

**Report of the Working Group
on Statistics, Assessment and Modelling**
(Virtual meeting, 28 June to 2 July 2021)

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**Report of the Working Group on
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Introduction to the meeting

1.1 The 2021 meeting of the Working Group on Statistics, Assessment and Modelling (WG-SAM) was held online from 28 June to 2 July 2021. The Co-conveners, Dr C. Péron (France) and Dr T. Okuda (Japan), welcomed the participants (Appendix A).

Adoption of the agenda and organisation of the meeting

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

2.2 Documents submitted to the meeting are listed in Appendix C. The Working Group thanked the authors of papers and presentations for their valuable contributions to the work of the meeting.

2.3 This report was prepared by the Secretariat and the Co-conveners. Sections of the report dealing with advice to the Scientific Committee and other working groups are highlighted and collated in 'Recommendations to the Scientific Committee'.

Development and progress of stock assessments

Stock assessments for krill

3.1 The Working Group recalled that Conservation Measure (CM) 51-07 will expire in November 2021 and will need to be replaced by an integrated krill management strategy. To establish this strategy, WG-ASAM-2021 has made progress on establishing baseline krill biomass estimates and a report has been submitted for review to WG-EMM-2021. WG-SAM-2021 has been requested to review the generalised R yield model (Grym) configuration, its assumptions and parameterisation. WG-EMM-2021 will develop the risk assessment, examining spatial allocation scenarios for the catch limits. WG-FSA-2021 will combine the outcomes for the Scientific Committee, which will provide advice to the Commission. In this context, the Working Group noted that it was important to differentiate between work needed for advice this year regarding the revision of CM 51-07 and work which could be incorporated later.

3.2 WG-SAM-2021/09 introduced an improvement to the proportional recruitment model developed by de la Mare (1994a, 1994b) to simulate stochastic recruitment based on proportional recruitment estimates derived from survey data. This development provides a more flexible representation of a number of recruitment distribution models within the Grym and more representative recruitment simulations under high recruitment variability using a parametric bootstrap method.

3.3 The Working Group welcomed this improvement to the Grym and noted that time series of US AMLR krill survey data show that estimated recruitment is highly variable, and that years with very large recruitment do not appear to occur consecutively. Recruitment parameters for Grym simulations should aim to reflect the potential recruitment variability while minimising biases introduced by data collection methods.

3.4 The Working Group reviewed an example of diagnostic plots showing interactions between simulations using different biological parameters in the Grym and noted that such plots will be very useful when calibrating plausible model scenarios.

3.5 WG-SAM-2021/10 described an extension of the Grym to permit the inclusion of multiple fleets within a season, allowing it to model more complex fishery behaviour and evolving fisheries practices.

3.6 The Working Group noted that at present this extension could be used in a range of fisheries assessments, and thanked the authors for these important developments which allow more flexibility in Grym assessments.

3.7 WG-SAM-2021/22 outlined some general considerations that needed to be taken into account when choosing an appropriate spatial scale to run Grym simulations, including that the chosen spatial scale may need to be large enough to cover the various components of the krill stock adequately. The pros and cons of using the biomass estimates resulting from the 2019 International Area 48 Krill Survey and the multiple mesoscale surveys were also discussed.

3.8 The Working Group welcomed this contribution and noted that there would be value in exploring results at both the mesoscale and large scales. It further noted that the spatial scale may be important for ensuring that recruitment is adequately represented, and that recruitment estimates derived from spatially restricted surveys may not necessarily be representative of recruitment at larger scales.

3.9 The Working Group agreed that the Grym could be run at different scales. In the absence of spatially explicit stock assessment models, focus needs to be on scales considered as appropriate given our current knowledge of the stock and available data and parameters.

3.10 WG-SAM-2021/07 presented estimates of krill proportional recruitment in Subareas 48.1–48.3, calculated using the Scheme of International Scientific Observation (SISO) observer data, as requested by WG-EMM-2019.

3.11 The Working Group noted that 40 mm was selected as an upper boundary for the recruitment ratio, which may include krill individuals aged between 1 and 2 years old, and the age-1 group may not be represented adequately.

3.12 The Working Group also noted that analyses of length frequency distribution can be influenced by variability in the gear types and mesh sizes used in the commercial krill fishery, and by an avoidance effect which occurs in scientific nets when the mouth openings are too small.

3.13 WG-SAM-2021/19 presented proportional recruitment and length-weight indices obtained during research trawls in Subareas 48.1 and 48.2 from the RV *Atlantida*. The paper noted that the length-weight relationship obtained by stratum differed from the length-weight equation used by the CCAMLR 2000 Krill Synoptic Survey of Area 48 (CCAMLR-2000

Survey) ($w = 2.236 \times 10^{-6} \times l^{3.314}$ (w = mass (mg), l = length (mm)) (WG-EMM-16/38), and that the use of the CCAMLR-2000 Survey relationship would underestimate the krill areal biomass density by 10 to 26% depending on the stratum, when compared to the length-weight relationships developed on this survey.

3.14 The Working Group noted the large number of krill measured as part of the survey, that data from these measurements could be used for parameter inputs into the Grym, and that the differing length frequency values for each stratum highlight the importance of working with appropriate spatial scale and having an appropriate length cut-off for the proportional recruitment parameter.

3.15 The Working Group requested that Members provide the raw length and weight data from surveys to the Grym e-group (paragraph 3.22) for combined analyses of the length-weight relationship and length frequencies from all sampled areas within Subarea 48.1.

3.16 WG-SAM-2021/20 Rev. 1 presented a summary of proportional recruitment and multiyear biomass variability for krill in Subarea 48.1, from historic research surveys and fishery data. The paper noted that the US AMLR research survey data showed highly structured length distributions for krill that varied with time on a five-to-six-year cycle but were similar across the four survey strata. These cohorts were not observed in the fishery data, and the variability on an interannual basis was much greater in the US AMLR survey data than in the fishery data.

3.17 The Working Group noted the high variability in the proportional recruitment parameters calculated from the US AMLR survey data, and that the selectivity of the fishery data may be due to pooling data from different vessels, as typical krill trawls use small mesh sizes (15–16 mm) which may produce comparable results with research survey trawls. The Working Group highlighted the importance of consistent time series of survey information in order to determine changes in population dynamics.

3.18 WG-SAM-2021/12 presented a summary table of preliminary Grym parameter values which resulted from discussions of the Grym e-group (paragraph 3.15).

3.19 The Working Group noted that the krill stock simulations using the Grym are a relatively simple representation of the krill population that, for example, assuming spatial homogeneity and that all parameters and data are reflective of processes of the krill population within the area represented by the simulation.

3.20 The Working Group further recalled that de la Mare (1994b), used the age-2 group, instead of the age-1 group collated in the summary table, to represent the recruits.

3.21 The Working Group noted the importance of an appropriate parameterisation of the Grym, and that there was no clear agreement yet on the most appropriate values to use for Grym parameters.

3.22 The Working Group agreed that a constructive way forward would be to investigate multiple parameter value combinations within an ensemble modelling approach, using the Grym. The Working Group noted that, as a result, a set of sustainable yield estimates could be presented to WG-FSA-2021. The Working Group agreed that this work would be carried out collaboratively via an e-group coordinated by Mr D. Maschette (Australia) (the Grym parameters ensemble e-group).

3.23 The Working Group noted that the Grym parameters ensemble e-group should focus on Subarea 48.1 and consider the following issues:

- (i) continue the development of diagnostic plots that can be used in the evaluation and comparison of simulation scenarios
- (ii) use of a length interval, rather than only an upper length boundary, to represent recruits
- (iii) explore dependencies and correlations between parameters (e.g. recruitment and natural mortality)
- (iv) develop a number of different scenarios which are ensembles of parameter values that are internally consistent. Scenarios (parameter value combinations) may take advantage of efforts that have already been made (e.g. WG-SAM-2021/07, 2021/12, 2021/19, 2021/20 Rev. 1)
- (v) scenarios could include a range of ecologically meaningful spatial scales (e.g. WG-SAM-2021/22), given the scales at which parameters have been estimated
- (vi) run the Grym for these different scenarios
- (vii) the realism of simulation outputs should be investigated and used to eliminate parameter combinations that do not provide sensible results (e.g. validation should include inspection of the internally estimated mortality rate to ensure it was not unrealistically low or high, and comparison between the variability in simulated biomass and long-term acoustic biomass estimate to ensure that it was consistent with results reported in WG-EMM-2021/05 Rev. 1).

3.24 The Working Group agreed that in order to undertake this work, contributions of length frequency and other data important for generating parameter values, and suggestions for sensibility tests, should be forwarded to the e-group by 30 July 2021. The e-group should undertake the work of developing and running plausible Grym scenarios in order to present a report in time to be submitted to WG-FSA-2021 at the end of August.

Stock assessments for toothfish fisheries

3.25 WG-SAM-2021/13 presented a proposed update to the method for the stock assessment of Antarctic toothfish (*Dissostichus mawsoni*) in the Ross Sea region. The analysis presented some alternative methods for the treatment of tag data and sensitivities that could be investigated for the next assessment. Diagnostic plots for a partial update of the 2021 assessment model (WG-SAM-2021/14) and a stock annex (WG-SAM-2021/15) accompanied this paper.

3.26 The Working Group noted the computational limitations of the current CASAL version as applied to the Ross Sea region assessment. As new data and new partitions are added to this assessment model, CASAL may be unable to compute a stock assessment for this stock with complete data in time for WG-FSA-2021.

3.27 The Working Group noted that although the exclusion of three years of tagging data (2001–2003) has the advantage of reducing computational difficulties, with virtually no impact on estimation results in the CASAL model assessment while improving overall model fit, the decision to exclude specific data requires careful consideration. The Working Group noted that the CCAMLR tagging protocol had not yet been established during these years.

3.28 The Working Group welcomed the intention of New Zealand to present Casal2 to Members at WG-FSA-2021 which may overcome these computational limitations in future assessments. The Working Group discussed the potential introduction of Casal2 for integrated stock assessments and recalled its previous discussions on software changes such that if Casal2 was to be introduced into CCAMLR, initial assessments using Casal2 would need to be presented using both CASAL and Casal2 methods for comparison.

3.29 The Working Group considered the inclusion of data from outside the CCAMLR area in the assessment model and noted that catches in the South Pacific Regional Fisheries Management Organisation (SPRFMO) areas are treated as removals from the Ross Sea in the assessment but are not included in the projection phase because it is not known if these catches will continue.

3.30 The Working Group recommended that the 2021 stock assessment of toothfish in the Ross Sea region be an update of the 2019 assessment, and requested that the paper to WG-FSA-2021 present additional information justifying any removal of tag cohorts and further exploring the impact of their removal on the assessment. It was also recognised that, if CASAL was unable to compute a stock assessment with tagging data for 2001–2020, the exclusion of the 2001–2003 tagging data may be warranted.

Trend analysis for data-limited toothfish fisheries

3.31 WG-SAM-2021/06 presented a provisional trend analysis for research blocks in data-limited fisheries and requested feedback from WG-SAM regarding four points, as listed in the paper.

3.32 The Working Group considered the requested feedback and recommended that:

- (i) A provisional trend analysis would only be required for presentation at WG-SAM if the underlying data (e.g. GEBCO bathymetry data) had changed or if the structure of the analysis itself was revised (e.g. adding or changing a step in the decision tree).
- (ii) The vulnerable biomass estimates from the reference areas (in Division 58.5.2 and the Ross Sea region) would only be used once the stock assessments for these areas had been agreed by the Commission.
- (iii) In order to establish catch limits in research blocks where fishing has not taken place in recent fishing seasons, the Working Group agreed that if data were not available from the most recent fishing season, the previous catch limit should be carried forward. Such an approach should be limited to five years, after which time the catch limit would need to be re-evaluated outside the current trend analysis framework.

- (iv) Fishable area estimates should be updated every time a new version of the GEBCO bathymetry data is released, and an analysis similar to the one presented in the appendix of the paper should be undertaken to compare the impact. The new GEBCO data should be used in its native resolution, e.g. 450 m resolution for the 2020 GEBCO dataset instead of 500 m as in previous versions (see WG-SAM-15/01).
- (v) When values for input variables change (e.g. seabed area, historical CPUE data or tagging data), the differences should be applied retrospectively to maintain comparability of values for the trend analysis.

Management strategy evaluations: consideration of alternative toothfish harvest control rules, including F-based rules for stocks with integrated assessments

4.1 WG-SAM-2021/08 presented simple simulations to outline alternative decision rules that would be consistent with the current CCAMLR decision rule and its objective. The rules in the paper were based on a harvest rate, H , which was stochastically estimated from stock productivity and fishery selectivity to result in the long-term 50% spawning stock biomass (SSB) depletion with a probability of 50%.

4.2 The Working Group recalled the discussions on the CCAMLR decision rules at WG-FSA in 2019 (WG FSA-2019, paragraphs 3.14 to 3.41) and at the Scientific Committee (SC-CAMLR-38, paragraphs 3.61 to 3.64), where it was noted that refinement of the current decision rule could include the addition of harvest control rules under specific circumstances, such as when productivity changes are detected or when the level of historical illegal, unreported and unregulated (IUU) catches is unknown.

4.3 The Working Group further recalled its recommendation to include in any future CCAMLR stock assessment a comparison of catch limits based on the CCAMLR decision rule alongside catch limits based on the harvest rate associated with achieving 50% B_0 (WG-SAM-2019, paragraphs 3.9 to 3.11).

4.4 The Working Group agreed that the approach taken by the paper (WG-SAM-2021/08) to conduct harvest control rule simulations as a proxy for management strategy evaluations for stock assessments was appropriate to evaluate decision rules.

4.5 The Working Group recommended exploration of different shapes for the harvest control rule in addition to those already explored in the paper (constant and ‘hockey-stick’ harvest rate where harvest rate decreased when the stock status was below the target) and presentation of comparisons of the risk to the stock and expected yield from the alternative rules.

4.6 The Working Group recommended further evaluation of alternative decision rules to explore the effects of, inter alia:

- (i) auto-correlation and bias in stock assessments, with values comparable to those seen in historical CCAMLR stock assessments
- (ii) delays and error in management implementation of catch limits.

Cross-cutting issues in toothfish fisheries affecting data or stock assessment model quality

5.1 No papers were submitted to this agenda item and the Working Group did not discuss it.

Development of a toolbox for designing research plans

6.1 No papers were submitted to this agenda item and the Working Group did not discuss it.

Data service advisory group

7.1 No papers were submitted to this agenda item and the Working Group did not discuss it.

Review of new research proposals

8.1 WG-SAM-2021/01 presented a proposal for a new research plan to continue research on *D. mawsoni* in Subarea 88.3 by the Republic of Korea and Ukraine.

8.2 The Working Group welcomed the proposal and recalled that WG-FSA had discussed in 2019 accessibility issues caused by sea-ice in this area and recommended that a revised proposal to WG-FSA should address this issue using updated data (WG-FSA-2019, paragraph 4.179). The Working Group noted that the survey design had taken into account past comments. It also noted that milestones on age determination should be incorporated in the proposal, that the proposed longitudinal extension of research block 1 would need to be justified within the context of its potential impact on tag recaptures, and that minimum sampling requirements should be set for by-catch species.

8.3 WG-SAM-2021/04 Rev. 2 presented a proposal for a new research plan to continue research on *D. mawsoni* in Subarea 48.6 by Japan, South Africa and Spain.

8.4 The Working Group welcomed the proposal and indicated that it would benefit from linking its objectives to those of the Workshop for the Development of a *D. mawsoni* Population Hypothesis for Area 48 (WS-DmPH). The Working Group noted the importance of understanding stock connectivity between research blocks in the area (seamounts versus continental shelf) and requested further details about how the stock structure will be represented in the planned CASAL assessment for the region. It also noted that the otolith sampling rate (10 otoliths per 5 cm length bin) was lower than in other areas and that minimum sampling requirements should be set for by-catch species and designed to meet the research objectives. The Working Group noted that the *Shinsei-maru No. 8* fished in the Ross Sea region in the 2020/21 season, hence improving the ability to link relative tagging performance to vessels in this research plan. It recalled that a structured fishing design was necessary to optimise tagging performance evaluation.

8.5 The Working Group endorsed the design of this research proposal and recommended that it proceed.

8.6 WG-SAM-2021/05 presented a proposal to conduct a new research survey targeting mackerel icefish (*Champsocephalus gunnari*) in Subarea 48.2 by Ukraine.

8.7 The Working Group welcomed this proposal and noted that given its significant acoustics component, it would need to also be reviewed by WG-ASAM. In particular regarding its areal coverage, choice of acoustic frequencies, day–night sampling, the size of trawl used for target identification and the methodology used to discriminate icefish from krill. The Working Group questioned the need for the high catch limit proposed, given the low expected standing stock in the area from the 2018 Chilean trawl survey (WG-SAM-18/25), and suggested that a by-catch limit might be required for krill instead of it being a proportion of the catch limit. The Working Group noted that given the proposed catch limit being greater than 50 tonnes of finfish, a revised proposal needed to follow the standardised guidelines and format adopted by the Scientific Committee given in CM 24-01, Annex 24-01/A, format 2.

8.8 WG-SAM-2021/18 presented a proposal for a new research plan to continue research on *D. mawsoni* in Divisions 58.4.1 and 58.4.2 by Russia.

8.9 The Working Group considered only the methodological aspects of this proposal since this research was not notified by the required deadline of 1 June. The Working Group discussed the issue of gear standardisation in multi-Member surveys and recalled past discussions on the subject, over several years and in different working group meetings (e.g. SC-CAMLR-39, paragraph 4.10; SC-CAMLR-38, paragraphs 3.105 to 3.108; SC-CAMLR-XXXVII, paragraphs 3.139 to 3.141). The Working Group further noted that standardisation is performed both through survey design (e.g. side-by-side sampling with different gears) and statistical analyses of the data.

8.10 Dr S. Kasatkina (Russia) reiterated her position in relation to methodical issues for the multi-Member research in the *Dissostichus* spp. exploratory fishery in Divisions 58.4.1 and 58.4.2 that she had raised in the past regarding the need for standardisation of fishing gear and survey design (SC-CAMLR-XXXVII, paragraph 3.137). Dr Kasatkina highlighted that any Member for participation in the particular exploratory fishery in Divisions 58.4.1 and 58.4.2 should prepare and submit to the Secretariat a Research Plan in accordance with CM 24-01 for review by WG-SAM, WG-FSA, the Scientific Committee and Commission and then reporting for evaluation and review of this Research Plan (CM 21-02, paragraph 6iii). The catch limit for the exploratory fishery in Divisions 58.4.1 and 58.4.2 is set only for implementation of this Research Plan and subdivided between vessels declared in this Research Plan. However, for the exploratory fishery in Subarea 88.2, being an example of other CCAMLR exploratory fisheries, the catch limit is set according to a stock assessment for the *D. mawsoni* population and any vessel can participate in the Olympic fishery here in accordance with CM 21-02. Dr Kasatkina noted that the *D. mawsoni* multi-Member research in East Antarctic should not be considered an exploratory fishery and continuing of such research requires standardisation of sampling fishing gear and survey design in accordance with common practice.

8.11 The Working Group noted that various longline gear types are permitted in exploratory fisheries in the Convention Area, and that integrated assessments have been, and are currently being, developed based on data collected using mixed gear types. The Working Group was unable to determine Dr Kasatkina's rationale as to why the exploratory fishery in Division 58.4.1 should proceed with only a standardised gear type requirement. The Working Group requested that the Scientific Committee discuss this.

8.12 The Working Group noted that catch allocation between participating Members of a research plan, as opposed to an Olympic fishing arrangement, allowed Members to conduct their research with sufficient catch available.

8.13 The Working Group recalled that the data-limited exploratory fishery in Subarea 88.2 had only sufficient tag-recapture data to perform a Chapman estimate of biomass in one research block in 2019 while it used to be assessed with an integrated stock assessment. As a consequence, SC-CAMLR-38 recommended to include small-scale research units (SSRUs) 882C–H as a data-limited exploratory fishery in CM 21-02, paragraph 6(iii) (SC-CAMLR-38, paragraphs 3.139 and 3.140).

8.14 The Working Group noted that the classification of all toothfish fisheries is an issue for the Commission.

Review of ongoing research results and proposals

Research results and proposals from Area 48

9.1 WG-SAM-2021/17 presented a report on the toothfish survey in Subarea 48.1 conducted by the Ukrainian vessel *Calipso* in 2021.

9.2 The Working Group welcomed this report and, while noting that this survey had to be interrupted again due to high macrourid by-catch levels, it had generated a large amount of data on toothfish, by-catch species and ecosystem information in a poorly surveyed area. The Working Group further noted that these results could inform the toothfish population hypothesis in Area 48.

9.3 Noting that the by-catch levels would render the establishment of a directed toothfish fishery in the area difficult, the Working Group recommended highlighting which research milestones could not be achieved due to by-catch issues (WG-SAM-2021/17), in order to inform any potential future research in this area.

9.4 WG-SAM-2021/21 presented an updated analysis of the sea-ice concentration in research blocks 4 and 5 of Subarea 48.6.

9.5 The Working Group welcomed this analysis and noted its pertinence to the research proposal in Subarea 48.6 (WG-SAM-2021/04 Rev. 1) given the effect of sea-ice on the accessibility of research blocks. The Working Group recalled the previous work on sea-ice accessibility done in Subarea 48.1 (WG-FSA-18/01) and suggested a similar analysis may be valuable for these areas.

Research results and proposals from Area 58

9.6 WG-SAM-2021/03 presented a multi-Member research proposal for continuing research in the *D. mawsoni* exploratory fishery in East Antarctica (Divisions 58.4.1 and 58.4.2). The proponents proposed to continue the research in the existing research blocks in Divisions 58.4.1 and 58.4.2 with a revised sampling design for hauls within each research

block. If directed fishing was again not allowed in Division 58.4.1 in 2021/22, the proponents proposed to continue the research plan in the one existing, and one new, research block in Division 58.4.2. The location of this new research block was determined by a suitability assessment and fishing in this block would be effort-limited.

9.7 The Working Group welcomed the change in survey design presented by the proponents following previous advice and recalled past discussions regarding the use of different gear types by the vessels involved, noting that no current conservation measure required the use of single gear types in exploratory fisheries (WG-FSA-2019, paragraphs 4.89 to 4.114). It also recalled that the catch allocation in research blocks was designed to facilitate vessel coordination and completion of research objectives. The Working Group further noted the strong interest of the proponents of this proposal to resume their research on toothfish stock assessment, stock structure hypothesis (e.g. using archival tags) and ecology (e.g. stomach contents).

9.8 The Working Group noted that the new research block, proposed for the case that directed fishing was not allowed in Division 58.4.1 in 2021/22, was located in SSRU 5842C. This SSRU has a current catch limit of 0 tonnes in CM 41-05.

9.9 The Working Group endorsed the survey design as presented, acknowledging the quality of the proposal, and collaborative research between several Members.

Research results and proposals from Area 88

9.10 WG-SAM-2021/02 presented a notification for the Ross Sea shelf survey in 2022.

9.11 The Working Group noted that this was the last year of this five-year research plan aiming at monitoring juvenile toothfish in the Ross Sea region. The Working Group noted the great importance of the time series generated by this survey for the stock assessment in this area given the information it provided on biomass and year-class strength. The Working Group recalled that the management areas to which the survey catch will be allocated will be decided by the Commission (CCAMLR-39, paragraph 5.39).

9.12 The Working Group recalled that data on the abundance of juvenile toothfish obtained by the Ross Sea shelf survey are reflected in the subsequent fish length frequency in fishing catch data, and integrated within the Ross Sea stock assessment to track recruitment into the adult population.

9.13 The Working Group highlighted that in previous years increasing catch rates had led to the survey not being completed and suggested WG-FSA-2021 consider if a higher catch limit should be set for this survey to avoid undermining its objectives.

Future work

10.1 The Working Group recalled that the five-year work plan agreed by the Scientific Committee in 2017 (SC-CAMLR-XXXVI/BG/40) needed to be updated. Noting previous discussions of future work (WG-SAM-2019, paragraph 7.2; SC-CAMLR-38, paragraph 13.4) it discussed potential future strategic areas of WG-SAM work that could be considered by the

Scientific Committee. Considering the topics of the 2017 work plan, the Working Group noted, in particular, the need to add krill issues to the WG-SAM work plan given the need to revise the krill management approach.

10.2 The Working Group noted that the list of future work topics for WG-SAM is large and growing through time and requested the Scientific Committee consider priority work topics and mechanisms to progress those issues given the limited time available during WG-SAM meetings and limited capacity for Members to prepare work for the meetings.

10.3 The Working Group discussed the possibility of holding online workshops and symposia during the intersessional period, including an update to the five-year work plan, and cross-working group workshops (e.g. WG-ASAM–WG-SAM to discuss statistical approaches to acoustic and other data), Casal2 and Grym training workshops. The Working Group noted that the Science Capacity Building Fund could be used for the organisation of such workshops.

10.4 The Working Group agreed that over the last two years, the burden sharing over the timing of the virtual meetings had been unequal across time zones and that an equitable solution needed to be devised in the future for formal and informal virtual meetings.

10.5 The Working Group noted the future Data Services Advisory Group (DSAG) webinar (see SC CIRC 21/112) and requested it be recorded for those who would be not available during the dark hours. It also noted the relevance of a tagging workshop involving the fishing industry (COLTO–CCAMLR Workshop, WG-EMM-2019, paragraph 4.8) as well as a krill observer workshop (SC-CAMLR-38, paragraph 3.38), which both have been delayed due to COVID-19.

10.6 The Working Group recommended that the Scientific Committee consider the following tasks for cooperation between WG-SAM and other working groups:

- (i) consideration of the statistical approaches to acoustic data emerging from new acoustic observation platforms (WG-ASAM)
- (ii) establishment of Grym parameters for krill stock assessments in Areas 48 and 58 (WG-EMM).

10.7 The Working Group requested that the Scientific Committee consider the following topics as potential future tasks for WG-SAM:

- (i) future evaluation of Casal2 and CASAL
- (ii) update and evaluation of the trend analysis framework
- (iii) evaluation of the CCAMLR decision rules and potential alternative harvest control rules
- (vi) progress on toothfish population hypothesis in Area 48.

Other business

11.1 WG-SAM-2021/11 presented an examination of fishery data collected by Russian scientific observers on longline vessels operating Spanish and trotline systems in CCAMLR

and adjacent Atlantic waters during the 2002–2017 fishing seasons. Considerations of the fishing impact zone of the gears were discussed, including the effect of bottom currents, bathymetry and water stratification on the area influenced by bait odour plumes.

11.2 The Working Group thanked the authors for their paper and noted that the catchability of gear types is dependent on many variables. The Working Group encouraged the continuation of the research and encouraged the authors to design field experiments or controlled experiments (e.g. aquaculture tanks) to test their hypotheses.

11.3 The Working Group noted that the term ‘fishing impact zone’ could be confused with the term ‘fishery footprint’ used to assess vulnerable marine ecosystem (VME) impact, and suggested to use the term ‘area fished’ instead. It also recalled that WG-FSA-18/62 and WG-EMM-2019/50 used baited remote underwater video cameras to document toothfish behaviour in proximity to bait.

11.4 WG-SAM-2021/16 presented a proposal to include corrected data from the Ukrainian fishing vessels *Simeiz*, *Koreiz* and *Calipso* in the CCAMLR database, as data from these vessels from 2014 to 2018 are currently quarantined by the Scientific Committee (SC-CAMLR-38, paragraph 3.56). The authors noted that both the corrected and original data should be available to Members, as well as information on the method used to correct the data.

11.5 The Working Group welcomed the work undertaken by Ukraine and the Secretariat to evaluate the causes of the data discrepancies from these vessels. The Working Group encouraged the continuation of this work, including a proposed alternative approach based on using observer data to identify and indicate actual catch weights and subsequently correct the C2 data.

11.6 The Working Group noted that the inclusion of corrected data in the CCAMLR database would potentially result in the overwriting of the original data, that it did not consider this best practice, and that DSAG may be a suitable forum for consideration of this topic.

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) trend analysis (paragraph 3.32)
- (ii) gear types in exploratory fisheries (paragraph 8.11)
- (iii) research proposal for continuing research in Divisions 58.4.1 and 58.4.2 (paragraph 9.9).

Adoption of the report and close of meeting

13.1 The report of the meeting was adopted.

13.2 At the close of the meeting Dr Péron and Dr Okuda thanked all the participants for their hard work and collaboration that had contributed greatly to the successful outcomes from WG-SAM this year, and to the Secretariat, Interprefy staff and the stenographers for their support. The Co-conveners further noted that although the length of the meeting had been shorter than an in-person event, a large body of work had been accomplished and a considerable future workplan developed for WG-SAM.

13.3 On behalf of the Working Group Dr C. Darby (UK) and Mr N. Walker (New Zealand) thanked Dr Péron and Dr Okuda for their guidance during the meeting, the Secretariat for their work compiling the report, and the technical support provided by the Interprefy team. The Working Group acknowledged the successful use of the Interprefy platform for hosting the meeting, and the provision of official advice to the Scientific Committee.

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(Virtual Meeting, 28 June to 2 July 2021)

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Agenda

Working Group on Statistics, Assessments and Modelling (Virtual meeting, 28 June to 2 July 2021)

1. Introduction
2. Opening of the meeting
 - 2.1 Adoption of the agenda and organisation of the meeting
3. Development and progress of stock assessments
 - 3.1 Stock assessments for krill
 - 3.2 Stock assessment for established toothfish fisheries
 - 3.3 Stock assessment for data-limited toothfish fisheries
 - 3.3.1 Trend analysis for data-limited toothfish fisheries
4. Management strategy evaluations: consideration of alternative toothfish harvest control rules, including F-based rules for stocks with integrated assessments
5. Cross-cutting issues in toothfish fisheries affecting data or stock assessment model quality
 - 5.1 Uncertainties in tagging programs (tag matching, vessel calibration method, etc.)
 - 5.2 Conversion factors
6. Development of a toolbox for designing research plans
 - 6.1 Demo of the CCAMLR R GIS package
 - 6.2 Tools to design sampling strategy for research surveys (under CM 24-01)
7. Data service advisory group
8. Review of new research proposals
9. Review of ongoing research results and proposals
 - 9.1 Research results and proposals from Area 48
 - 9.2 Research results and proposals from Area 58
 - 9.3 Research results and proposals from Area 88
10. Future work
11. Other business
12. Advice to the Scientific Committee
13. Adoption of report and close of meeting.

List of Documents

Working Group on Statistics, Assessments and Modelling
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WG-SAM-2021/01	New research plan for <i>Dissostichus</i> spp. under CM 24-01, paragraph 3 in Subarea 88.3 by Korea and Ukraine from 2021/22 to 2023/24 Delegations of the Republic of Korea and Ukraine
WG-SAM-2021/02	Notification for the Ross Sea shelf survey in 2022 Delegation of New Zealand
WG-SAM-2021/03	Continuing research in the <i>Dissostichus mawsoni</i> exploratory fishery in East Antarctica (Divisions 58.4.1 and 58.4.2) from 2018/19 to 2021/22; Research plan under CM21-02, paragraph 6(iii) Delegations of Australia, France, Japan, Republic of Korea and Spain
WG-SAM-2021/04 Rev. 2	Proposal for continuing research on Antarctic toothfish (<i>Dissostichus mawsoni</i>) in Statistical Subarea 48.6 in 2021/22 from a multiyear plan (2021–2024): Research Plan under CM 21-02, paragraph 6(iii) Delegations of Japan, South Africa and Spain
WG-SAM-2021/05	Proposal to conduct a local survey of <i>Champscephalus gunnari</i> in Statistical Subarea 48.2 Delegation of Ukraine
WG-SAM-2021/06	Provisional Trend Analysis – Preliminary 2021 research blocks biomass estimates Secretariat
WG-SAM-2021/07	Antarctic krill proportional recruitment indices (2010–2020) in Subareas 48.1–48.3 from the observer data Secretariat
WG-SAM-2021/08	Preliminary exploration of H-based decision rules for managing toothfish fisheries R. Hillary, P. Ziegler and J. Day

WG-SAM-2021/09	Recruitment modelling for <i>Euphausia superba</i> stock assessments considering the recurrence of years with low recruitment C. Pavez, S. Wotherspoon, D. Maschette, K. Reid and K. Swadling
WG-SAM-2021/10	Multi-fleet stock assessment modelling with the Grym J. Liu, S. Wotherspoon and D. Maschette
WG-SAM-2021/11	Analysis of the factors influencing the fishing impact zone for the longline toothfish fishery O. Krasnoborodko, S. Kasatkina and A. Remeslo
WG-SAM-2021/12	Grym parameter values for Subareas 48.1, 48.2 and 48.3 S. Thanassekos, K. Reid, S. Kawaguchi, S. Wotherspoon, D. Maschette, P. Ziegler, D. Welsford, G. Watters, D. Kinzey, C. Reiss, C. Darby, P. Trathan, S. Hill, T. Earl, S. Kasatkina and Y.-P. Ying
WG-SAM-2021/13	Updated stock assessment model for the Antarctic toothfish (<i>Dissostichus mawsoni</i>) population of the Ross Sea region for 2021 A. Grüss, A. Dunn and S. Parker
WG-SAM-2021/14	Diagnostic plots for the 2021 assessment model for the Antarctic toothfish (<i>Dissostichus mawsoni</i>) population of the Ross Sea region A. Grüss, A. Dunn and S. Parker
WG-SAM-2021/15	Stock Annex for the 2021 assessment of the Antarctic toothfish (<i>Dissostichus mawsoni</i>) population of the Ross Sea region A. Grüss, A. Dunn and S. Parker
WG-SAM-2021/16	Options to include the Ukrainian quarantined data to the CCAMLR database I. Slypko and K. Demianenko
WG-SAM-2021/17	Report on the toothfish survey in the Subarea 48.1 by the Ukrainian vessel <i>Calipso</i> in 2021 Delegation of Ukraine
WG-SAM-2021/18	Research Plan under CM 21-02, paragraph 6 (iii). Proposal for new multi-Member research on <i>Dissostichus</i> spp. in Divisions 58.4.1 and 58.4.2 from 2021/22 to 2023/24 Delegation of the Russian Federation

- WG-SAM-2021/19 Proportional recruitment and weight-length relationship for krill in Subarea 48.1 and 48.2 from RV *Atlantida* survey, 2020
S. Kasatkina and S. Sergeev
- WG-SAM-2021/20 Rev. 1 Summary of proportional recruitment and multiyear biomass variability for krill in Subarea 48 from research surveys
D. Kinzey
- WG-SAM-2021/21 2021 updated analysis of the sea ice concentration (SIC) in research blocks 4 (RB4), and 5 (RB5) of Subarea 48.6 with sea surface temperature (SST) and winds
T. Namba, R. Sarralde, T. Ichii, T. Okuda, S. Somhlaba and J. Pompert
- WG-SAM-2021/22 Moving from biomass estimates towards precautionary catch limit: spatial scale revisited
Y. Ying, X. Wang, X. Zhao, Y. Zhao, G. Fan and J. Zhu