR needs to collect information to detect such changes. The Working Group recalled the request by SC-CAMLR-42 (paragraph 2.149) to provide a summary of evidence for changes in stock assessment parameters or processes that could be due to the effects of environmental variability or climate change for all fisheries. The Working Group recommended that research and data collection plans in exploratory fisheries and under CM 21-01 include the collection of data that may assist in providing such information.

5.24 The Working Group noted that time-varying parameters can be included in Casal2 stock assessments. Exploration of this approach in assessments is another method to account for temporal changes in productivity.

5.25 The Working Group noted that a dynamic carrying capacity or $B_0$ is more likely for short-lived species and that the concept is already applied in some of CCAMLR's fisheries, notably mackerel icefish where essential parameters and biomass are frequently re-estimated.

5.26 The Working Group recalled that an approach following dynamic $B_0$ may not be precautionary if stocks are decreasing (SC-CAMLR-38, paragraph 3.61). This could also result in situations where stocks that have been exploited for a long period would appear to have higher current stock status when the estimate of $B_0$ was assumed to be lower due to decreased productivity.

5.27 The Working Group noted that, to proceed with a dynamic $B_0$ approach for managing stocks, there needs to be evidence for changes in stock productivity and its cause, and that these effects can be separated from the effects of fishing (WS-CC-2023/20).

General

5.28 The Working Group encouraged Members to consider the following new approaches in integrated toothfish stock assessments:

(i) use of Student's-t priors for non-informative priors instead of uniform priors which result in similar model estimates but improve MCMC convergence

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(ii) use of one-step-ahead (OSA) residual patterns for age compositions residuals (Trijoulet et al. 2019) instead of Pearson residuals, since OSA residuals may be more appropriate for non-normal multivariate distributions that have inherent correlations (Trijoulet et al. 2023)

(iii) application of length-based relationships for natural mortality. Huynh et al. (2018), Then et al. (2018), and Lorenzen (2022) have suggested that the rate of natural mortality is correlated with length, with Lorenzen (2022) providing empirical evidence that the rates of natural mortality were inversely proportional to length across a range of finfish species.

5.29 The Working Group recommended that, in addition to the standard model diagnostics (WG-SAM-2023 paragraph 6.33-6.34), a number of tables and plots be included routinely into future stock assessment papers, showing:

(i) trends in dissimilarity of fishing effort over time

(ii) trends in proportions of tag recaptures by release cohort and recapture time lag

(iii) trends in biomass estimates from the stock assessment against biomass indices from surveys (if available)

(iv) trends in estimated spawning stock status against harvest rates over time (Kobe plots)

(v) trends in estimated biomass against recruitment from the stock assessment

(vi) evidence for changes in stock assessment parameters or processes that could be due to the effects of environmental variability or climate change (WG-FSA-2023, Table 5).

WS-ADM2-2024

5.30 WG-SAM-2024/14 presented a draft report from the Conveners of the 2nd Age Determination Workshop (WS-ADM2-2024). The report summarised the progress made at the meeting and identified future work required to evaluate and improve consistency between Members' otolith ageing programs. The Working Group welcomed the work of WS-ADM2 and recognised the importance of accurate and consistent age readings for providing management advice.

5.31 The Working Group noted that the consistency of age estimates within individual labs was high. However, there was substantial variation in procedures used to prepare otoliths for ageing and interpretation, and a lack of consistency of age estimates between labs.

5.32 WS-ADM2 requested that WG-SAM:

(i) provide feedback to the otolith network about how readability scores were used within assessments and, if not, what information should be reported for the needs of the assessment

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(ii) consider whether there was a systematic bias created by the use of data from different readability scores and whether a bias would impact on the stock assessment

(iii) provide feedback to the otolith network on how stock assessments incorporate age uncertainty, so that production age readers understand the impact of the uncertainty in ageing

(iv) recommend to the Scientific Committee that the CCAMLR otolith network restart

(v) request that the Secretariat update the observer manuals to retain and freeze all small toothfish (< 40 cm), including from the krill fishery and that Members should notify the Secretariat that these collections exist, as small fish otoliths are extremely valuable and that there are many needs for these otoliths in age and growth work

(vi) recommend to the Scientific Committee that the age determination workshops continue annually in the short-term to ensure work is completed on the CCAMLR otolith reference sets, and to consider requesting funding from SCAF for the next calendar year to fund participation at the next workshop

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

5.33 Concerning requests (i) and (ii), the Working Group noted that although the readability scores of toothfish otoliths were typically recorded as 1-5 (with 1 usually being easiest to read, and 5 impossible, although in some cases the opposite order was used), very few otoliths were recorded with scores of 1 and 2, with most scored as 3 or 4. The Working Group noted that ages with readability scores of 1-4 were typically used in the assessment and that it would therefore be sufficient for stock assessment purposes to record whether the age associated with an otolith should be used for an assessment or not. The readability scores served mainly as a tool for a self-assessment by the age reader but have also been used to estimate ageing error matrix (Candy et al. 2012). Candy et al. (2012) have also shown that the increase in between-reader variability with more difficult otoliths is small.

5.34 The Working Group recommended that age-reading technicians monitor and report whether the proportion of unreadable otoliths shows any trend with length, which may introduce a bias when used in a stock assessment.

5.35 Concerning request (iii), the Working Group noted the importance of comparing readings from multiple age readers both on individual otoliths, and overall, as relatively small differences may have a substantial effect if there is a systematic difference across a large number of otoliths or across ages. The Working Group noted that although double-reading is important to estimate uncertainty and ensure quality, different ageing labs may have different capabilities for achieving this. The Working Group noted that previous work had identified that yield-per-recruit reference points were relatively insensitive to variability in ageing (Jones, 1990), however the impact on integrated stock assessments was unknown. The Working Group

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recommended that Members conduct further analysis on the effect of ageing uncertainty on the stock assessment to present to future meetings of WG-SAM, and that this task be added to the WG-SAM workplan (Table 2).

5.36 The Working Group noted that the Scientific Committee has endorsed restarting the CCAMLR otolith network (SC-CAMLR-42, paragraph 2.133) and looked forward to additional progress that this network will support. Additionally, the Working Group noted the value of inter-lab ageing comparisons to develop consistency between labs, and encouraged Members ageing toothfish to continue to participate in them.

5.37 The Working Group noted that request (v) may result in small fish (up to 40 cm) being retained in some toothfish fisheries, and that the intent to gain more samples of very young fish may be better achieved by encouraging Members to communicate with scientists collecting data from research trawls and maintaining sample collections to investigate the availability of toothfish less than 20 cm.

5.38 The Working Group recommended to the Scientific Committee that the Age Determination Workshop series continue to address its workplan in the coming year and focus particularly on the requirements for age determination in research plans that are working towards developing an age-structured stock assessment, such as that in Subarea 48.6. The Working Group noted that the meeting benefitted significantly from in-person attendance so that age readers could effectively collaborate and requested that the Scientific Committee provide funding to support participation.

5.39 The Working Group noted request (vii) and agreed that reference collections should reflect the composition of the fishery otoliths to be read in respect of the range of sex, length, season and readability, from each fishery area for which ageing is being conducted. The Working Group noted that the reference set should be large enough to ensure multiple fish at each age spanning the range of ages expected, and that it may be appropriate to add additional samples each year to ensure that it remains representative of the catch. For an initial training set, a relatively large sample would be needed, with age readers initially focusing on the easiest otoliths. To allow experienced readers to 'recalibrate' their age interpretations before production ageing there should be a low probability of the reader selecting the same samples each year.

5.40 Dr Okuda (Japan) informed the Working Group that in the short period since the workshop, the Japanese ageing laboratory had identified daily growth increments in the otolith of a toothfish, allowing additional confirmation of the location of the first anulus in a thin section, and that the results would be submitted by Japan to WG-FSA.

## Management strategy evaluations for target species

6.1 WG-SAM-2024/15 presented a general introduction to Management Strategy Evaluations (MSEs) and Harvest Control Rules (HCRs) and a glossary of common terms used in management strategies. MSEs provide a more robust approach than the traditional use of individual stock assessments to provide scientifically-based fisheries management advice. The effectiveness of management strategies relies on a set of agreed management objectives for the fishery and the stock, and then using MSEs to select the HCR that is most likely to achieve the

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management goals. In addition, it proposes standardised terms for probability and uncertainty for the Scientific Committee to use when reporting performance indicators and HCRs.

6.2 The Working Group acknowledged the importance of this paper and recommended that it should be submitted to the Scientific Committee.

6.3 The Working Group noted that the paper could be improved by including the formal statistical terminology in the definition of the terms for probability and uncertainty.

6.4 The Working Group noted that the Table 2 of the document provided a useful example of management objectives and performance indicators developed for toothfish fisheries in the SIOFA Area and could be easily adapted for CCAMLR.

**Evaluation of the CCAMLR decision rules and potential alternative harvest control rules for assessed fisheries**

6.5 WG-SAM-2024/16 presented a summary of the history of the CCAMLR decision rules, summarised how these are applied in integrated statistical catch-at-age toothfish stock assessments using constant catch HCRs, and developed potential ways in which HCRs based on a harvest rate U (Catch/SSB) could be implemented for the assessed toothfish stocks in CCAMLR.

6.6 WG-SAM-2024/17 presented simulations based on operating models using the most recent (2023) toothfish stock assessments in the Ross Sea region, Subarea 48.3, Division 58.5.1 and Division 58.5.2 to evaluate a range of HCRs which were based on harvest rates *'U'*. For each HCR, target harvest rates that would be consistent with the CCAMLR decision rules for toothfish and that ensured the target level of 50% spawning stock biomass ($B_0$) was met. The paper also presented an evaluation of the robustness of these HRCs to a range of assumed future recruitment patterns.

6.7 The Working Group noted that the 6 harvest control rules presented were alternative rules to the current constant catch CCAMLR HCR (Figure 2).

6.8 The Working Group noted that in contrast to the constant catch HCR which are used in the current CCAMLR decision rules, U-based HCRs do not rely on any assumptions about future recruitment patterns. Nevertheless, their performance depended on the future recruitment used in the simulations. When historical and future recruitment conditions were similar, all evaluated constant or ramp U-based HCRs achieved the target level (50% $B_0$) and avoided the depletion level (20% $B_0$). When future recruitment was lower than the historical average, all evaluated HCRs resulted in long-term spawning stock status below the target level. Ramp rules, as opposed to constant harvest rate rules, were more precautionary under low recruitment conditions, at the cost of lower catches and higher catch variability.

6.9 The Working Group noted that U-based methods could be integrated within the current toothfish decision rules and that one approach could be to supplement the current rules with an additional U-based rule, for example, for a given HCR (additions shown in underline and deletions shown in strikethroughs) the toothfish decision rules could be:

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1. Choose a yield γ1, so that the probability of the spawning biomass dropping below 20% of its median pre-exploitation level over a 35-year harvesting period is 10%.

2. Choose a yield γ2, so that the median escapement of the spawning biomass at the end of a 35-year period is 50% of the median pre-exploitation level.

3. Choose a yield γ3, so that the exploitation rate of the spawning biomass is equal to the long-term exploitation rate that ensures the stock will be at 50% of the median pre-exploitation level under the [X] harvest control rule.

4. Select the lower of γ1, ~~and~~, γ2, and γ3 as the yield.

6.10 The Working Group recommended that scientists developing integrated stock assessments consider including simulations based on rules 1, 3 and 6 (Figure 2) in relation to recruitment scenarios (i.e. based on all and recent estimated years), as well as the following performance indicators for WG-FSA 2024:

(i) median spawning biomass relative to $B_0$

(ii) proportion of years below 20% of $B_0$

(iii) proportion of years below 30% of $B_0$

(iv) proportion of years below 40% of $B_0$

(v) proportion of years below the target level

(vi) median total annual catch (t)

(vii) standard deviation of total annual catch (t)

(viii) distribution of changes in the catch limit

6.11 The Working Group noted that these HCR specifications could also be used for future MSE development.

6.12 The Working Group noted that developing a full MSE requires a substantial, multi-year commitment (e.g. Table 1).

6.13 The Working Group recommends that the Scientific Committee:

(i) considers what would be suitable U-based HCRs for use by CCAMLR to determine catch limits in assessed toothfish fisheries

(ii) considers the relevant performance indicators (PIs), and possible approaches for trade-offs, that could be used to evaluate the performance of HCRs

(iii) considers which HCRs, the operating and estimation model scenarios, and questions that should be investigated in an MSE to evaluate HCRs and their combined effects, e.g.

(a) what types of HCRs and decision rules should be tested?

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(b) what historical and future population and productivity scenarios should be tested?

(c) what type of stock assessment features and misspecifications should be investigated?

(d) whether other constraints (e.g. on changes to catch limits or breakout rules) should be evaluated?

(iv) considers how U-based HCRs could be integrated into the current CCAMLR decision rules.

6.14 The Working Group thanked the authors and acknowledged the impressive collaborative work of the 13 scientists who participated in the intersessional works, leading to the submission of seven outstanding papers to WG-SAM 2024.

Development and testing of data-limited fishery decision rules

6.15 WG-SAM-2024/01 presented a parameter perturbation analysis for the Agent-Based Model (ABM) previously presented in WG-SAM-2023/17. This analysis provided a baseline response of the model which will be useful to assess the effects of changes to the model in the future.

6.16 The Working Group noted that this work had been done following the recommendation by WG-SAM-2023 (paragraph 7.3(ii)). It noted that the ABM approach allowed a high level of complexity so that it was able to fully replicate and simulate the current trend analysis rules and management processes. The Working Group suggested that the authors use the ABM to evaluate where this complexity was required and if it had a meaningful influence on the model outcomes and conclusions.

6.17 WG-SAM-2024/09 presented comparisons of outputs between the ABM and Casal2. Starting from a baseline simulation, additional complexity was incrementally added to both models.

6.18 The Working Group noted that this work had been done following the recommendation by WG-SAM-2023 (paragraph 7.3(iii)). It noted that the ABM and Casal2 had produced the same outcomes when using the same assumptions and population processes and agreed that this demonstrated that the processes implemented in the ABM had been validated. The Working Group noted that the next step of this project was to conduct a similar comparison while including tagging and recapture processes.

6.19 WG-SAM-2024/12 presented the preliminary trend analysis for research blocks in data-limited toothfish fisheries and requested feedback from the Working Group. The document included summaries of fish releases and recaptures within and between research blocks, annual biomass estimates and updated trends, the decision tree of the trend analysis, preliminary catch limits and retrospective analyses. The general bathymetric chart of the Oceans (GEBCO) dataset was used to estimate fishable areas and associated CPUE-by-seabed area biomass estimates and preliminary catch limits, and this was compared with the International Bathymetric Chart of the Southern Ocean (IBCSO) data.

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6.20 The Working Group noted the relatively small impact on biomass estimates, the greater coverage and more frequent updates of the GEBCO dataset, and recommended continuing the use of the GEBCO dataset for the purpose of the CPUE-by-seabed area calculations.

6.21 The Working Group noted the long-distance movements of a small number of tagged fish that was presented in the paper and that some of these movements seemed implausible, while the tag-linking algorithm suggested that there was a very high confidence in the link between these releases and recaptures. However, the Working Group also noted that there may be alternative explanations for some of the movements, including data recording errors that may arise when vessels record release events.

6.22 The Working Group noted that there had been a few tagged fish that had moved between the CCAMLR and SIOFA Areas. The Secretariat noted that these data had been summarised in a paper to the SIOFA Scientific Committee (SC-09-26 rev. 1) under the Scientific Data Exchange Agreement between CCAMLR and SIOFA, and a summary would also be provided to the CCAMLR Scientific Committee later this year.

**Review of new research proposals**

7.1 Three new proposals were submitted and reviewed by the Working Group (Table 2).

New proposals under CM 21-02

7.2 WG-SAM-2024/04 presented a new research proposal by Japan, the Republic of Korea (Korea), South Africa and Spain for participation in the exploratory fishery for *Dissostichus mawsoni* in Statistical Subarea 48.6 from 2024/25-2027/28. This proposal included three objectives: (i) providing an assessment of the stock status including size/age structure of *D. mawsoni*, (ii) investigating ecological traits of *D. mawsoni*, and (iii) improving knowledge of Antarctic marine ecosystems.

7.3 The Working Group suggested that an overall summary of information gained from the previous research proposal would provide a stronger rationale for the scientific value of the new research proposal. The Working Group noted that Research Block 486_2 was assumed as the spawning ground in the previous proposals, and suggested that this hypothesis might be tested in the new proposal by collecting biological data and exploring movement patterns to other areas. The Working Group noted that papers addressing the remaining milestones from the previous research plan, including a Casal2 assessment, will be presented to WG-FSA-2024.

7.4 The Working Group recommended an increase in the sample size of by-catch species' collected, and conducting particle tracking modelling work to inform the updated stock hypothesis milestone for the area.

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

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

New proposals under CM 24-01

7.7 WG-SAM-2024/03 presented a proposal by Korea and Ukraine for participation in the exploratory fishery under CM 24-01 for *D. mawsoni* in Statistical Subarea 88.3 from 2024/25–2026/27. The proposal included four objectives: (i) providing an assessment of the stock status of Antarctic toothfish, (ii) improving the understanding of biology of Antarctic toothfish including abundance, distribution and stock structure, (iii) identifying information on by-catch species, and (iv) improving the understanding of trophic relationships and ecosystem changes.

7.8 The research plan proposed to close research blocks 883_6 and 883_7 due to the presence of young individuals, and research blocks 883_8, 883_9 and 883_10 due to difficult fishing conditions. The research plan proposed to add two new research blocks (883_11 and 883_12) in the slope between research blocks 883_1 and 883_3.

7.9 The proponents noted that the bathymetry and location of these two proposed research blocks (883_11 and 883_12) would be useful in exploring and refining the stock hypothesis for this Subarea. The Working Group suggested that the rationale for the two new proposed research blocks should be provided in the research proposal.

7.10 The Working Group suggested that, when proposing new research blocks that are close to land, WG-EMM be asked to review whether there is overlap with important bird or marine mammal areas. The Working Group further suggested that the survey design, including the justification for retaining research block 883_2, which is difficult to access due to sea ice, and research block 883_5, which has low catch rates, should be linked closely with the objectives of the revised research plan.

7.11 The Working Group discussed the calculation of catch limits for the two new research blocks (883_11 and 883_12). The Working Group recommended that the catch limits be re-calculated based on the standard process used for effort-limited research blocks, i.e. determining the number of stations needed per block and then using the 75$^{th}$ percentile of the relevant catch rate data to estimate a catch limit.

7.12 The proponents noted that they would engage in discussions related to the proposed D1MPA to ensure there was consistency of the Subarea 88.3 research plan with this initiative.

7.13 The proponents indicated that training and support in the development and implementation of a Casal2 stock assessment model was required to meet the objectives of the new research proposal. A GCBF proposal has been developed to address this need.

7.14 The Working Group recommended that the Scientific Committee endorse the Cap-DLISA funding proposal to the General Capacity Building Fund to hold a Casal2 stock assessment workshop in 2025.

7.15 The Working Group recommended that the outstanding milestones from the current research proposal be presented to WG-FSA-2024, and that WG-FSA take into account any lack of progress in outstanding milestones when evaluating research proposals.

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7.16 WG-SAM-2024/06 presented a proposal by Ukraine to conduct an acoustic trawl survey under CM 24-01 of mackerel icefish (*Champsocephalus gunnari*) in Subarea 48.2 from 2024/25-2027/28. The main objective of the research was to determine the distribution and the abundance of *C. gunnari* in Subarea 48.2.

7.17 The Working Group noted that WG-ASAM-2024 had supported this proposal (paragraphs 7.1 to 7.8) and suggested that results from new surveys should be submitted for evaluation to WG-ASAM in the future.

7.18 The use of historical reference catch rate values for the calculation of catch limits for the research plan was discussed. The proponents noted their willingness to re-calculate catch limits. However, it was also noted that this is an effort-limited survey and so the catch limits should be set in a way to allow the completion of the survey

7.19 The proponents suggested that data collected from their surveys would provide a minimum rather than an absolute abundance estimate for *C. gunnari*. They also indicated that they had agreement for the provision of training in acoustic methodologies which would be a benefit to this research.

7.20 The number (and frequency) of acoustic frequencies to be used for this research plan was discussed, particularly in regard to the estimation of pelagic biomass. The proponents indicated that the research plan would not proceed if all necessary research equipment was not available.

7.21 The Working Group noted that the stock structure for mackerel icefish in the Scotia Sea is complex and so information on a local biomass estimate would be useful.

**Review of ongoing research plan results and proposals**

Research results and proposals from Area 48

8.1 WG-SAM-2024/07 presented an updated analysis of sea ice concentration (SIC) sea surface temperature (SST) and winds, as well as a statistical analysis of repeated accessibility (RA) in Subarea 48.6 research blocks 486_5 and 486_4 with fishing locations.

8.2 The Working Group noted that the SICs in 486_5 and 486_4 from January to March 2024 were the lowest of the 2017–2024 period, and that there appears to be a warming phase from 2022 to the present in both RBs in the southern research blocks. It was noted that 486_5 has considerably more ice and was least accessible, and that 486_4 is more accessible.

8.3 The Working Group agreed that sea ice analysis would be useful to undertake for all research blocks in the Convention area. It noted that this analysis was undertaken after specifically requesting data and code from colleagues in Germany. The Secretariat offered to contact German colleagues and explore the provision of code and creation of these analyses for the Convention Area.

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Research results and proposals from Area 58

8.4 WG-SAM-2024/02 presented an update of the research plan for continuing research in the *D. mawsoni* exploratory fishery in Divisions 58.4.1 and 58.4.2 from 2022/23 to 2025/26 under CM 21-02, paragraph 6(iii) that was presented in WG-SAM-2023/03. The Working Group noted the addition of a vessel and a proposal to structure fishing in Division 58.4.1 to allow for an evaluation of the effects of gear type on the collected data.

8.5 The Working Group noted that exploratory fishing under this research plan has been conducted in Division 58.4.2 by two Members using autoline, but that no exploratory fishing for toothfish has been allowed in Division 58.4.1 since 2018/19.

8.6 The Working Group noted that the exploratory fishery and associated research in Division 58.4.1 are important if a robust assessment of *D. mawsoni* is ever to be achieved. The Working Group noted that the research plan includes a proposal for structured fishing in this Division using two gear types in each research block to evaluate the effect of gear type on collected data.

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

8.8 Dr Kasatkina noted that currently, there is no scientifically based evidence adopted by the Scientific Committee that allows proponents of the program to ignore the international practice of using standardised fishing gears in multivessel resource programs. Therefore, the use of standardised fishing gear will meet the objectives of the research plan for data-limited fisheries and comply with current Conservation Measures.

8.9 The other participants of the Working Group noted that standardised gear type is not a requirement for research proposals submitted under CM 21-02 paragraph 6(iii), and recalled extensive discussion on this issue (WG-SAM-2019/25; WG-SAM-2019, paragraphs 6.1–6.7 and 6.54–6.72; WG-FSA-2019, paragraphs 4.89–4.114; SC-CAMLR-2019, paragraphs 3.102–3.123; SC-CAMLR-2020, paragraphs 4.10–4.13; WG-SAM-2021, paragraphs 8.8–8.14; WG-FSA-2021, paragraphs 4.17–4.28; SC-CAMLR-2021, paragraphs 3.100–3.104; WG-SAM-2022, paragraphs 5.8–8.20; WG-FSA-2022, paragraphs 5.21–5.39; SC-CAMLR-2022, paragraphs 3.125–3.136; WG-SAM-2023, paragraphs 9.12–9.19; WG-FSA-2023, paragraphs 4.168–4.174; SC-CAMLR-2023, paragraphs 2.192–2.195).

8.10 The Working Group noted that this was not an issue of the scientific approach or sampling design set out in WG-SAM-2024/02, but arose from different interpretations of the requirement of standardised gear in CM 24-01, Annex 24-01/A, format 2 which is used for research plans operating under CM 21-02. The Working Group agreed that the interpretation of CMs was an issue for the Commission.

8.11 The Working Group discussed the design of a structured sampling program in Division 58.4.1 to formally compare selectivity of gear types and the effects of different gear types on data collected by the fishery such as tagging data and catch length compositions.

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8.12 The Working Group noted that there are three gear types used in the proposal, and that a comparison of two gear types within each research block could be designed according to a random, or prescribed, structured sampling design. It recognised that a structured design would be logistically challenging due to the difficulties with sea ice in Division 58.4.1, and that there have been numerous successful comparisons using random sampling designs.

8.13 Given that the objective of this research is ultimately a successful mark-recapture study that would provide information for a stock assessment, the Working Group considered how the use of mixed gear types would impact a tagging study.

8.14 The Working Group noted that the *D. mawsoni* fishery in the Ross Sea uses multiple gear types, and that there is no evidence that the tagging data which underpins these assessments has been impacted by gear configuration. It noted that gear types are not preferential in relation to sampling tagged and untagged fish, and that Member, and not gear type, is a better predictor of the tagging performance and survivability.

8.15 The Working Group noted that the depth of fishing can influence selectivity since increasingly larger fish are found at greater depths. The Working Group agreed that the comparison of gear types could mitigate potential selectivity effects by undertaking paired hauls in close proximity.

8.16 The Working Group recalled a comparison of Spanish and Trot line set out in WG-FSA-12/49 which showed there was no impact on the tagging program from the different gear types on tagging-related mortality and fish condition, and that there were no differences in the size distribution of fish between the two gear types.

8.17 The Working Group recommended that a comparison of gear types in Division 58.4.1 would best be undertaken by using a depth-stratified, random sampling design, using two gear types in each research block, with paired sets being as close together as feasible. It further concluded that this study would be a valuable, controlled experiment that could be used to examine the effects of mixed gear types on a variety of different aspects.

8.18 The Working Group also recommended that effects of different gear types on collected data be compared using data from the Ross Sea region fishery, where extensive data sets from vessels using the three longline gear types will allow for data analyses at small spatial scales. The Working Group noted that results of such analyses could differ between the Ross Sea region and Division 58.4.1 since the two fish stocks and fisheries exhibit different characteristics.

8.19 The Working Group recommended that the research proposal as detailed in WG-SAM-2024/02 proceed for Division 58.4.2 and that a comparison of gear types using a depth-stratified, random sampling design, using two gear types in each research block be conducted in Division 58.4.1.

Research results and proposals in Area 88

8.20 WG-SAM-2024/21 provided a progress report on the 2024 Ross Sea shelf survey. The Working Group noted that this was the 13th consecutive survey undertaken by New Zealand on the southern Ross Sea shelf to continue the time series of relative abundance and age

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structure, and to provide information on year class strength, variability, and autocorrelation, for input into the Ross Sea region toothfish stock assessment. On behalf of New Zealand, Mr Dunn thanked the invited scientist, Dr C. Jones (USA), as well as the previous international scientists who have contributed time and effort to participate on these surveys.

8.21 The Working Group noted that this was the first of such surveys in this series that was not completed as planned. During this survey, only 12 of the planned 45 stations in the core survey area (10 in stratum A, and 2 in stratum B) were completed because freeze-up occurred following a lengthened commercial season. It was also noted that the biennially surveyed McMurdo Sound (the stratum N) was successfully completed.

8.22 The Working Group noted that, although the core area of the survey was not completed, there was some evidence in the length frequency data of a new cohort coming through the core strata.

8.23 The Working Group noted that the voluntary seabird exclusion zone in the McMurdo stratum, imposed on the survey by New Zealand, reduced the access of the survey stratum by 43%. The Working Group agreed that this created problems in relation to assigning random sets for the McMurdo strata and potential access to important stations near the ice shelf. The Working Group noted that there have only been two flying seabirds caught in the Ross Sea region by fishing vessels in the history of the fishery, both north of 70°S. As such, the Working Group requested that New Zealand consider whether these seabird exclusion zones were necessary or could be reduced in size, as the risk of a seabird interaction was very low.

8.24 The Working Group noted that this survey was undertaken later in the season than any of the other southern shelf surveys, and that this was likely the most important factor in not being able to successfully complete the survey. It was also noted that survey timing may influence catch rates, though this would be difficult to conclude without having another survey earlier in the same season to compare.

8.25 The Working Group agreed it would be worthwhile to examine historical data on early and late season catch rates prior to the establishment of the Ross Sea region MPA, when there was annual commercial fishing being undertaken in the southern Ross Sea region.

8.26 The Working Group recommended that future surveys plan to complete the three core strata first, to ensure that the age and abundance data can continue to be used in the Ross Sea region stock assessment. Should lengthened commercial seasons continue, a more fundamental solution may be required for future surveys, and this should be considered when future multi-year research plans are submitted.

8.27 The Working Group noted that three pop-up satellite tags were deployed during the survey, and encouraged all scientists deploying satellite tags to coordinate with the Korean project to consolidate all satellite tagging activities and data sources in the Convention Area.

8.28 WG-SAM-2024/05 provided a notification for the Ross Sea Region shelf survey for the 2024/25 season, which is the third year of an approved three-year research plan under CM 24-01 that was proposed in WG-SAM-2022/01 Rev. 1 and WG-FSA-2022/41 Rev.1. The Working Group noted that the same design will be used as described in WG-SAM-17/39. The Working Group noted that the survey plan was not required to be reviewed by WG-SAM this year (CCAMLR-38, paragraph 5.64), and recommended that the survey progress as planned.

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8.29 WG-SAM-2024/13 provided a progress report on the joint research for *Dissostichus* spp. in Subarea 88.3 by Korea and Ukraine during the 2023/24 fishing season. Research fishing was conducted by two vessels following the survey design described in WG-FSA-2022/26.

8.30 The Working Group noted that CPUE for *D. mawsoni* varied widely among the research blocks, with high variability in research blocks 883_1, 883_3 and 883_4. It was further noted that there were very few fish caught in 883_5, though it was also noted that the fishable area of 883_5 is very small.

8.31 The Working Group agreed that the analyses presented in WG-SAM-2024/13 were comprehensive. It was recommended CPUE be standardised to allow for trends in stock size potentially be detected. It was noted that there is likely enough information to permit standardisation, and that this will be presented by Korea and Ukraine at WG-FSA.

8.32 The Working Group noted that there appear to be some similarities to Ross Sea toothfish with respect to length frequency and maturity, and that there are likely linkages between the Ross, Amundsen, and Bellingshausen seas. The Working Group agreed that it would be worthwhile undertaking a more formal comparison of *D. mawsoni* demographics between these areas to investigate this further.

8.33 The Working Group noted that Figure 5 of WG-SAM-2024/13 shows bi-modal length frequencies, similar to fish on the slope in Subarea 88.2. It further noted the lack of fish near the 100 cm length class in fish along the shelf of the Bellingshausen Sea. The Working Group suggested that separating the length samples by depth may indicate that the large fish inhabited a different depth zone than the smaller fish.

8.34 The Working Group noted that the proportion of juveniles appears to decrease from east to west, similar to patterns observed in the Amundsen Sea. More analysis is required to determine whether this is related to the stock hypothesis of this region.

8.35 The Working Group recommended that Korea and Ukraine present updated milestones at WG-FSA to ensure that all elements are being met and on-track.

8.36 WG-SAM-2024/19 provided a preliminary notification of the intention to evaluate the feasibility of pot fishing to catch *Dissostichus* spp. in the Ross Sea in the 2025/26 season. The trial aims to investigate the effectiveness of pot fishing in reducing by-catch of skates and macrourids, relative levels of benthic impacts, and to increase the quality and viability of tagged fish. This trial would be undertaken in conjunction with longline fishing and will include cameras.

8.37 The Working Group noted that efforts to conduct pot fishing for toothfish have been undertaken in the past by some other Members, including France and the United Kingdom, although different pot configurations were used. It was noted that there were some issues with fish condition being impacted by amphipod depredation (by scavenging sea lice), and physical injuries of being in confined spaces. It was also noted that previous pot trials had low CPUE and that there were often high levels of by-catch.

8.38 The Working Group noted that the intention was to attach pots on longlines during the fishing season and cautioned that data reporting could be problematic if catches were reported on the C5 form. The Working Group encouraged the authors to discuss with the Secretariat how

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data from longlines and pots, where pots were also used, would be recorded on the C2 and C5 data forms, and include the planned method for data recording within any future notification.

8.39 The Working Group speculated that the deployment of strings of pots may have higher CPUE as a result of the bait plume, and that it would be valuable to test this in the future following the initial single-pot trials. The Working Group noted a potential issue with tangles in the use of combined pots and longlines, and that the occurrence of such tangles should be tracked.

8.40 The Working Group agreed that attention should be paid to the condition of fish as they may be subject to greater injuries and unsuitable for tag and release. It suggested that the use of knotless pot netting may reduce this problem, and encouraged the authors to collect information on the fish condition and their suitability for tagging as a part of the data collection for the trial.

8.41 The Working Group noted that the proposed use of 10 pots in this trial was not intended to collect statistically robust catch information, but instead to evaluate the operational feasibility of fishing using this gear.

8.42 The Working Group agreed that this would be a useful trial and encouraged the authors to submit a notification for the trial in 2025. If the trials are successful, the Working Group agreed that this sort of fishing technique could be scaled up.

**Ecosystem monitoring**

9.1 WG-SAM-2024/11 presented a summary of incidental mortalities of seabirds and marine mammals associated with fishing from data reported by the vessels and SISO observers throughout the history of the fisheries, including partial 2023/24 season data. It also presented an update on the methods for the extrapolation of IMAF and warp strikes, taking into consideration the recommendations from WG-IMAF-2023 (paragraph 2.7 (iii, iv)) by including uncertainty, through the use of bootstrap methods, and defining the unit of observation effort.

9.2 The Working Group noted diversity in the rate of data collection for IMAF observations and warp strikes, also noting that warp strike observation times had been increased for the upcoming seasons (SC-CAMLR-42, paragraph 3.35).

9.3 The Working Group noted that there may be issues with the consistency of the data, such as the occurrence of vessels operating during the same timeframe in the same location having very different bird observations, which seemed implausible. The Working Group recommended that the underlying data be fully explored to understand the plausibility of the data and whether changes in mitigation measures may need to be included in the analysis.

9.4 The Working Group noted that there was ambiguity regarding the recording of IMAF events and whether recording was by the scientific observer or vessel crew for finfish trawl fisheries. Therefore, it would be useful for data collection forms to include a field to capture this information to aid in future analysis and extrapolation exercises.

9.5 The Working Group noted the use of bootstrap methods to incorporate uncertainty and recommended that modelling approaches such as GAMs should be explored given that the observed counts may have a highly skewed distribution, and observations may not always be

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independent. The Working Group noted that zero-inflated distributions (e.g. zero-inflated Poisson or negative binomial) are likely to be more appropriate for modelling these events. The Working Group noted that there had already been extensive work in global fisheries modelling bird and mammal interactions and recommended that a literature review would help with selecting appropriate models. The Working Group recommended presenting a 95th percentile range of uncertainty in future iterations of the work.

9.6 The Working Group recommended that the Secretariat work with WG-SAM participants to provide an update on progress to WG-SAM-2025 exploring appropriate modelling approaches and diagnostics – initially focusing on the krill fishery, which appears to have the highest numbers of interactions.

9.7 The Working Group noted that given temporal trends in the encounter rates, it may be appropriate to select different time periods depending on the purpose for which the extrapolated data were being used. For example, it may be most appropriate to use only the most recent five years of data to provide information about the effectiveness of current management measures.

## Future work

10.1 The Working Group reviewed the current workplan (SC-CAMLR-42, Annex 15) and adjusted the timing and collaborators associated with the current tasks (Table 3). It also added several new tasks generated from discussions during the meeting.

10.2 The Working Group noted that Tasks 9 through 13 in the 2023 report of the Scientific Committee (shown in tracked changes in this report) had been incorporated into the workplan of the age determination workshops and therefore were not needed as part of the WG-SAM workplan. However, the Working Group added two other tasks related to the use of age data.

10.3 The Working Group noted that Task 19, relating to the determination of effective sample size of fish by-catch in the krill fishery, required more information before it could be evaluated by WG-SAM. The Working Group noted that issues relating to by-catch in the krill fishery are pertinent to the work of WG-EMM and WG-FSA as well as to the work of the scientific observers. Recent analysis of by-catch sampling has highlighted increases in the number of species reported, issues with the sample selection procedure, and sampling frequency (WS-KFO-2023). The Working Group requested WG-FSA to consider the purpose(s) of by-catch sampling in the krill fishery in order to better advise on an effective sampling design.

## Other business

11.1 CCAMLR-42/18, sought to establish clear and transparent requirements for the term ‘best available scientific evidence’ under Article IX(1)(f) of the CAMLR Convention and to develop a process for CCAMLR to verify and validate whether data meets the requirements of the ’best available scientific evidence’.

11.2 The Working Group noted that the paper was reviewed by CCAMLR-42 (paragraphs 4.14–4.19), and further noted that the CCAMLR Resolution on Best Available Science

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(31/XXVIII) already addresses the main points of the paper including review, transparency, independence and application.

11.3 The Working Group noted significant discussions in the Scientific Committee and its working groups on the development and use of science in its work (SC-CAMLR-XXXV, Annex 7, paragraph 3.91). It further referred to Sullivan et al. (2006), which summarised that to achieve high-quality science, scientists conduct their studies using what is known as the scientific process, which typically includes the following elements:

(i) a clear statement of objectives

(ii) a conceptual model, which is a framework for characterising systems, stating assumptions, making predictions, and testing hypotheses

(iii) a good experimental design and a standardised method for collecting data

(iv) statistical rigor and sound logic for analysis and interpretation

(v) clear documentation of methods, results, and conclusions; and

(vi) peer review.

11.4 The Working Group thanked New Zealand for the development and updating of Casal2 software for conducting its stock assessments. The Working group noted that the development of CASAL and Casal2 had allowed CCAMLR to significantly progress the integrated stock assessments for toothfish and represented a substantial investment by New Zealand. The Working Group thanked New Zealand for developing and making the software available to CCAMLR, and noted that it would be beneficial for Members to contribute to its future development. The Working Group encouraged Members who use the software or participate in fisheries that were assessed by Casal2 to contribute to the development of the underlying code, supplementary code, and user manuals and guides for Casal2 to help ensure it remains up-to-date and relevant to the work of CCAMLR.

11.5 The Secretariat notified the Working Group that the UN Food and Agriculture Organisation (FAO) would like to include information on CCAMLR fisheries in its annual Status of Fisheries report, but that to do so it needed relevant metrics which could be linked to their fishery status classification system. FAO was seeking these metrics from CCAMLR fisheries to publish by the end of 2024.

11.6 The working group noted that the FAO metrics were tiered, and included a list of potential metrics which applied to fisheries depending on their level of information. These included:

(i) stock abundance

  (a) biomass expressed as percent of unfished biomass

  (b) catch rates (CPUE) expressed as percent of initial levels

  (c) survey indices expressed as a percentage of initial values

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(ii) spawning potential

(a) spawning stock biomass expressed as percent of unfished biomass

(iii) catch trends

(a) catch trends over time and comparisons with fishing effort trends

(iv) size/age compositions

(a) size/age composition trends in comparison with the initial stages of the fishery.

11.7 The Working Group noted that FAO's criteria would likely classify CCAMLR's fisheries as 'non-fully exploited,' and that the application of this terminology should be evaluated by the Scientific Committee.

11.8 The Working Group noted that the metrics involved for the integrated assessments were typically calculated as part of the assessment process and could be provided this year to the FAO if agreed by CCAMLR. The Working Group recommended the Scientific Committee consider this issue.

11.9 WG-SAM-2024/20 reported on an updated R package 'CCAMLRTOOLS', which contains an easy-to-use function to calculate the tag overlap statistic from standard CCAMLR data extracts. Additional functions can be added to this package upon request by Members.

11.10 The Working Group thanked the Secretariat for producing the R package and encouraged Members to use it in calculating the tag overlap statistic, as well as to provide or request new functions to increase its versatility.

**Advice to the Scientific Committee**

12.1 The Working Group's advice to the Scientific Committee is summarised below; these advice paragraphs should be considered along with the body of the report leading to the advice:

(i) Toothfish data collection plans (paragraph 5.23)

(ii) Support for the next Age Determination Workshop Proposal (paragraph 5.38)

(iii) Harvest Control Rules (paragraph 6.13)

(iv) Research plan for 58.4.1 (paragraph 8.19)

(v) Research proposal for the Ross Sea Shelf Survey (paragraph 8.28)

(iv) FAO Status of Fisheries Reporting (paragraph 11.8).

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## Adoption of the report and close of the meeting

13.1 The report of the meeting was adopted, with the adoption process requiring three hours of discussion.

13.2 At the close of the meeting, Dr Okuda thanked the participants for their collaboration and coordination in completing the meeting. He also thanked the rapporteurs and the Secretariat for their work and support in developing the report.

13.3 Mr Dunn (New Zealand) thanked Dr Okuda for his clear and efficient leadership, organisation of the meeting, and expert guidance. He noted that the report was adopted in record time, which indicated the skill of the Convener and collaboration among the participants.

13.4 On behalf of the meeting participants, Dr Ziegler thanked the hosts for their hospitality, choice of such a lovely town to host the meeting, lunch on Monday and dinner on Thursday, as well as sourcing excellent meeting facilities and organising fantastic weather for the week.

13.5 Dr Schaafsma thanked the participants for coming to Leeuwarden, conducting a productive meeting, and wished all a safe trip home.

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Table 1: Draft workplan to complete Management Strategy Evaluation (MSE) tasks for the evaluation of Harvest Control Rules (HCRs).

| Task | Collaborators | Year | Reporting to | SC and Commission |
|---|---|---|---|---|
| Develop MSE framework and initial testing of candidate HCRs | | 2024/25 | WG-SAM-2025<br>WG-FSA-2025 | Review and guidance from SC-44 |
| Extensive testing of candidate HCR and their combination in decision rules under different productivity scenarios | | 2025/26 | WG-SAM-2026<br>WG-FSA-2026 | Decision from Commission-45 |
| Implementation of updated Decision Rules | | 2026/27 | WG-SAM-2026<br>WG-FSA-2026 | |

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Table 2: Summary review schedule of proposed and ongoing research proposals under CM 21-02 and CM 24-01 as of 15 June 2024. 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 – Republic of Korea, NZL – New Zealand, UKR – Ukraine, ZAF – South Africa.

| CM | Research notification | Title of notification | Member | Area | Fishing seasons | Years since approval (approved year) | Meeting year | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 2024 | 2025 | 2026 |
| 21-02 | WG-SAM-2024/02 | Continuing research in the *Dissostichus mawsoni* exploratory fishery in East Antarctica (Divisions 58.4.1 and 58.4.2) from 2022/23 to 2025/26; Research plan under CM 21-02, paragraph 6(iii) | AUS, FRA, JPN, KOR, ESP | 58.4.1 | 2022/23-2025/26 | New | SAM[*2] FSA | - | |
| 21-02 | WG-SAM-2024/02 | Continuing research in the *Dissostichus mawsoni* exploratory fishery in East Antarctica (Divisions 58.4.1 and 58.4.2) from 2022/23 to 2025/26; Research plan under CM 21-02, paragraph 6(iii) | AUS, FRA, JPN, KOR, ESP | 58.4.2 | 2022/23-2025/26 | 2 (2022, WG-SAM-2022/04[*1]) | FSA | - | |
| 24-01 | WG-SAM-2024/03 | New research plan for Antarctic toothfish (*Dissostichus mawsoni*) under CM 24-01, paragraph 3 in Subarea 88.3 by Korea and Ukraine from 2024/25 to 2026/27 | KOR, UKR | 88.3 | 2024/25-2026/27 | New | SAM FSA | FSA | FSA |
| 21-02 | WG-SAM-2024/04 | New research plan for Antarctic toothfish (*Dissostichus mawsoni*) exploratory fishery in Statistical Subarea 48.6 from 2024/25-2027/28): Research Plan under CM21-02, paragraph 6(iii) | JPN, KOR, ZAF, ESP | 48.6 | 2024/25-2027/28 | New | SAM FSA | - | FSA |
| 24-01 | WG-SAM-2024/05 | Notification for the Ross Sea shelf survey in 2025: third year of an approved three-year research plan. Research plan under CM 24-01, paragraph 3 - Continuing Research | NZL | 88.1 | 2022/23-2024/25 | 2 (2022, WG-FSA-2022/41 Rev.1) | FSA | | |
| 24-01 | WG-SAM-2024/06 | New Fishery Research Proposal (Plan) Under CM 24-01, Paragraph 3, the Acoustic-Trawl Survey *Champsocephalus gunnari* in the Statistical Area 48.2 | UKR | 48.2 | 2024/25-2026/27 | New | SAM FSA | FSA | FSA |

*1: The proposal was approved for only Division 58.4.2.
*2: Review for research plan at Division 58.4.1.

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Table 3: Annotated table of WG-SAM workplan updated for 2024. Timeframe periods are: short = 1–2 years, medium = 3–5 years and long = 5+ years. Items tasked to WG-SAM from the Scientific Committee Strategic Plan (SC-CAMLR-41, Table 6). Numbers following level of urgency indicates the stated value in the box which replaced 'X', i.e., the year. CEMP – CCAMLR Ecosystem Monitoring Program, MSE – management strategy evaluation, SISO – Scheme of International Scientific Observation. Grey indicates specific tasks identified.

| Theme | Priority research topic | Timeframe | | | Contributors | Secretariat participation |
|---|---|---|---|---|---|---|
| | | Global | 2025 | 2026 | | |
| 1. Target species | (a) Develop methods to estimate biomass for krill | | | | | |
| | (iii) Data collection – SISO and vessels and CEMP | | | | | |
| | Task 1: Effective sampling to estimate length-frequency distribution | Short | X | | Ms Robson, Dr Kawaguchi | |
| | (b) Develop stock assessments to implement decision rules for krill | | | | | |
| | Task 2: Development of integrated stock assessment for krill | Medium | X | X | Mr Mardones, Dr Watters | |
| | (c) Develop methods to estimate biomass for finfish | | | | | |
| | (i) Survey design | | | | | |
| | Task 3: Gear standardisation – tagging program | Medium | X | X | Dr Péron, Dr Masere, Dr Kasatkina | Yes |
| | (ii) Data collection – SISO and vessels | | | | | |
| | Task 4: Metrics of vessel tagging performance | Medium | | X | Dr Péron, Dr Masere, Mr Dunn, Dr Hoyle | Yes |
| | Task 5: Recording selection of non-random biological data | Medium | X | X | Mr Gasco, Dr Massiot-Granier | Yes |
| | Conversion factors | | | | | |
| | Task 6: Develop protocol for conversion factors | Short | X | | Mr Gasco, Dr Massiot-Granier, Mr Walker | Yes |
| | (iii) Improve biomass estimation methods | | | | | |
| | Task 7: Optimise tag-based study (spatial overlap) | Medium | X | X | Dr Masere, Dr Péron, Dr Devine | |
| | Task 8: Vessel configuration factors affecting tagging mortality | Medium | X | X | Dr Devine | Yes |

(continued)

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Table 3 (continued)

| Theme | Priority research topic | Timeframe | | | Contributors | Secretariat participation |
|---|---|---|---|---|---|---|
| | | Global | 2025 | 2026 | | |
| | (iv) Data for stock assessment | | | | | |
| | Task 9: Determine the number of fish per age class needed to capture the variability needed for an adequate reference | Medium | | X | Dr Devine, Dr Quiroz, Mr Sarralde | Yes |
| | Task 10: Examine the effect of age uncertainty on the stock assessment | Medium | | X | Dr Devine | |
| | (d) Develop stock assessments to implement decision rules for finfish | | | | | |
| | (i) Research to develop new assessments | | | | | |
| | (1) Research plan evaluations: | Medium | | | | |
| | Task 11: Research plan assessment | | | | WG-SAM | |
| | 48.2 Icefish | | X | X | | |
| | 48.6 Antarctic toothfish | | X | | | |
| | 58.4.1–58.4.2 Antarctic toothfish | | X | X | | |
| | 88.1 shelf survey Antarctic toothfish | | X | X | | |
| | 88.3 Antarctic toothfish | | X | | | |
| | (ii) Develop new assessment tools | | | | | |
| | (1) Casal2 development | | | | | |
| | (e) Management strategy evaluations for target species (Second Performance Review, Recommendation 8) | | | | | |
| | | Short | | | | |
| | Task: 12: Evaluation of the CCAMLR decision rules and potential alternative harvest control rules for assessed fisheries using MSE | | X<br>X | X<br>X | Dr Ziegler, Mr Dunn, Dr Massiot-Granier, Dr Earl, Mr Somhlaba, Dr Masere | |
| | Task 13: Development and testing of data-limited fishery decision rules using MSE | Medium | X | X | Dr Ziegler, Mr Dunn, Dr Massiot-Granier, Dr Earl, Mr Somhlaba, Dr Masere | Yes |
| | (iii) Finfish management strategies that are robust to climate change | Long | | | Stock assessors | |

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Table 3 (continued)

| Theme | Priority research topic | Timeframe | | | Contributors | Secretariat participation |
|---|---|---|---|---|---|---|
| | | Global | 2025 | 2026 | | |
| 2. Ecosystem impacts | (a) Ecosystem monitoring (Second Performance Review, Recommendation 5)<br>Structured ecosystem monitoring programs (CEMP, fishery)<br>Task 14: effective sample size for fish by-catch monitoring in the krill fishery | Medium | X | X | Dr Jones | |
| 3. Adminis-trative topics | (e) Communication of progress, internal and external:<br>Task 15: Diagnostic graphs on stock status | Short | X | X | Stock assessors | |

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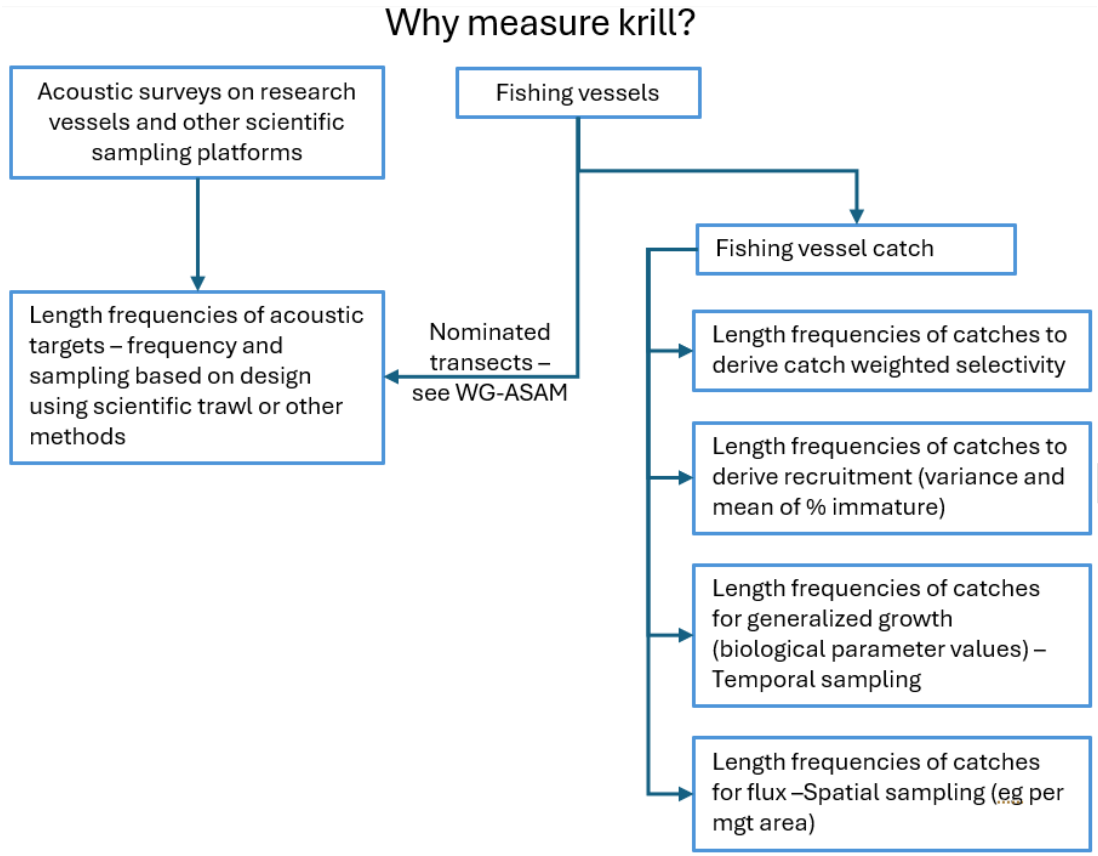


Figure 1: Schematic of key uses of krill length frequency data.

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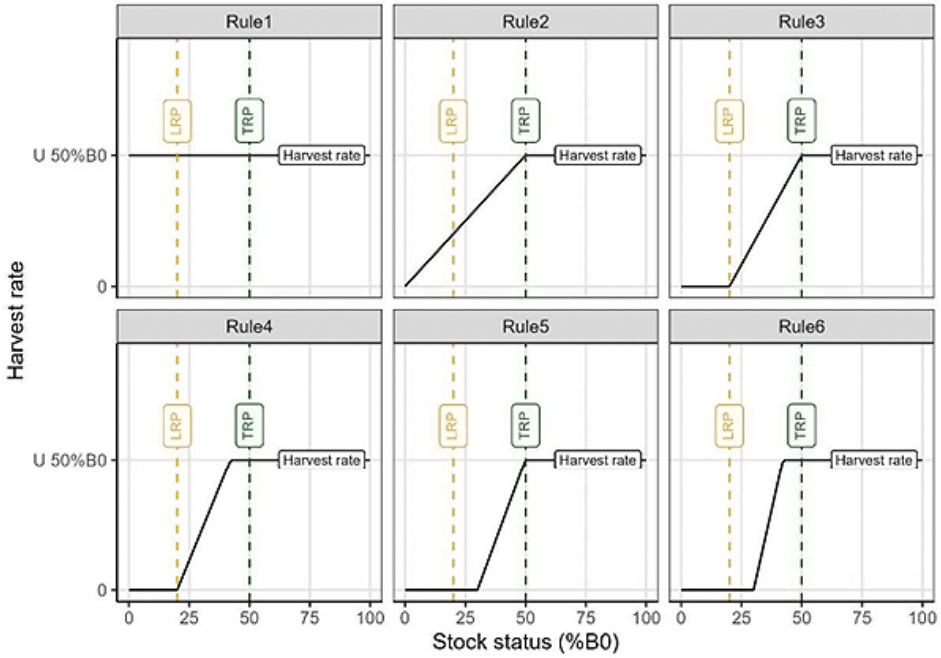


Figure 2: Candidate harvest control rules evaluated for CCAMLR integrated toothfish stock assessments. Black lines indicate the applied harvest rates $U$ given spawning stock status (Stock status (%$B_0$)). For example, in Rule 1, the harvest rate is equal to $U_{50\%B0}$ independent of spawning stock status. In Rule 2, the harvest rate increases linearly from 0 when spawning stock status is also at 0, to $U_{50\%B0}$ when spawning stock status is at the TRP (dashed green line), and is equal to $U_{50\%B0}$ when spawning stock status above the TRP. In Rule 3, the harvest rate is 0 for spawning stock status below the LRP (dashed orange line), increases linearly for spawning stock status between the LRP and TRP, and is equal to $U_{50\%B0}$ when spawning stock status is above the TRP.

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Appendix A

## List of Participants

**Working Group on Statistics, Assessments and Modelling**
(Leeuwarden, The Netherlands, 24 to 28 June 2024)

| | |
|---|---|
| **Chair** | Dr Takehiro Okuda<br>Fisheries Resources Institute, Japan Fisheries Research and Education Agency |
| **Australia** | Dr Philippe Ziegler<br>Australian Antarctic Division, Department of Climate Change, Energy, the Environment and Water |
| | Dr Cara Masere<br>Australian Antarctic Division, Department of Climate Change, Energy, the Environment and Water |
| **Chile** | Mr Mauricio Mardones<br>Doctoral student, Antarctic and Subantarctic Program, Universidad de Magallanes |
| **China** | Professor Guoping Zhu<br>Shanghai Ocean University |
| **France** | Dr Marc Eléaume<br>Muséum national d'Histoire naturelle |
| | Dr Félix Massiot-Granier<br>Muséum national d'Histoire naturelle |
| | Ms Renée Le Clech<br>Muséum national d'Histoire naturelle |
| **Japan** | Dr Mao Mori<br>Japan Fisheries Research and Education Agency |
| **Korea, Republic of** | Dr Sangdeok Chung<br>National Institute of Fisheries Science (NIFS) |
| | Mr Kunwoong Ji<br>Jeong Il Corporation |
| | Mr Taebin Jung<br>TNS Industries |

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| | |
|---|---|
| | Mr Sang Gyu Shin<br>National Institute of Fisheries Science (NIFS) |
| **Netherlands, Kingdom of the** | Mrs Giulia Gai<br>Arctic Centre, University of Groningen |
| | Dr Fokje Schaafsma<br>Wageningen Marine Research |
| | Mr Frits Steenhuisen<br>Arctic Centre, University of Groningen |
| **New Zealand** | Mr Alistair Dunn<br>Ocean Environmental |
| **Russian Federation** | Dr Svetlana Kasatkina<br>AtlantNIRO |
| **Spain** | Mr Roberto Sarralde Vizuete<br>Instituto Español de Oceanografía-CSIC |
| | Dr Takaya Namba<br>Pesquerias Georgia, S.L |
| **Ukraine** | Dr Kostiantyn Demianenko<br>Institute of Fisheries, Marine Ecology and Oceanography (IFMEO), State Agency of Ukraine for the Development of Melioration, Fishery and Food Programs |
| | Dr Leonid Pshenichnov<br>SSI "Institute of Fisheries, Marine Ecology and Oceanography" (IFMEO) of the State Agency of Melioration and Fisheries of Ukraine |
| | Mr Illia Slypko<br>SSI "Institute of Fisheries, Marine Ecology and Oceanography" (IFMEO) |
| **United Kingdom** | Dr Timothy Earl<br>Centre for Environment, Fisheries and Aquaculture Science (Cefas) |
| | Dr Sarah Alewijnse<br>Centre for Environment Fisheries and Aquaculture Science (Cefas) |
| | Ms Lisa Readdy |

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| | |
|---|---|
| | Centre for Environment, Fisheries and Aquaculture Sciences (Cefas) |
| **United States of America** | Dr Christopher Jones<br>National Oceanographic and Atmospheric Administration (NOAA) |
| **CCAMLR Secretariat** | Dr Steve Parker<br>Science Manager |
| | Dr Stephane Thanassekos<br>Fisheries and Ecosystems Analyst |

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Appendix B

**Agenda**

Working Group on Statistics, Assessments and Modelling

(Leeuwarden, Netherlands, 24 to 28 June 2024)

1. Introduction
1.1. Opening of the meeting
1.2. Adoption of the Agenda

2. Development of methods to estimate biomass for krill

3. Develop stock assessments to implement decision rules for krill

4. Develop methods to estimate biomass for finfish
   4.1 Survey design
   4.2 Data collection – SISO and vessels
   4.3 Improve biomass estimation methods

5. Develop stock assessments to implement decision rules for finfish
   5.1 Communication of progress, internal and external
   5.2 WS-ADM2-2024

6. Management strategy evaluations for target species
   6.1 Evaluation of the CCAMLR decision rules and potential alternative harvest control rules for assessed fisheries
   6.2 Development and testing of data-limited fishery decision rules
   6.3 New proposals under CM 21-02
   6.4 New proposals under CM 24-01

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7. Review of ongoing research plan results and proposals
    7.1 Research results and proposals from Area 48
    7.2 Research results and proposals from Area 58
    7.3 Research results and proposals from Area 88

8. Ecosystem monitoring

9. Future work

10. Other business

11. Advice to the Scientific Committee

12. Adoption of report and close of meeting

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Appendix C

**List of Documents**

Working Group on Statistics, Assessments and Modelling
(Leeuwarden, The Netherlands, 24 to 28 June 2024)

| | |
|---|---|
| WG-SAM-2024/01 | Agent-Based Model - Parameter perturbation analysis<br><br>Thanassekos, S. |
| WG-SAM-2024/02 | Continuing research in the *Dissostichus mawsoni* exploratory fishery in East Antarctica (Divisions 58.4.1 and 58.4.2) from 2022/23 to 2025/26; Research plan under CM 21-02, paragraph 6(iii)<br><br>Delegations of Australia, France, Japan, Republic of Korea and Spain |
| WG-SAM-2024/03 | New research plan for Antarctic toothfish (*Dissostichus mawsoni*) under CM 24-01, paragraph 3 in Subarea 88.3 by Korea and Ukraine from 2024/25 to 2026/27<br><br>Delegations of the Republic of Korea and Ukraine |
| WG-SAM-2024/04 | New research plan for Antarctic toothfish (*Dissostichus mawsoni*) exploratory fishery in Statistical Subarea 48.6 from 2024/25-2027/28): Research Plan under CM21-02, paragraph 6(iii)<br><br>Delegations of Japan, Republic of Korea, South Africa, and Spain |
| WG-SAM-2024/05 | Notification for the Ross Sea shelf survey in 2025: third year of an approved three-year research plan. Research plan under CM 24-01, paragraph 3 - Continuing Research<br><br>Delegation of New Zealand |
| WG-SAM-2024/06 | New Fishery Research Proposal (Plan) Under CM 24-01, Paragraph 3, the Acoustic-Trawl Survey *Champsocephalus gunnari* in the Statistical Area 48.2<br>Delegation of Ukraine |

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| | |
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| WG-SAM-2024/07 | 2024 updated analysis of the sea ice concentration in research blocks 4(RB4), and 5(RB5) of Subarea 48.6 with sea surface temperature and winds and statistical analysis of repeated accessibility<br><br>Namba, T., R. Sarralde, K Teschke, H. Pehlke, T. Okuda, S. Somhlaba and J. Pompert |
| WG-SAM-2024/08 | Evaluating a CPUE by seabed area analogy approach to estimate by-catch limits for macrourids in toothfish fisheries<br><br>CCAMLR Secretariat |
| WG-SAM-2024/09 | ABM - Casal2 comparison of simple implementations<br><br>Thanassekos, S. and A. Dunn |
| WG-SAM-2024/10 | Updates to Observer and Vessel forms and manuals for Longline Fisheries<br><br>CCAMLR Secretariat |
| WG-SAM-2024/11 | An updated method for the extrapolation of IMAF and warp strikes<br><br>CCAMLR Secretariat. |
| WG-SAM-2024/12 | 2024 provisional trend analysis: preliminary estimates of toothfish biomass in Research Blocks<br><br>CCAMLR Secretariat |
| WG-SAM-2024/13 | Progress report on the joint research for *Dissostichus* spp. in area 88.3 by Republic of Korea and Ukraine in 2024<br><br>Delegations of the Republic of Korea and Ukraine |
| WG-SAM-2024/14 | Draft report of the co-conveners of the 2nd CCAMLR Ageing Determination Workshop (WS-ADM2)<br><br>Devine, J., P. Hollyman and C. Brooks |
| WG-SAM-2024/15 | An introduction to management strategies and harvest control rules<br><br>Dunn, A., P. Ziegler, S. Alewijnse, J. Devine, T. Earl, R. Le Clech, D. Maschette, C. Masere, F. Massiot-Granier, F. Ouzoulias, C. Péron, L. Readdy and N. Walker |

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| WG-SAM-2024/16 | Development of U-based harvest control rules for assessed toothfish fisheries - 1. Background<br><br>Ziegler, P., A. Dunn, S. Alewijnse, J. Devine, T. Earl, R. Le Clech, D. Maschette, C. Masere, F. Massiot-Granier, F. Ouzoulias, C. Péron, L. Readdy and N. Walker |
| WG-SAM-2024/17 | Development of U-based harvest control rules for assessed toothfish fisheries - 2. Exploration of U-based HCRs<br><br>Ziegler, P., A. Dunn, S. Alewijnse, J. Devine, T. Earl, R. Le Clech, D. Maschette, C. Masere, F. Massiot-Granier, F. Ouzoulias, C. Péron, L. Readdy and N. Walker |
| WG-SAM-2024/19 | Evaluating the Feasibility of Pot Fishing for Toothfish in the Ross Sea<br><br>Plum, B., H. Tijsen, A. Berry and N. Walker |
| WG-SAM-2024/20 | CCAMLRTOOLS - an R package for working with CCAMLR data extracts<br><br>CCAMLR Secretariat |
| WG-SAM-2024/21 | A progress update on the 2024 Ross Sea shelf survey<br><br>Devine, J., C.D. Jones and N.A. Walker |
| WG-SAM-2024/22 | Consideration of the impact of tagging and recapture effort on mark-recapture abundance estimators within integrated Casal2 stock assessments<br><br>Masere, C., R. Le Clech, S. Alewijnse, J. Devine, A. Dunn, T. Earl, D. Maschette, F. Massiot-Granier, F. Ouzoulias, C. Péron, L. Readdy, N. Walker and P. Ziegler |
| WG-SAM-2024/23 | Approaches to projecting recruitment in toothfish assessment models<br><br>Earl, T., L. Readdy, S. Alewijnse, J. Devine, A. Dunn, R. Le Clech, D. Maschette, C. Masere, F. Massiot-Granier, F. Ouzoulias, C. Péron, N. Walker, and P. Ziegler |
| WG-SAM-2024/24 | Consideration of the impact of tagging and recapture effort on mark-recapture abundance estimators within integrated Casal2 stock assessments – supplementary material<br><br>Masere, C., R. Le Clech, S. Alewijnse, J. Devine, A. Dunn, T. Earl, D. Maschette, F. Massiot-Granier, F. Ouzoulias, C. Péron, L. Readdy, N. Walker, and P. Ziegler |

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| WG-SAM-2024/25 | Effects of implementing dynamic $B_0$ in toothfish fisheries<br><br>Ouzoulias, F., F. Massiot-Granier, S. Alewijnse, J. Devine, A. Dunn, T. Earl, R. Le Clech, D. Maschette, C. Masere, C. Péron, L. Readdy, N. Walker, and P. Ziegler |
| WG-SAM-2024/26 | Integrated approach to modeling krill population dynamics in Western Antarctic Peninsula. Spatial and ecosystem considerations<br><br>Mardones, M., L. Krüger; F. Santa Cruz; C. Cárdenas and G. Watters |
| WG-SAM-2024/27 | Derive growth parameters and natural mortality rates for krill considering spatial heterogeneity in Subarea 48.1<br><br>Mardones, M., C. Cárdenas, L. Krüger and F. Santa Cruz |
| Other | |
| CCAMLR-42/18 | On the status of the 'best available scientific evidence' Delegation of the Russian Federation |

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