**Report of the Working Group on Statistics, Assessment and Modelling (WG-SAM-2025)**
(Tenerife, Spain, 16 to 20 June 2025)

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## Introduction

1.1 The 2025 meeting of the Working Group on Statistics, Assessments and Modelling (WG-SAM-2025) was hosted by the Instituto Español de Oceanografía, Consejo Superior de Investigaciones Cientificas (IEO-CSIC) in Santa Cruz de Tenerife, Spain, from 16 to 20 June 2025, and organised by Mrs V. Rojo, Mr R. Sarralde and Dr J.M. Arrieta.

### Opening of the meeting

1.2 The meeting co-conveners, Dr T. Okuda (Japan) and Mr D. Maschette (Australia) welcomed participants (Appendix A) to the meeting and expressed their goals for the meeting. The participants were then welcomed to Tenerife by Dr J.M. Arrieta, Director of the Canarias IEO-CSIC. He noted the history of the IEO and that the goals of the founder aligned well with the mandate of CCAMLR 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 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. Alewijnse (UK), S. Chung (Korea), A. Dunn (New Zealand), T. Earl (UK), E. Kim (Korea), R. Leeger (New Zealand), M. Mardones (Chile), C. Masere (Australia), M. Mori (Japan), F. Ouzoulias (France), S. Parker (Secretariat), C. Péron (France), R. Sarralde (Spain), I. Slypko (Ukraine), 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-43, Table 7. The Secretariat proposed options to simplify the revision of the workplan by noting revisions proposed in report text of the Working Group and developing an online composite workplan

for the Scientific Committee combining topics for all Working Groups which included specific tasks lead by Members. The Working Group agreed to discuss additional modifications to the workplan under 'Future Work'.

## Krill

Data collection

2.1 WG-SAM-2025/21 presented a draft workflow for the calibration of Generalised Additive Models (GAMs) to extrapolate SISO observations to total fishing effort, using warp strike observations in the krill fishery. The workflow informed both model parameter value choices and appropriate gridding of the input data in space and time. The CCAMLR Secretariat requested feedback from the Working Group regarding the methods, the estimation of uncertainty, and the use of additional explanatory variables.

2.2 The Working Group welcomed the analysis, which provided a clear approach to setting parameter values in the GAMs considered. It noted that the method closely predicted the sum of observed warp strikes in each season from 2015 to 2024 for Subareas 48.1, 48.2 and 48.3, but resulted in large uncertainty ranges, particularly for Subarea 48.2. The Working Group considered that the problems encountered when estimating prediction uncertainty were highly likely due to low historic sampling effort. The Working Group noted that observation rates were increasing in the coming season to 5% of total fishing time and agreed that a regular review of this analysis would be beneficial.

2.3 The Working Group also noted the similarity of median estimates between the previous bootstrap method (WG-FSA-IMAF-2024/10) and the GAM and discussed the trade-off between complexity and usability. It noted that fishing method (i.e., continuous vs traditional) was accounted for by the inclusion of random effects for vessels in the analysis. The Working Group discussed the potential inclusion of seabird species in the model and noted that this would require increased sampling effort, particularly to get reliable estimates for less common species. The Working Group also noted that the analysis provided valuable insights into potential differences between Subareas where for instance, the best model fits where obtained by pooling records at a smaller spatio-temporal scale in Subarea 48.1 than in Subarea 48.2.

2.4 The Working Group recommended the Scientific Committee consider these results and discussion, recalling that based on the analysis presented in WG-IMAF-2023/16 the Commission had agreed to increase warp strikes observation efforts (CCAMLR-42, paragraph 4.111). Further, the Working Group noted that in addition to estimating total interactions, this modelling approach had potential for the assessment of the effectiveness of mitigation measures if more data from increased observations rates were available.

2.5 WG-SAM-2025/29 presented an analysis of inter-vessel variability in the length composition of krill in commercial catches in Subarea 48.2 during March 2024 undertaken to evaluate the efficiency of the Scientific Observer Guidelines for sampling 200 krill every 3 or 5 days, regardless of the number of hauls and the catch per haul and per day (CM 51-06). The authors obtained additional evidence that the existing observation protocol tends to under-sample krill for different length groups, especially recruitment groups, by assuming homogeneity of krill length composition in the catch regardless of catch size and duration of

fishing operation as well as not taking into account potential spatio-temporal heterogeneity in krill distribution patterns within fishing grounds. In general, krill samples were taken from only 10% of the catches and one sample of 200 krill is taken from a catch that varies from 121 tons to 600 tons for vessels using the traditional fishing method. The proportion of catch accompanied with krill samples undertaken by at-sea observers varied from 9% to 0.2%, the proportion of recruitment groups varied from 37% to 0% and one sample of 200 krill (weighing 120 g) accounts for a catch reaching 7 347 tons for vessels using the continuous fishing method. Statistically significant inter-vessel variability in krill length compositions in catches was found both between vessels using traditional fishing methods as well as between vessels using continuous fishing methods. The most vulnerable to the gear construction, fishing method and observer krill protocols is the retention of recruitment group and adult krill in the catches. Data collected in 2024 provide additional evidence of the need to revise the efficiency of observer sampling protocols with special attention to observer krill samples collected onboard vessels using the continuous fishing method. The current levels of krill sampling in the krill fishery, occurring in both Subarea 48.2 and Subarea 48.1, have no scientific justification. The authors pointed out the necessity of preparing unified requirements for the sample size and its design for SISO, taking into account the number of hauls per day and the amount of catch per haul, so that C1 data and samples collected by at-sea observers would provide the best information to support the strategic objectives for scientific observations of the krill fishery.

2.6 The Working Group welcomed the analysis as it fitted well within Task 1 of its workplan (SC-CAMLR-43, Table 7). Recalling past discussions on the use of krill length frequency data (WG-SAM-2024, Figure 1), it reiterated that effective sample size should be driven by the intended use of these data, and that this issue needed further research. As outlined in the analysis, estimating the length distribution of the catch for assessment purposes using ~100 individuals to represent several thousand tonnes of catch was likely insufficient. The Working Group noted that the analysis would benefit from considering a broader area and time period to help generalise its conclusions. The length frequency analysis would however need to consider fishing events that occurred in proximity to each other in space and time to avoid the potential bias introduced by krill flux.

2.7 The Working Group highlighted that concrete proposals for changes in sampling regimes were needed to progress this task. It recommended WG-EMM-2025 consider this paper, noting that EMM's interest likely lay more in the use of length frequency data for biological inferences (e.g. maturity estimation) than for stock assessment or biomass estimation purposes.

Stock assessment model

2.8 WG-SAM-2025/11 Rev. 1 presented an integrated length-to-age stock assessment model of Antarctic krill population dynamics using Stock Synthesis 3 (SS3). Focusing on Subarea 48.1, the spatially implicit model accounted for environmental forcings (e.g. satellite-derived Chlorophyll-a concentration) predator pressure (three penguin species) fishery monitoring data and survey estimations (e.g. SISO LFDs and AMLR biomass indices). Through the exploration of four scenarios, the study demonstrated the potential of integrated models within an ecosystem-based approach to support the management of the krill fishery.

2.9 The Working Group noted the large amount of work conducted and congratulated Mr Mardones, a previous CCAMLR scholarship recipient, for his continued efforts towards progressing Task 2 of its intersessional work plan (SC-CAMLR-43, Table 7). It discussed potential further areas of research, including non-linear effects of environmental processes, the use of MCMC simulations to assess parameter estimates, consideration of the contributions of different sub-processes into total RMSEs and further investigation of the estimated mortality-at-age. While welcoming the inclusion of environmental forcings, the Working Group noted that satellite-derived data corresponded to surface conditions, while the diel vertical migration of krill resulted in individuals experiencing subsurface conditions. It noted that a length-based model would better incorporate growth uncertainty, and that further consideration needed to be given to the spatial scale of the model, both due to the potential effect of flux and the uneven availability of predator data across Management Units. The Working Group noted that while accounting for the effect of environmental drivers on recruitment had potential (e.g. Crone et al., 2019; Sylvester et al., 2025), such an approach may require further development of SS3.

2.10 The Working Group further noted that other modelling approaches, such as age-structured catch-at-length models are underway (e.g. Dong et al., 2024). The Working Group encouraged the authors to continue refining their modelling work and to consider collaborating with other Members (see also WG-SAM-2024, paragraph 3.1) and stock assessors.

## Finfish data collection

### Ageing

3.1 WG-SAM-2025/22 presented the results of a calibration exercise between Japanese and Spanish laboratories on toothfish age determination using otolith samples prepared with different methods to compare ageing and readability between the two laboratories. The main objective was to determine whether the age data provided by the Spanish laboratory in 2023 were suitable as input data for the 48.6 stock assessment model. Japan applied the thin section method, while Spain used the bake and embed method. For thin section samples, the results showed good consistency of readers within the Japanese laboratory, but high variability in ages between the Japanese and Spanish laboratories (16.63% average percent error (APE) and 31.73% CV). The inter-lab discrepancy was moderately lower for the bake and embed method. Some of the differences in interpretation of otolith ages appeared to stem from unfamiliarity with otolith image characteristics resulting from the different preparation procedures.

3.2 The Working Group noted that the current Spanish age data were likely to be biased and recommended that the Spanish laboratory re-read otoliths following calibrations with Japanese or other laboratories.

3.3 The Working Group acknowledged the complexity of this type of analysis and recommended using the CV as the primary metric for comparison. The exercise was considered highly productive, and the Working Group emphasised the importance of future collaboration and the ongoing comparisons between ageing laboratories.

3.4 The Working Group noted that finalising the reference sets for each species and method should be a priority. The Working Group noted that a manual with clear instructions on how to read otoliths had been used in the past to improve consistency among readers in the Japanese

laboratory, and that during the most recent workshop, growth curves were estimated and compared to identify differences in age interpretation.

3.5 WG-SAM-2025/23 presented the Conveners Report of the 3rd Workshop on Age Determination Methods (WS-ADM3) which had been held at the British Antarctic Survey, Cambridge, UK from 19 to 23 May 2025. The Workshop was organised, developed, and convened by K. Owen (UK), Dr P. Hollyman (UK), Dr J. Devine (NZ) and Dr C. Brooks (USA) and supported by the CCAMLR Secretariat. Scientists and technical experts from 7 Members attended the Workshop. The workshop aimed to progress inter reader comparisons among laboratories using different preparation methods, and to progress the development of otolith reference sets for each toothfish species and preparation method as both training and reader calibration tools.

3.6 The Working Group noted that the WS-ADM3 had identified that a key issue was the involvement of many new readers, which may have contributed to the inconsistencies. Therefore, the Working Group agreed that a formal calibration process among readers is essential moving forward.

3.7 The Working Group noted the importance of the work undertaken at WS-ADM3, particularly in facilitating inter-laboratory reading and comparison. While otolith readers are well-practiced at reading images from their own laboratories, they are typically less familiar with reading otoliths prepared in other laboratories using different otolith preparation procedures. WS-ADM3 facilitated improving their experience reading otoliths prepared by different laboratories and methods.

3.8 The WS-ADM3 made two requests of WG-SAM:

(i) advise on which precision threshold method and level is most appropriate for use in age-based stock assessments; and

(ii) recommend a mechanism for CCAMLR to support mentoring and the development of ageing programs.

3.9 The Working Group encouraged a mechanism for CCAMLR to support mentoring and the development of ageing programs. In particular, the mentoring of otolith readers which is facilitated via CCAMLR is valuable and should continue to be supported. The Working Group further noted the need for significant investment in otolith reader training and time, as well as capital investment required for purchasing thin sectioning equipment. However, the Working Group also noted that Members putting forward Research Proposals under CM 24-01 and CM 21-02 have committed to analysing the samples they are collecting, which includes ageing. The Working Group noted question 3(c) in the Format for submitting finfish research proposals in accordance with paragraph 3 of CM 24-01 and paragraph 6(iii) of CM 21-02, which asks about methods for data analysis (paragraph 8.4).

3.10 The Working Group recommended the Scientific Committee continue to support inter-laboratory collaboration and mentoring for ageing programmes. The Working Group further recommended that the current Research Proposal template be expanded, so that question 3(c) specifies how readers will be trained, otoliths will be prepared, aged, and calibrations conducted, and a milestone detailing when these data will be submitted to CCAMLR (paragraphs 6.11 and 7.23).

3.11 The Working Group noted that any of the methods defining a precision threshold used to determine when otoliths should be re-read are useable within stock assessment models, but that the method used must be specified and consistent among the ageing data sources pooled for a stock assessment.

3.12 The Working Group recalled discussion by WG-SAM-2024 (paragraph 5.33) which noted that a binary classification indicating whether an otolith reading was suitable for inclusion in an assessment was preferable to a 1–5 readability score. The Working Group noted that having at least two readers was advantageous in determining the uncertainty in the age of a given otolith.

3.13 The Working Group noted that currently, practitioners of integrated stock assessments treat age data differently before inclusion in stock assessment models. The Working Group recommended that the authors of integrated stock assessments conduct a joint survey to summarise how ageing data are incorporated into their assessments.

3.14 The Working Group noted that using age-length keys from nearby areas could be applied to data poor areas where ageing data are unavailable, although this would require a strong assumption that both growth and year class strengths were identical between the two areas. The Working Group recommended that spatio-temporal or hierarchical modelling of the length-age relationship may offer a better approach, but that these methods were technically challenging. The Working Group suggested that Members develop methods, where resources allowed, for such approaches.

Tagging and survey design

3.15 WG-SAM 2025/24 presented the summary of the result of the POKER ('POissons de KERguelen') V survey, which was carried out around the Kerguelen Islands in CCAMLR Division 58.5.1 in October 2024. The sampling design was modified compared to previous POKER surveys (2006, 2010, 2013 and 2017) to focus on Patagonian toothfish recruitment. A total of more than 25 fish species was recorded along with biological data. Three dominant species in biomass were marbled rockcod (*Notothenia rossi*), unicorn icefish (*Channichthys rhinoceratus*) and Patagonian toothfish (*D. eleginoides*). While there were no changes in the composition of the benthic fish community through time, these species showed significant changes in distribution and biomass compared to previous surveys. Despite an increase in Patagonian toothfish biomass compared to 2017, it remained below the long-term average. Strong cohorts of both 2- and 3-year-old fish suggest strong toothfish recruitment in recent years (2021 and 2022), especially on the northern shelf. Work is ongoing to estimate biomass by age class using spatially explicit models. In addition, a series of annual recruitment surveys are planned for the next three years to track 2024 cohorts and understand factors influencing recruitment.

3.16 The Working Group welcomed the new POKER survey results and thanked the authors. It encouraged the authors to tabulate all the operational factors and their changes (e.g. gear, vessel and sampling design) for all five surveys which could influence biomass estimates and present those results to WG-FSA.

3.17 The Working Group noted that the survey included day and night hauls, and that these could be used to investigate different behaviours of icefish between day and night.

3.18 The Working Group noted the *N. rossi* catch was at its highest recorded level since the population of this species collapsed in the 1970s and shows recovery in the last 15 years. It also highlighted that the authors could potentially investigate the movement and connectivity between the Kerguelen Islands, Crozet Island, and adjacent areas through collaboration among Members. The Working Group also discussed priority for otolith readings of POKER samples.

3.19 The Working Group encouraged the continuation of these surveys in future years to explore the effect of environmental factors and climate change on recruitment variability.

3.20 WG-SAM-2025/28 presented the requirements for a standardised acoustic survey methodology for finfish in the CCAMLR Convention Area. The authors pointed out that in terms of the requirements of Article II of CCAMLR, species such as icefish are both a 'harvested' and a 'dependent' species, and icefish acoustic surveys in the CCAMLR Convention Area should provide the following three items: (i) an estimate of the biomass and distribution of icefish in the pelagic zone, (ii) an estimate of the biomass and distribution of krill and other finfish species (e.g., myctophids) in the pelagic zone, and (iii) an analysis of the interactions between the spatial distribution of krill and icefish, as well as the interactions between the spatial distribution of icefish and other finfish as a source of potential alternative food webs between icefish and krill. The paper discussed methodical aspects of data collection and processing, including echosounders and their calibration, survey design, target backscattering identification (krill, icefish and other fish), fish target strength, and estimating fish biomass by length groups. The effect of various sources of uncertainty was simulated using the example of an icefish survey that was implemented in Subarea 48.3 in 2002.

3.21 The Working Group recommended that WG-ASAM rather than WG-SAM review this document, as it primarily focuses on the methodology of an acoustic survey. The Working Group also noted that WG-ASAM has developed surveys for protocols for krill and could do the same for finfish.

3.22 The Working Group recalled that the advantage of acoustic surveys is that they sample the entire water column and can identify diurnal vertical movements and that the author's recommendation to use only daytime hauls may not apply to all acoustic surveys, depending on the target species and research aims.

Data collection: SISO and vessels

3.23 Following a request by WG-SAM (WG-SAM-2024, paragraph 4.2), WG-SAM-2025/01 presented a power analysis to estimate the number of longline sets and fish sampled from each set to reach an 80% power in detecting a 3% change in conversion factor values over a month using Convention Area-wide data. The paper determined minimum sample sizes using subsets of SISO data as well as simulated data. Based on the results, the authors proposed sampling at least 20 fish from a haul when (or soon after) entering an area, and at least once a week if remaining in that area. Regular review of the effectiveness of the sampling regime could be conducted in the future.

3.24 The Working Group recommended the Scientific Committee endorse the proposed sampling regime and requested that its effectiveness be assessed regularly. It further recommended fish be sampled individually rather than in batch due to the documented sources of variability in conversion factors (see WG-FSA-2022/12). The Working Group recommended the Scientific Committee task the Secretariat with updating the forms and protocols to reflect this change.

3.25 WG-SAM-2025/07 presented a revised C1 trawl fine scale catch and effort form, separated into individual forms for finfish and krill trawl fisheries following a request from WG-FSA-IMAF-2024 (paragraph 1.20). The paper noted that additional revisions are expected as the revision of the krill fishery management approach progresses (e.g. SC-CAMLR-41, paragraph 3.51; WG-EMM-2023, paragraph 5.58; WG-FSA-2023, paragraph 2.37). Updates included detailed gear configuration reporting and linking to individual fishing events, improved description of marine mammal exclusion devices, and identification of the personnel reporting IMAF.

3.26 The Working Group thanked the Secretariat for the revised C1 forms. It encouraged the Secretariat to propose specific names for each form type to WG-FSA-2025 to avoid confusion between multiple types of C1 forms and identify where Conservation Measures may need to be updated to accommodate this change.

3.27 The Working Group recommended the new forms replace the current C1 forms and further noted that the new forms will assist the Secretariat in developing more efficient automated data loading procedures.

## Develop stock assessments to implement decision rules for finfish

### Ageing

4.1 The Working Group succinctly discussed cross-cutting issues related to ageing, including the crucial importance of age data for stock assessments, the outcomes of the WS-ADM3 (WG-SAM-2025/23) and the need to add clearly identified ageing milestones in research plans (paragraph 3.10). Regarding the ageing workshop, the Working Group noted that advances in ageing methods could inform the frequency of these workshops.

4.2 Regarding the unevenness of ageing efforts across fisheries, the Working Group recalled the need for increased efforts in Subarea 88.2, as highlighted in the past (e.g. SC-CAMLR-XXXII, paragraph 3.169; WG-FSA-16, paragraph 3.129; WG-FSA-17, paragraph 3.122; WG-FSA-18, paragraph 4.173). While it noted the importance of solving this issue in Subarea 88.2, the Working Group discussed the development of ageing effort metrics to help track progress across research proposals and plans (paragraph 6.2).

### Tagging performance

4.3 The Working Group discussed inter-vessel variability in tagging survival and/or detection rates and encouraged Members to conduct descriptive analyses of their tagging data to document potential issues and help solve them. It further noted that such descriptive analyses

could help document residence time variability in space and according to sex, which would help better understand stock structure.

Stock assessment developments

4.4 WG-SAM-2025/17 presented an overview of assumptions made when using mark-recapture (M-R) models, with focus on the use of tag release and recapture data in CCAMLR integrated stock assessments. Violations of assumptions were identified as potential sources of bias. Guidance was provided to qualitatively and quantitatively evaluate adherence to M-R model assumptions, and for situations where assumptions were strongly inconsistent and could not be met that it may be useful to consider implementing alternative M-R models.

4.5 The Working Group noted the importance of ensuring that tagging data are assessed for adherence to the assumptions of given M-R models and welcomed the guidance for how to undertake this process. The Working Group noted the importance of evaluating the characteristics of the given tagging dataset for elements such as the number of multiple recaptures to ensure they aligned with requirements for alternative M-R models also.

4.6 The Working Group noted that there has been some development of the Chapman estimator within Casal2 compared to the classical Chapman estimation of abundance, to account for issues such as tag loss, tag-related mortality and tag detection rates. It further noted the importance of examining raw data directly as a regular quality control check. The Working Group recommended that R code to test M-R models and standardised diagnostics should be developed and shared amongst those researchers using M-R data in their analyses (paragraph 8.2).

4.7 The Working Group noted that CCAMLR relied on a number of model frameworks to develop fishery stock assessments, notably Casal2 for toothfish and the Grym for krill. These model frameworks have been largely developed by individual CCAMLR members. 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 (WG-SAM-2024, paragraph 11.4). The Working Group also highlighted the value of developing standardised diagnostics across assessments to support comparability and transparency.

4.8 WG-SAM-2025/14 presented a conceptual model to inform the spatial structure of Patagonian toothfish in Division 58.5.2. It reviewed key factors such as depth, genetics, fishing footprint, tagging density, and movement patterns. Seven candidate spatial area scenarios were proposed to support future development of a spatially structured stock assessment. The paper highlighted the need for evaluating movement between areas, identifying metrics for comparing scenarios, and selecting appropriate methods for delineation.

4.9 The Working Group welcomed the approach proposed to inform spatial structuring of Patagonian toothfish. The Working Group also suggested that the review of observations such as age frequencies and sex ratio and seasonal variation therein, and residence time within areas may also be helpful to better inform spatial delineation.

4.10 The Working Group noted that using objective methods, such as clustering or regression trees, to define depth strata, rather than arbitrary depth bins, could be useful. It also emphasised that analyses should focus more on data and observations rather than outputs from stock assessment models.

4.11 WG-SAM-2025/26 estimated sex-specific biological parameters (length–weight relationships, maturity-at-age, and growth curves) for Patagonian toothfish in Subarea 48.3. Results confirmed that females grow larger, mature later, and are heavier at length than males. The combined-sex biological parameters used in the current Casal2 model were more closely aligned to those for females than for males, since more female toothfish are caught and sampled in the fishery. The authors recommended that these parameter estimates provided a foundation for developing a sex-disaggregated Casal2 model to better reflect population structure in future assessments.

4.12 The Working Group noted males were estimated to mature at young ages and recommended accounting for potential misidentification of maturity stage 2 from macroscopic staging, and suggested the authors consider methods that adjust for spatial bias in maturity estimates (e.g. Cousido-Rocha et al., 2024).

4.13 The Working Group recalled the relevance of the work by Marsh et al. (WG-SAM-2023/15) on environmental effects on growth and noted the importance of continuing to investigate trends in biological parameters of all toothfish stocks over time.

4.14 Dr Kasatkina noted that the data from groundfish trawl surveys used as a source of data on toothfish recruitment groups and data on localised fisheries are insufficient to assess the biological parameters of toothfish in Subarea 48.3. Dr Kasatkina referred to the recommendations of Independent Reviews (2018, 2023) and pointed out the need to assess the spatial structure of toothfish biological parameters across the entire distribution area of its population in Subarea 48.3 and noted the need to improve data collection to better account for this spatial structure, which requires data from longline survey across the entire distribution area of toothfish population. Dr Kasatkina noted that it is necessary to comprehensively use data from such longline survey and groundfish trawl surveys to assess toothfish biological parameters across the Subarea 48.3 and the Casal2 parameterisation.

4.15 The Working Group discussed the value of estimating biological parameters from a dedicated longline survey only. Most participants considered that the combined data from the groundfish survey and the commercial fishery in Subarea 48.3 covered a large range of the species distribution and provided more statistical power for the analysis of biological parameters than data from longline surveys alone.

4.16 The Working Group noted that including the diagnostic plots to evaluate the fit of biological models was valuable and should be included in all such analyses. The Working Group recommended that R code for the analysis of biological parameters and simulated datasets should be shared via a GitHub repository and welcomed the offer from the Secretariat to facilitate this (paragraph 8.2).

4.17 WG-SAM-2025/16 compared a sex-disaggregated stock assessment with the current single-sex model for Patagonian toothfish in Division 58.5.2. The largest impact on biomass estimates was found when introducing sex-specific growth, but with poorer model fits linked

to high values of length-at-age variance estimated for females. A sensitivity run with reduced variance resulted in improved fits.

4.18 The Working Group welcomed the development of a sex-disaggregated stock assessment model in Division 58.5.2 and its comparison to the current single-sex model. It noted that the estimated CV for female growth was unusually high and recommended exploring alternative approaches to estimate female growth more robustly.

4.19 The Working Group noted that a sex-disaggregated model in Division 58.5.2 could be developed that used combined sex parameters where the sex-specific parameters were uncertain. Further work was recommended before adopting a fully sex-disaggregated model for management advice.

4.20 The Working Group discussed the specifications of selectivity in the assessment model and encouraged further investigation using transformation of some of the selectivity parameters (e.g. transformation of the declining left- or right-hand limb parameters to log or inverse space).

Developments in diagnostics and trends

4.21 The Working Group noted ongoing efforts to improve diagnostic tools and their standardisation across assessments and recalled its discussions on stock assessment diagnostics at WG-SAM-2023 (paragraphs 6.33 and 6.34). It highlighted the value of compiling a list of diagnostic plots, building on the framework proposed by Ziegler et al. (WG-SAM-15/26) to support transparency and comparability of model outputs (paragraph 8.1).

4.22 The Working Group recommended that stock assessment diagnostics should generally present observed and expected values, model fits, residuals, and residual patterns appropriate to the item being assessed. The Working Group also noted that suitable diagnostics include, inter alia, standardised Kobe plots and retrospective plots. The Working Group noted that current stock assessments provide Pearson residuals, but alternative methods such as 'one step ahead' residual plots could be used instead for compositional observations. However, further development work is needed, as there may be challenges in implementing and interpreting these alternatives. The Working Group also noted that Probability Integral Transform (PIT) residuals could be considered.

4.23 The Working Group recommended that integrated toothfish stock assessments should include posterior predictive plots, and likelihood distributions of parameters from the MCMC.

4.24 The Working Group agreed that when an assumption is made, a diagnostic plot should be shown, or relevant tests should be conducted to evaluate how this assumption is being met if possible (e.g. WG-SAM-2025/17, Table 2).

4.25 The Working Group suggested that a list of diagnostic plots be compiled and brought to WG-SAM-2026 to develop a standard reference set for future assessments. It encouraged Members to collaborate on this issue (paragraph 8.1 (xvii)). The list should include the rationale for each diagnostic, and a guide on their interpretation. The Working Group acknowledged the utility of such objective criteria in facilitating the evaluation of model performance and in supporting management advice.

**Management strategy evaluations for target species**

5.1 WG-SAM-2025/10 discussed current approaches for forecasting recruitment in fisheries stock assessment models with a focus on medium- to long-lived species such as toothfish. The paper recommended using average recent recruitment for short-term projections (1–5 years). For longer-term projections (30+ years) the author suggested incorporating environmental covariates into stock recruitment models and employing ensemble modelling approaches that may better capture potential trends and variability under changing climate conditions. The author noted a number of key challenges including the breakdown of historical climate-recruitment relationships under climate change, the assumption of stationarity in traditional approaches, and the need to balance biological realism with practical management requirements. The author recommended a multi-faceted approach that explicitly acknowledges uncertainty through stochastic simulations, is regularly updated as new data becomes available, and employs Management Strategy Evaluation (MSE) frameworks to test robustness under various recruitment scenarios.

5.2 WG-SAM-2025/27 explored the recruitment assumptions used in integrated assessments of toothfish stocks within the CAMLR Convention Area. The review found areas of both similarity and differences between the four stocks. General areas of agreement included: (1) assumptions about future recruitment levels and variability should be informed by past estimates; (2) where available, time series of standardised surveys provide valuable fishery-independent indices of recruitment trends; and (3) where there is evidence of a change in recruitment which was not modelled, a more recent time period should be used to forward project recruitment.

5.3 The paper made the following recommendations for the four integrated stock assessments: (1) projections using the entire assessment time series are presented in all assessments as a baseline; (2) where there is evidence of a change in recruitment, either positive or negative, a recent time period (~10 years) should be used to project future recruitment; and (3) where fishery-independent surveys are available, these should be used to compare indices of recruitment to those in the model.

5.4 The Working Group noted that fishery-independent data on recruitment and young age classes such as from research surveys was useful to review. However, differences between the survey designs may mean that the calculation of recruitment indices would be undertaken in different ways. The Working Group noted that using the trend from the survey index to project future recruitment would not replace the need to investigate and, where possible, resolve discrepancies between the estimates of recruitment trends from the assessment and the survey.

5.5 The Working Group discussed the difficulty of longer-term projections given the assumptions associated with using historical data for projections. The appropriate time frame for drawing historical recruitments to use, potential non-stationarity of year class strength values, as well as the lack of strong environmental correlates with recruitment were all discussed as issues to consider. The Working Group noted that the current CCAMLR Decision Rules for toothfish require a 35-year projection, but that there were a range of alternative harvest strategies where such a long-term projection is not required. The Working Group recommended that a harvest rule that was not dependent on these long-term recruitment projections should be evaluated within the ongoing MSE work.

5.6 The Working Group agreed that a pragmatic way forward was required as stock assessments will be presented to the Scientific Committee in 2026. It agreed that there may be slightly different implementation of forward projections, yet the principles should be consistent between assessments.

Evaluation of the CCAMLR Decision Rules for toothfish and
potential alternative harvest control rules for assessed fisheries

5.7 WG-SAM-2025/12, WG-SAM-2025/19 and WG-SAM-2025/25 presented work addressing the Scientific Committee's workplan for MSEs as set out in SC-CAMLR-43, paragraph 3.14. The tasks identified for WG-SAM-2025 were to provide advice to the Scientific Committee in 2025 on the range of uncertainties to which the management strategy should be robust (WG-FSA-IMAF-2024, paragraph 4.48(i)(a-d)) and suitable operating models for consideration in the MSE (WG-FSA-IMAF-2024, paragraph 4.48(ii)).

5.8 WG-SAM-2025/12 presented a range of uncertainties for each of the key input parameters used in the toothfish stock assessments. The author proposed following the recommendation of Rademeyer et al. (2007) and Punt et al. (2016) to split the uncertainties into a reference scenario that should be used to evaluate the success of the Management Strategy, and a range of robustness trials, under which the Management Strategy should still perform acceptably. The paper proposed to simulate a generic toothfish population and fishery so that the results of the MSE could be applied to any toothfish population and fisheries, including for both Antarctic and Patagonian toothfish species and across all fished CCAMLR areas. In addition to Management Strategies based on an integrated assessment, the paper proposed that the MSE should also investigate alternative approaches where the estimation of stock abundance is based on relatively simple methods such as spatial or non-spatial tag-based estimators rather than integrated stock assessments to set catch limits.

5.9 WG-SAM-2025/19 presented key parameters and their uncertainty ranges for MSEs for Antarctic toothfish in the Ross Sea region. It focused on the parameters that influenced assessment outcomes and hence management advice. This identified critical parameters requiring initial evaluation, including natural mortality, recruitment patterns, growth parameters, tagging-related parameters, maturity, selectivity patterns, and bias in tag-related abundance estimates. For each parameter, the authors provide plausible ranges derived from previous assessments, and meta-analyses that could be used to test the robustness of alternative harvest control rules. The authors recommended developing the MSE process in stages, initially prioritising work on parameters that are likely to be the most influential, and noted that recruitment assumptions would be a high priority.

5.10 WG-SAM-2025/25 presented the outputs of a two-day informal workshop held at the Centre for Environment, Fisheries and Aquaculture Science (UK) to bring together stock assessors and MSE experts to identify approaches to addressing the CCAMLR Scientific Committee’s Workplan. The authors presented approaches to choosing a range of uncertainties for assessment input parameters and proposed that for the Subarea 48.3 toothfish assessment, the highest priorities to investigate within the MSE framework would be mis-estimation of natural mortality and trends in recruitment. The authors considered the use of Casal2 or FLR (Fisheries Library in R) as the basis for suitable operating models and identified approaches to

approximating the Casal2 assessment and 35 years forecasts that may be helpful to evaluate the current for CCAMLR Decision Rules for toothfish efficiently.

5.11 The Working Group noted that the three papers shared many common conclusions in their approaches to selecting plausible range of parameters and the identification of high priority assumptions. The Working Group recommended that scientists working on these MSEs should collaborate to share resources and ensure that the results were presented in a consistent way as much as possible in order to assist the Scientific Committee and Commission in interpreting the outputs.

5.12 The Working Group recalled that the Commission, as the main stakeholder of the MSE, would need to be kept informed about the progress of the process.

5.13 The Working Group proposed two components to Phase 1 of the Management Strategy Evaluation (Phase 1, MSE). As the first component, a generic toothfish operating model with a relatively simple fishery and data generation would be used to compare the current constant catch CCAMLR Decision Rules for toothfish to alternative harvest rules such as those identified in WG-SAM-2024 paragraph 6.10. The Working Group noted that the 35-year projection period of the current CCAMLR Decision Rules for toothfish could be approximated with faster approaches than MCMC sampling (such as multivariate normal sampling or a harvest rate simulated under equilibrium age conditions). For the second component of Phase 1, harvest control rule(s) that were identified by the first component as being promising should be evaluated in stock- specific simulations to ensure that the harvest strategy is robust for that particular fishery.

5.14 The Working Group noted that key uncertainties to be evaluated in Phase 1, MSE should include those relating to estimates of natural mortality, growth and maturity, bias in abundance estimates, and recruitment patterns such as stock-recruitment steepness, recruitment variability, autocorrelation and trends (Table 5.1). For the stock-specific MSE, any other key stock-specific uncertainties and parameter values should be evaluated.

5.15 The Working Group recommended the MSE simulate the fish populations over at least a 200-year time period and to evaluate the performance of the harvest control rules at time steps of 5 years, 10 years, 20 years, 40 years and 200 years.

5.16 The Working Group noted that results of the Phase 1, MSE should be presented in 2026 with the aim that the Scientific Committee will have sufficient information to make a recommendation on the choice of a harvest control rule for each toothfish stock. During the subsequent Phase 2, the MSE could be extended to evaluate other uncertainties of relevance that were not listed as the highest priority and included in Phase 1, MSE, and any other emerging issues.

5.17 The Working Group recommended that the need for further evaluations of harvest control rules be reviewed every 6 years.

5.18 The Working Group noted that the evaluation of the MSE would use the same reference points as specified in the current CCAMLR Decision Rules for toothfish, i.e. maintaining the stock at 50% of $SSB_0$ and having a low probability of being below 20% of $SSB_0$.

Development and testing of data-limited fishery decision rules

5.19 WG-SAM-2025/06 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.

5.20 The Working Group recommended that:

(i) the trend analysis procedure was now mature and did not need to be presented to future meetings of WG-SAM for methodological review, unless there were methodological changes

(ii) the influence of updates in the GEBCO bathymetry would only need to be investigated if requested

(iii) the retrospective analysis of the catch limit advice would only be calculated on request

(iv) the Secretariat should publish a full time series of CPUE trends (or CPUE-derived biomass estimates) and catch limits for each Research Block, either in future iterations of this document, or through the fishery reports.

**Review of new research proposals**

6.1 Five new proposals were submitted and reviewed by the Working Group.

6.2 The Working Group recommended that the Scientific Committee note that evaluating the likelihood of success of new and ongoing research plans would be assisted by a broader review of the research plan review tables which includes a summary of the achievement of previous milestones (paragraph 4.2).

New proposals under CM 21-02

6.3 There were no new research proposals under CM 21-02.

New proposals under CM 24-01

6.4 WG-SAM-2025/08 presented a proposal by New-Zealand to continue the time series of longline research surveys to monitor abundance of Antarctic toothfish (*Dissostichus mawsoni*) in the southern Ross Sea for the next three years (2025/26 to 2027/28). The objectives are to (1) monitor Antarctic toothfish recruitment, (2) monitor trends in abundance of the larger (sub-adult and adult) toothfish in regions where predators of toothfish are abundant (McMurdo

Sound and Terra Nova Bay), and (3) collect and analyse a wide range of data and samples from these areas including benthic invertebrates, fish stomach and tissue samples, and associated environmental and acoustic data. Objectives (2) and (3) are specified as high priority research topics in the research and monitoring plan for the Ross Sea region Marine Protected Area (RSRMPA).

6.5 The Working Group noted that the proposal was using the same methods and design as in previous surveys. The Ross Sea Shelf Survey was an important time series for informing the Ross Sea region stock assessment and delivered a long-term time series of recruitment and provided the ability to track age and length cohorts as they move from the shelf to deeper areas where the exploratory fishery occurs.

6.6 The Working Group noted the trend in toothfish abundance in Terra Nova Bay since 2015 and suggested that the proposal be updated with any available details on research programs conducted on toothfish predators in that region, and the specific contribution of the survey to the RSRMPA research and monitoring plan.

6.7 The Working Group also requested further information on how collected by-catch data from the survey was being used.

6.8 The Working Group noted the change in the sampling rates with all toothfish measured for length, weight, sex and maturity stage data being proposed to be measured up to a maximum of 120 individuals. The Working Group requested that a summary of the number of toothfish caught on each set, and the proportion of times this had exceeded 120, be presented to WG-FSA to allow it to evaluate the effect of this maximum.

6.9 The Working Group evaluated the proposal and the self-assessment provided in Appendix 1 of WG-SAM-2025/08, and agreed that the survey design would achieve its objectives. The Working Group recommended that Scientific Committee approve the research proposal.

6.10 WG-SAM-2025/04 presented a proposal by Chile to conduct a longline survey in Subarea 48.2 from 2025/26 to 2027/28. The main objectives are to (1) obtain relative abundance estimates for toothfish by depth strata using CPUE indices, (2) investigate the toothfish population structure (ratio between Antarctic and Patagonian toothfish, size and age structure, mean length), (3) continue the tagging and recapture program, (4) characterise by-catch species and (5) characterise the interactions of seabirds and marine mammals with fishing operation.

6.11 The Working Group noted that the randomised stratified survey design of the proposed survey was appropriate to estimate abundance, however it recommended the proponents address the following for submission to WG-FSA-2025:

(i) provide additional information on how this survey will complement previous studies conducted in this subarea by Ukraine and UK in previous years and how it will fill gaps in the knowledge on the stock hypothesis of Area 48 (for example, the connectivity and movement of toothfish across this area)

(ii) clarify how the relative abundance estimates will be used to derive an estimate of absolute abundance that can be used by CCAMLR to manage toothfish stocks

(iii) clarify how the objectives would apply to each of the two toothfish species (*D. eleginoides* and *D. mawsoni*)

(iv) modify the sampling regime for toothfish and by-catch species to (a) meet the minimum sampling requirements as used in other CCAMLR fisheries, and (b) collect data on gonad weight and undertake gonad histological analyses to improve knowledge on key life history traits of toothfish in this area

(v) provide more details on the number of otoliths that would be aged and how the age data would be analysed and used, as well as describe the ageing protocols. The Working Group recommended the proponents also consider joining the CCAMLR expert group on toothfish age reading.

(vi) include additional information in the proposal, such as the name of the lead researcher conducting the analysis, sampling protocols, and the tagging procedure form developed by CCAMLR for all research plans

(vii) include a table which summarises the scientific results obtained on previous surveys conducted in Subarea 48.2, including referencing the documents that had been previously submitted to CCAMLR Working Groups where these results were presented

(viii) include the self-assessment table as recommended by WG-FSA (WG-FSA-2019, paragraph 4.28).

6.12 The Working Group noted that the trend analysis cannot be used to calculate catch limits for this survey as there had not been any research fishing in this area over the last 5 years (WG-SAM-2025/06). The Working Group noted that the survey would have to be effort limited, with a catch limit appropriate for the level of effort proposed.

6.13 WG-SAM-2025/18 presented a proposal by Ukraine to conduct a longline survey in Subarea 48.2 from 2025/26 to 2027/28. The main objectives are to (1) obtain a relative abundance of the adult population of *Dissostichus* spp. and determine their biological parameters, (2) determine the spatial distribution of two toothfish species in the study area, (3) assess the impact of fishing operations of different types of bottom longlines on vulnerable marine bottom ecosystems, by-catch, and the environment in general using underwater video systems, (4) carry out electronic monitoring of the processes of setting and hauling longlines, and tagging procedures, (5) undertake plankton and oceanographic research, (6) obtain biological and other observational data in order to evaluate the achievement of the objectives of the South Orkney Islands Southern Shelf Marine Protected Area, and (7) collect biological data for toothfish and by-catch species.

6.14 The Working Group recommended the proponents address the following for submission to WG-FSA-2025:

(i) provide additional information on how this survey will complement previous studies conducted in Subarea 48.2 by Ukraine and UK in previous years and how it will fill gaps in the knowledge on stock hypothesis of Area 48 (for example, the connectivity and movement of toothfish across this area)

(ii) clarify how the relative abundance estimates will be used to derive an estimate of absolute abundance that can be used by CCAMLR to manage toothfish stocks

(iii) undertake a power analysis to help determine the proposed catch limits, and sampling rates for the survey

(iv) clarify how the electronic monitoring data would be analysed and subsequently used

(v) include a table which summarises the scientific results obtained on previous surveys conducted in Subarea 48.2, including referencing the documents that had been previously submitted to CCAMLR Working Groups where these results were presented.

6.15 The Working Group encouraged the proponents of the research proposals in WG-SAM-2025/04 and WG-SAM-2025/18 submit a joint proposal that combined the two research proposals into an integrated proposal to WG-FSA. The Working Group encouraged the proponents to include in this proposal further justification on the need for research in what is a closed area if the intention is not to reach a stock assessment and subsequent fishery.

6.16 WG-SAM-2025/05 presented a proposal by Chile to conduct a longline survey in Subarea 48.3A from 2025/26 to 2027/28. The main objectives are (1) to obtain relative abundance estimates for toothfish by depth stratum, (2) investigate the toothfish population structure (including the relative proportions of Antarctic and Patagonian toothfish, and their size and age structure), (3) continue the tag release and recapture program, (4) characterise bycatch species, and (5) characterise interactions of seabirds and marine mammals with fishing operation.

6.17 The Working Group noted that most of the current information for the fish in this area was from Management Areas 48.3B-C, where an established fishery operates, and Management Area 48.3A may be connected to stocks in both Management area 48.3B-C as well as FAO Area 41. The Working Group also noted that this area may be an important habitat for juvenile Patagonian toothfish and is likely to have a significant occurrence of VME indicator taxa.

6.18 The Working Group requested the proponents address the same comments as were provided for their research proposal presented in WG-SAM-2025/04 where they are applicable (paragraph 6.9 (ii to vi), and (viii)). The Working Group also recommended the proponents address the following for submission to WG-FSA-2025:

(i) consider how the survey will investigate stock structure, given that the randomised stratified random survey had only one station in depths less than 1000m

(ii) consider revising the by-catch limits to be appropriate for the survey area given current limits are calculated for Management Areas 48.3B-C

(iii) consider revising the toothfish tagging rate from 1 fish per tonne to 5 fish per tonne, consistent with the tagging rate proposed in WG-SAM-2025/04 for Subarea 48.2

(iv) review the timing of milestones to ensure that the reporting to CCAMLR is achievable

(v) ensure that the correct vessel is referred to throughout the research plan.

6.19 Dr Kasatkina noted that the proposed research plan is localised and does not cover the distribution area of the toothfish population in Subarea 48.3 and there is no clarity how the data from this plan meets the goals of enhancing the understanding of toothfish population dynamics and inform conservation measures stock assessments. Dr Kasatkina noted that research plan does not respond to recommendations of the Independent Review on biological parameters used in assessment (SC-CAMLR-42/02 Rev. 2).

6.20 Dr Kasatkina noted the position of Russia, repeatedly indicated at the Scientific Committee and the Commission on the need to conduct an international longline survey in Subarea 48.3 to assess the status of the toothfish population. Dr Kasatkina emphasised that, given the above, she does not support the proposed research plan.

6.21 WG-SAM-2025/15 presented a proposal by Ukraine to conduct a trawl and acoustic survey in Subarea 48.2 from 2025/26 to 2027/28. The main objective of the research is to determine the distribution and the abundance of *Champsocephalus gunnari* in the Subarea 48.2.

6.22 The Working Group noted that the research proposal would be supported by acoustic expertise from Norway, who have provided calibration of the onboard 38, 120, and 200 kHz echosounders.

6.23 Dr Kasatkina noted that the first stage of the icefish trawl - acoustic survey was completed in 2022. However, there is still no clarity on the results of this program and recalled that the external expert did not provide any analysis of the acoustic data or its quality (WG-FSA-2022, paragraph 5.45). Dr Kasatkina noted that the proposal required clarity for fundamental aspects such as the acoustic trawl survey methodology, acoustic data collection and processing procedures, expected survey results and survey catchability estimates. The proposal states that data collection and processing will be performed at three frequencies: 38, 120, and 200 kHz. However, the vessel's notification does not specify the installation of a 38 kHz echosounder. Therefore, there is still no clarity regarding the survey acoustic equipment and the proposed use of the multi-frequency data collection and processing method. The proposal specifies estimating the midwater trawl catchability, however, there is still no clarity regarding estimation of catchability and the method of assessment. Dr Kasatkina noted the proposal requires revision, taking into account the above comments.

6.24 The Working Group noted that the acoustic component of this survey will be presented to WG-ASAM-2025 for its review due to the technical expertise required.

6.25 The Working Group requested that a revised proposal be submitted to WG-FSA-2025 that addressed the following issues:

(i) the relevance of the work to CCAMLR, specifically how would the information from the survey be used by CCAMLR

(ii) clarification of trawling operations, and specifically that the trawling will take place at night during the survey

(iii) clarification of the survey data collection and processing.

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

Research results and proposals from Area 48

7.1 WG-SAM-2025/02 presented a revised multi-Member research proposal by Japan, Korea, South Africa, and Spain for the continuation of the exploratory fishery for *D. mawsoni* in Subarea 48.6 from 2024/25 to 2027/28. The proposal maintains the spatial design of four research blocks and includes Korea's participation from 2024/25 to enhance research capacity. The three main objectives are: (i) to provide an assessment of stock status including size/age structure of *D. mawsoni*, (ii) to investigate ecological traits of *D. mawsoni* (e.g. growth, movement and reproduction), and (iii) to improve knowledge of Antarctic marine ecosystems including by-catch composition, predator interactions, and oceanographic conditions.

7.2 The Working Group noted that this proposal was endorsed in 2024 and is currently in its first year of implementation. As there were no substantial changes to the research plan, the proposal was introduced and no issues were raised.

7.3 The proponent noted that the identified icefish nest site in Subarea 48.6 (CCAMLR-43/02. Annex 91-XX/A, paragraph 4(ii), Site 2), is located in Research Block 486_5 but at depths shallower than 550 m, where toothfish fishing is prohibited under CM 22-08, and therefore will not be impacted by fishing operations.

Research results and proposals from Area 58

7.4 WG-SAM-2025/03 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) for the last year of the 4-year research plan. Compared to the research plan that was presented in WG-FSA-IMAF-2024/25, there was one vessel replacement. The plan retained a proposal for structured fishing in Division 58.4.1 to allow for an evaluation of the effects of gear type on the collected data which had been developed based on a recommendation by WG-SAM-2024 (paragraph 8.19).

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

7.6 The Working Group noted that the exploratory fishery and associated research in Division 58.4.1 are important for achieving the robust assessment of *D. mawsoni* and that the research proposal has an appropriate design to meet objectives.

7.7 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 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.

7.8 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 as proposed will not meet the objectives of the research plan for data-limited fisheries and comply with current Conservation Measures.

7.9 The other participants of the Working Group noted that the specially designed experiment presented in the research plan to assess the impact the different gear types on research fishing would be valuable. These participants 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 to 6.7 and 6.54 to 6.72; WG-FSA-2019, paragraphs 4.89 to 4.114; SC-CAMLR-38, paragraphs 3.102 to 3.123; SC-CAMLR-39, paragraphs 4.10 to 4.13; WG-SAM-2021, paragraphs 8.8 to 8.14; WG-FSA-2021, paragraphs 4.17 to 4.28; SC-CAMLR-40, paragraphs 3.100 to 3.104; WG-SAM-2022, paragraphs 5.8 to 8.20; WG-FSA-2022, paragraphs 5.21 to 5.39; SC-CAMLR-41, paragraphs 3.125 to 3.136; WG-SAM-2023, paragraphs 9.12 to 9.19; WG-FSA-2023, paragraphs 4.168 to 4.174; SC-CAMLR-42, paragraphs 2.192 to 2.195; WG-SAM-2024, paragraphs 8.7 to 8.18; WG-FSA-IMAF-2024, paragraphs 4.3 to 4.10; SC-CAMLR-43, paragraph 3.67 to 3.70).

7.10 The Working Group recommended that the research proposal as detailed in WG-SAM-2025/03 proceed for Division 58.4.2, but did not reach consensus on this research plan for Division 58.4.1.

Research results and proposals from Area 88

7.11 WG-SAM-2025/09 provided a report on the results of the 2025 Ross Sea Shelf Survey – the 14th in the time series including a summary of the survey series to date. The 2025 survey was successfully conducted and confirmed strong recent recruitment of Antarctic toothfish, with smaller individuals observed across all strata. Standardised indices, including those for fish under 90 cm, showed a notable increase in abundance compared to 2023. A total of 30.1 tonnes of toothfish were caught, and two previously tagged fish were recaptured – after 5 and 10 years at liberty. Tagging efforts over the years have resulted in 2 405 tagged individuals, with a 96% tagging overlap statistic in 2025.

7.12 The survey continues to provide essential input to stock assessments and addresses 17 of the 22 research priorities under the RSRMPA research and monitoring plan. By-catch was mainly composed of *Trematomus loennbergii* and *Pogonophryne* spp, and small amounts of VME indicator taxa were recorded on most lines. The Working Group recognised its scientific value and the effective use of fishing vessels as research platforms.

7.13 Mr Dunn (New Zealand) thanked Dr Mori (Japan) for her participation on the survey and noted that she had provided a valuable contribution to the survey. Dr Mori thanked New Zealand for allowing her participation in the survey, which she found to be very constructive.

7.14 The Working Group discussed the top predator monitoring conducted onboard and agreed that more detailed information of the time series/strata will be of interest.

7.15 The Working Group noted that different variables could affect the catch rates, such as environmental factors, limited period of the year and migrations, but these did not significantly alter the standardisation of the catch rates.

7.16 The Working Group noted that scavenging amphipods could have an impact on the catch rates by, for example, consuming bait. The Working Group recommended consideration of how their presence may have affected catch rates to be provided in future analyses.

7.17 The Working Group noted that Figures 6 and 7 of WG-SAM-2025/09 had used different scales in the plots for the toothfish catch per set and requested that the scales be standardised in future reports.

7.18 The Working Group noted that a time series of the abundance of small fish as well as all fish was presented, and that the development of age-specific abundance indices was planned to be evaluated within the Ross Sea region toothfish stock assessment.

7.19 WG-SAM-2025/13 provided a notification for a research plan targeting Antarctic toothfish in the Bellingshausen Sea (Subarea 88.3) by Korea and Ukraine. This is the first year of the three-year research plan under CM 24-01 (2024/25–2026/27) endorsed in 2024 and WG-SAM-2025/20 provided a progress report on the joint research for *Dissostichus* spp. in Subarea 88.3 by Korea and Ukraine during the 2024/25 fishing season.

7.20 Research fishing was conducted by two vessels following the survey design described in WG-FSA-IMAF-2024/52 Rev. 1. Two new research blocks have been visited along with three of the existing research blocks. Two of the existing research blocks were not accessible due to sea ice. Two toothfish recaptures were reported and CPUE values were variable across blocks, with notably high catch rates in the newly incorporated research blocks 883_11 and 883_12, supporting hypotheses on westward movement and connectivity with Subarea 88.2.

7.21 Proponents noted that the two research blocks that have not been fished this season will be a priority in the next season.

7.22 The Working Group noted that although the sampling design is randomised across the research blocks, research block 883 4 showed activity exclusively in the western part of the research block and that this was due to bad weather conditions experienced by one of the vessels.

7.23 The Working group noted that ageing work on toothfish is an essential step for the development of a stock assessment. Korea informed the Working Group that they have started to progress otolith ageing over recent years (WG-FSA-IMAF-2024/62 Rev. 1, pages 13 to 15) and participated in the last two CCAMLR ageing workshops, supporting ageing work particularly in Subarea 88.3. It also noted Ukraine has already collaborated with Chinese scientists to contribute to the ageing work.

7.24 The Working Group noted the low number of tag recaptures. The Working Group noted the importance of tracking tagging performance to understand the likelihood of collecting enough tagging data to support a stock assessment. The Working Group requested the proponents consider this issue for their revision and submission to WG-FSA-2025. In research blocks 883 1, 883 3 and 883 4 the bad weather together with the planned location of the sets have prevented the return year after year to the same locations.

7.25 The Working Group requested the proponents provide a map to WG-FSA-2025 of the proposed locations of the stations along with the actual fishing locations to help to understand ability of the vessels to implement the agreed research plan.

**Future work**

8.1 The Working Group considered revisions to its current task list as described in SC-CAMLR-43, Table 7 and recommended the following changes:

(i) remove the 'years' columns when the table is updated but retain the timeframe

(ii) significant progress has been made in progressing Task 2 on developing an integrated stock assessment for krill. However, the Working group noted that Dr Watters has retired. The Working Group thanked him for his invaluable contributions and noted that he will be missed.

(iii) revise Task 3 to read: Evaluate tagging performance using different gear types

(iv) Dr Hoyle can be removed as a contributor to Task 4

(v) task 5 has been completed and can be removed

(vi) should the conversion factor recommendations made by WG-SAM-2025 be adopted by the Scientific Committee, Task 6 can be removed

(vii) revise Task 7 to read: Evaluate bias in tagging data in abundance estimation

(viii) revise Task 9 to read: Estimation of sample size requirements per age class for an ageing reference set

(ix) task 10 is considered to be a low priority and can be removed

(x) in addition to the tasks identified in the Terms of Reference for WG-SAM, additional tasks are prioritised within this workplan, and therefore Task 11 can be removed.

(xi) in the row labelled '1, d, ii, 1)', the rows for 'T17-6 and 7', can be removed from SAM topic lists as remaining aspects of this topic are covered by WG-FSA

(xii) add Ms Ouzoulias as a contributor to Task 12

(xiii) revise 1, d, iii) to begin with 'CCAMLR Decision Rules for finfish…'

(xiv) move rows 1, d, iii) 'T17-8, 22, and 18-10' to be included under Task 12 with other aspects of that row to be covered by WG-FSA

(xv) revise Task 14 to read: Effective sample size estimation for monitoring fish by-catch in the krill fishery

(xvi) considerable progress has been made on Task 15, and with additional work next year the Diagnostic and stock status graphs task can be removed

(xvii) add a new task to: Develop a repository of code with examples of standardised diagnostics. This should have a time frame of 'Short' and include Secretariat support with contributions by WG-SAM

(xviii) add a new task to: Develop a repository for code to estimate biological parameters, including worked examples. This should have a time frame of 'Short' and include Secretariat support with contributions by WG-SAM

(xix) add a new task to: Develop code for stock assessment diagnostics and stock status. This should have a time frame of 'Short' and include Secretariat support with contributions by WG-SAM.

8.2 The Working Group noted requests to the Secretariat for developing code repositories in 8.1 (xvii) and (xviii), and requested that the Secretariat develop a structure for these Github repositories and assist contributors to ensure that contributed code and simulated data were organised in a consistent manner.

8.3 The Working Group noted that it was given and has addressed tasks associated with improving tag bias in stock assessments and developing an MSE framework last year (SC-CAMLR-43 and 3.8 and 3.15). It noted that additional tasks from SC-CAMLR-43, paragraph 3.8 should be added to the workplan.

8.4 The Working Group noted that the current task list is ambitious and highlighted that with limited resources WG-SAM may fail to complete some tasks (paragraphs 3.4 and 9.3).

## Other business

9.1 The Working Group noted that most items from the toolbox for research plan design (SC-CAMLR-38, paragraph 4.17) had been completed in the past five years due to contributions from the Secretariat and Members. These tools included: (i) mapping tools or tutorials; (ii) scripts for statistical power analysis; (iii) scripts for the random selection of stations; (iv) indications on the definition and delimitation of sampling strata; (v) diagnostic methods for sea-ice conditions; and (vi) scripts for comparative analysis of vessel tagging performance.

9.2 The Working Group noted further tool development by the Secretariat such as research planning tools within the spatial data viewer, or particle tracking tools to study stock connectivity would be useful. The Working Group recommended the Scientific Committee consider the extent to which these tools be made available for Member use throughout the year.

9.3 The Working Group also noted that additional capacity development support, being piloted as the CAP-D-LISA workshop to be held in Tenerife, Spain in the following week (23 to 27 June) also contributes to tool development for research plans.

9.4 The Working Group noted that the proposed review template for the evaluation of research plan and proposal results is likely to identify further useful analytical tools.

## Advice to the Scientific Committee

10.1 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) Estimating warp strikes in the krill fishery (paragraph 2.4)

(ii) Toothfish ageing programs (paragraph 3.10)

(iii) Conversion factor sampling (paragraph 3.24)

(iv) C1 form revision (paragraph 3.27)

(v) Stock assessment status projections (paragraph 5.5)

(vi) Development of MSEs (paragraph 5.12 to 5.18)

(vii) Toothfish trend analysis (paragraph 5.20)

(viii) Research plan review and proposals (paragraphs 6.2, 6.9 and 7.10)

(ix) Future work (paragraphs 8.1 and 8.4)

(x) Development of research planning tool (paragraph 9.2).

## Adoption of report and close of meeting

11.1 The report of the meeting was adopted, with the adoption process requiring 2.6 hours of discussion.

11.2 Dr Okuda, noting that this was his last meeting as a convener of WG-SAM, thanked the participants for their support, and the Secretariat for their assistance. He thanked the IEO and the hosts for organising a successful meeting in a beautiful city on the beach. He noted that the short adoption process seemed to be a miracle, but that it was a result of good discussions and clear text. He confidently welcomed Mr Maschette to take over the role of convener.

11.3 Mr Dunn (New Zealand) thanked to co-conveners for their leadership and organisation, and especially Dr Okuda for his years of service, noting he should be back in a leadership role in the near future. He also congratulated Mr Maschette for the great work in his first meeting as a convener, and looked forward to the coming years of WG-SAM meetings.

11.4 Mr Maschette thanked the participants and the Secretariat for their support, and their forbearance with his rapid speaking. He looked forward to progressing the many issues within WG-SAM's workplan.

## References

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Table 1: Specification of the Phase 1 Management Strategy Evaluation (Phase 1, MSE) for component 1 (Generic MSE) and component 2 (Stock-specific MSE), and key parameters that the MSE should include, and harvest rules to be evaluated.

| **Issue** | **Parameters** | **Generic MSE (component 1)** | **Stock specific MSE (component 2)** |
|---|---|---|---|
| Uncertainties to be evaluated | Natural mortality | X | X |
| | Maturity | X | X |
| | Growth | X | X |
| | Bias in abundance estimates | X | X |
| | Recruitment patterns | X | X |
| | Steepness | X | X |
| | Recruitment variability | X | X |
| | Recruitment autocorrelation | X | X |
| | Recruitment trend | X | X |
| | Stock-specific uncertainties and parameter values | | X |
| Harvest control rules to be evaluated | Current CCAMLR decision rules for toothfish | X | |
| | Constant harvest rate (rule 1 in WG-SAM-2024, paragraph 6.10) | X | X |
| | Alternative ramp rule (e.g. rules 3 and 6, WG-SAM-2024, paragraph 6.10) | X | X |

Appendix A

## List of Participants

Working Group on Statistics, Assessments and Modelling
(Tenerife, Spain, 16 to 20 June 2025)

| | |
|---|---|
| **Co-convener** | Mr Dale Maschette<br>Institute for Marine and Antarctic Studies (IMAS), University of Tasmania |
| **Co-convener** | 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** | Dr Roberto Licandeo<br>Independent consultant |
| | Mr Mauricio Mardones<br>Doctoral student, Antarctic and Subantarctic Program, Universidad de Magallanes |
| | Dr Carlos Montenegro Silva<br>Instituto de Fomento Pesquero de Chile |
| **China** | Professor Guoping Zhu<br>Shanghai Ocean University |
| **France** | Dr Clara Péron<br>Muséum national d'Histoire naturelle |
| | Ms Fanny Ouzoulias<br>Muséum national d'Histoire naturelle |
| **Japan** | Dr Mao Mori<br>Japan Fisheries Research and Education Agency |

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|---|---|
| **Korea, Republic of** | Dr Sangdeok Chung<br>National Institute of Fisheries Science (NIFS) |
| | Dr Eunjung Kim<br>National Institute of Fisheries Science |
| | Mr Hyun Joong Choi<br>TNS Industries Inc. |
| | Mr Kunwoong Ji<br>Jeong Il Corporation |
| **New Zealand** | Mr Alistair Dunn<br>Ocean Environmental |
| | Ms Rose Leeger<br>University of Colorado |
| **Russian Federation** | Dr Svetlana Kasatkina<br>AtlantNIRO |
| **South Africa** | Mr Sobahle Somhlaba<br>Department of Agriculture, Forestry and Fisheries |
| **Spain** | Mr Roberto Sarralde Vizuete<br>Instituto Español de Oceanografía-CSIC |
| | Mrs Vanessa Rojo Méndez<br>IEO-CSIC Spanish Institute of Oceanography |
| | 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) |
| **CCAMLR Secretariat** | Dr Steve Parker<br>Science Manager |
| | Dr Stéphane Thanassekos<br>Fisheries and Ecosystems Analyst |

Appendix B

# Agenda

Working Group on Statistics, Assessments and Modelling
(Tenerife, Spain, 16 to 20 June 2025)

1. Introduction
    1.1. Opening of the meeting
    1.2. Adoption of the Agenda
2. Krill
    2.1. Data collection
    2.2. Stock assessment model
3. Finfish data collection
    3.1. Ageing
    3.2. Develop methods to estimate biomass for finfish
4. Develop stock assessments to implement decision rules for finfish
    4.1 Ageing
    4.2 Tagging performance
    4.3 Stock assessment developments
    4.4. Developments in diagnostics and trends
5. Management strategy evaluations for target species
    5.1 Evaluation of the CCAMLR decision rules and potential alternative harvest control rules for assessed fisheries
    5.2 Development and testing of data-limited fishery decision rules
6. Review of new research proposals
    6.1 New proposals under CM 21-02
    6.2 New proposals under CM 24-01
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. Future work

9. Other business

10. Advice to the Scientific Committee

11. Adoption of report and close of meeting

Appendix C

**List of Documents**

Working Group on Statistics, Assessments and Modelling
(Tenerife, Spain, 16 to 20 June 2025)

| | |
|---|---|
| WG-SAM-2025/01 | Power analysis to assist in establishing a sampling regime for Conversion Factors in CCAMLR toothfish fisheries<br>CAMLR Secretariat |
| WG-SAM-2025/02 | Continuation of Research on Antarctic toothfish (*Dissostichus mawsoni*) exploratory fishery in Statistical Subarea 48.6 from 2024/25-2027/28): Research Plan under CM 21-02, paragraph 6(iii)<br>Delegations of Japan, Korea, South Africa and Spain |
| WG-SAM-2025/03 | Continuing research in the *Dissostichus mawsoni* exploratory fishery in East Antarctica (Divisions 58.4.1 and 58.4.2) from 2022/23 to 2025/26; Research plan under CM 21-02, paragraph 6(iii)<br>Delegations of Australia, France, Japan, Korea and Spain |
| WG-SAM-2025/04 | New Research Plan for Toothfish (*Dissostichus* spp.) under CM 24-01, paragraph 3 in Subarea 48.2, conducted by Chile from season 2025/26 to 2027/28<br>Delegation of Chile |
| WG-SAM-2025/05 | New Research Plan for Toothfish (*Dissostichus* spp.) under CM 24-01, paragraph 3 in Subarea 48.3A, conducted by Chile from season 2025/26 to 2027/28<br>Delegation of Chile |
| WG-SAM-2025/06 | 2025 provisional trend analysis: preliminary estimates of toothfish biomass in Research Blocks.<br>CCAMLR Secretariat |
| WG-SAM-2025/07 | Proposed new separate C1 trawl haul by haul forms for krill and finfish fisheries<br>CCAMLR Secretariat |
| WG-SAM-2025/08 | Proposal to continue the time series of research surveys to monitor abundance of Antarctic toothfish (*Dissostichus mawsoni*) in the southern Ross Sea, 2025/26–2027/28: Research Plan under CM 24-01<br>Delegation of New Zealand |

| | |
|---|---|
| WG-SAM-2025/09 | Results of the 2025 Ross Sea Shelf Survey and summary of the survey series to date<br>Mormede, S., M. Mori and W. Lyon |
| WG-SAM-2025/10 | Approaches to forecasting recruitment in age-structured stock assessment modelling<br>Dunn, A. |
| WG-SAM-2025/11 Rev. 1 | Assessing environmental and predator impacts on Antarctic Krill (*Euphausia superba*) population dynamics from an integrated length-to-age assessment model perspective<br>Mardones, M., E.J. Mason, A. Pinones, L. Krüger, F. Santa Cruz, C. Cárdenas and R. Methot |
| WG-SAM-2025/12 | Considerations about the specification of a management strategy evaluation (MSE) for CCAMLR toothfish fisheries<br>Ziegler, P. |
| WG-SAM-2025/13 | Continuing 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>Delegations of Korea and Ukraine |
| WG-SAM-2025/14 | Developing robust approaches to define areas to represent spatial structure of Patagonian toothfish in Heard Island and McDonald Islands (HIMI)<br>Masere, C., A. Coghlan, D. Maschette and P. Ziegler |
| WG-SAM-2025/15 | Fishery research proposal – The acoustic-trawl survey *Champsocephalus gunnari* in the Statistical Subarea 48.2<br>Delegation of Ukraine |
| WG-SAM-2025/16 | Initial investigations of a sex-specific stock assessment model for *Dissostichus eleginoides* in Division 58.5.2<br>Maschette, D., S. Wotherspoon, C. Masere and P. Ziegler |
| WG-SAM-2025/17 | Investigating the adherence of fisheries' tagging data-sets to mark-recapture assumptions<br>Masere, C., A. Coghlan, D. Maschette and P. Ziegler |
| WG-SAM-2025/18 | New Fishery Research Proposal Plan Under CM 24-01 Paragraph 3 to Conduct the Survey *Dissostichus* spp. in the Statistical Subarea 48.2 during seasons 2025/2026, 2026/2027, 2027/2028<br>Delegation of Ukraine |
| WG-SAM-2025/19 | Parameters for Management Strategy Evaluation for toothfish using integrated age-structured models<br>Dunn, A. |

| | |
|---|---|
| WG-SAM-2025/20 | Progress report on the joint research for *Dissostichus* spp. in Subarea 88.3 by Republic of Korea and Ukraine in 2025<br>Delegations of Korea and Ukraine |
| WG-SAM-2025/21 | Draft workflow for the calibration of Generalized Additive Models to extrapolate warp strikes observations in the krill fishery<br>CCAMLR Secretariat |
| WG-SAM-2025/22 | The calibration exercise of age determination of Antarctic Toothfish from Subarea 48.6 by Japanese and Spanish aging laboratories<br>Mori, M., T, Okuda, R. Sarralde Vizuete and N.D. Gonzalez-Fernandez |
| WG-SAM-2025/23 | Conveners Report of the 3rd Workshop on Age Determination (WS-ADM3)<br>Owen, K., P. Hollyman, J. Devine and C. Brooks |
| WG-SAM-2025/24 | Results from the 2024 Kerguelen shelf survey (POKER V) in Division 58.5.1<br>Péron, C., M. Kauffmann, N. Gasco, F. Massiot-Granier, F. Ouzoulias, C. Chazeau and A. Martin |
| WG-SAM-2025/25 | Steps towards the development of a CCAMLR Management Strategy Evaluation<br>Earl, T., S.R. Alewijnse and L. Readdy |
| WG-SAM-2025/26 | Sex-disaggregated biological parameters for Patagonian toothfish (*Dissostichus eleginoides*) in Subarea 48.3<br>Alewijnse, S.R. and T. Earl |
| WG-SAM-2025/27 | Recruitment assumptions in integrated assessments of toothfish<br>Alewijnse, S.R., L. Readdy and T. Earl |
| WG-SAM-2025/28 | Acoustic assessments of fish pelagic resources in the CCAMLR area: Some proposals on methodological aspects for fish acoustic survey<br>Kasatkina, S. |
| WG-SAM-2025/29 | Comments on the krill samples undertaken by observers to evaluate efficiency of SISO sampling protocols in the krill fishery<br>Sergeev, S. and S. Kasatkina |