SC-CAMLR-38

SCIENTIFIC COMMITTEE FOR THE CONSERVATION OF ANTARCTIC MARINE LIVING RESOURCES

REPORT OF THE THIRTY-EIGHTH MEETING OF THE SCIENTIFIC COMMITTEE

HOBART, AUSTRALIA
21–25 OCTOBER 2019

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Chair of the Scientific Committee
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Abstract

This document presents the adopted report of the Thirty-eighth Meeting of the Scientific Committee for the Conservation of Antarctic Marine Living Resources held in Hobart, Australia, from 21 to 25 October 2019. Reports of meetings and intersessional activities of subsidiary bodies of the Scientific Committee, including the Working Groups on Statistics, Assessments and Modelling; Ecosystem Monitoring and Management; Fish Stock Assessment; and the Subgroup on Acoustic Survey and Analysis Methods, are appended.

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Contents

Report of the Thirty-eighth
Meeting of the Scientific Committee
(Hobart, Australia, 21 to 25 October 2019)

Opening of the meeting

1.1 The Scientific Committee for the Conservation of Antarctic Marine Living Resources met from 21 to 25 October 2019 at the CCAMLR Headquarters in Hobart, Tasmania, Australia. The meeting was chaired by Dr M. Belchier (UK).

1.2 Dr Belchier welcomed to the meeting representatives from Argentina, Australia, Belgium, Chile, People's Republic of China (China), European Union (EU), France, Germany, India, Italy, Japan, Republic of Korea (Korea), Namibia, New Zealand, Netherlands, Norway, Russian Federation (Russia), South Africa, Spain, Sweden, Ukraine, United Kingdom of Great Britain and Northern Ireland (UK), United States of America (USA) and Uruguay.

1.3 Dr Belchier welcomed the Netherlands to their first Scientific Committee meeting as Members of CCAMLR and congratulated Dr F. Schaafsma in her role as the first Scientific Committee Representative of the Netherlands. He also recalled that Dr Schaafsma had first attended WG-EMM as a recipient of a CCAMLR scientific scholarship and that this was a very good example of the success of the scholarship scheme.

1.4 Other Contracting Parties, Bulgaria, Canada, Cook Islands, Finland, Greece, Mauritius, Islamic Republic of Pakistan, Republic of Panama, Peru and Vanuatu were invited to attend the meeting as Observers. Luxembourg and Ecuador were also invited and attended the meeting.

1.5 Dr Belchier also welcomed to the meeting Observers from intergovernmental organisations the Agreement on the Conservation of Albatrosses and Petrels (ACAP), Commission for the Conservation of Southern Bluefin Tuna (CCSBT), Committee on Environmental Protection (CEP), the International Union for the Conservation of Nature and Natural Resources – the World Conservation Union (IUCN), the Scientific Committee on Antarctic Research (SCAR), the Scientific Committee on Oceanic Research (SCOR), the South East Atlantic Fisheries Organisation (SEAFO), the Southern Indian Ocean Fisheries Agreement (SIOFA), the South Pacific Regional Fisheries Management Organisation (SPRFMO) and non-governmental organisations the Association of Responsible Krill harvesting companies (ARK), the Antarctic and Southern Ocean Coalition (ASOC), the Coalition of Legal Toothfish Operators (COLTO), the International Association of Antarctic Tour Operators (IAATO) and Oceanites Inc.

1.6 The List of Participants is given in Annex 1. The List of Documents considered during the meeting is given in Annex 2.

1.7 While all parts of this report provide important information for the Commission, paragraphs of the report summarising the Scientific Committee's advice to the Commission have been highlighted. Contributed statements are indicated in italics.

1.8 The report of the Scientific Committee was prepared by T. Brey (Germany), C. Darby (UK), D. De Pooter (Secretariat), A. Dunn (New Zealand), T. Earl (UK), M. Eléaume (France), J. Fenaughty and G. Funnell (New Zealand), S. Grant and S. Gregory (UK), J. Hinke and

C. Jones (USA), S. Kawaguchi (Australia), B. Krafft and A. Lowther (Norway), D. Maschette (Australia), B. Meyer (Germany), P. Penhale (USA), C. Péron (France), K. Reid (Secretariat), G. Robson (UK), M. Santos (Argentina), M. Söffker (EU), S. Somhlaba (South Africa), S. Thanassekos (Secretariat), P. Trathan (UK), N. Walker (New Zealand), G. Watters (USA), G. Zhu (China) and P. Ziegler (Australia).

Adoption of the agenda

1.9 The Scientific Committee discussed the Provisional Agenda which had been circulated as SC CIRC 19/86 prior to the meeting consistent with Rule 7 of the Scientific Committee's Rules of Procedure. The Agenda was adopted without change (Annex 3).

Chair's report

1.10 Dr Belchier noted the Scientific Committee's work in the 2018/19 intersessional period. The following meetings had taken place:

(i) Working Group on Statistics, Assessments and Modelling (WG-SAM), 17 to 21 June 2019, Concarneau, France (Annex 4). Convened by Dr S. Parker (New Zealand) and Dr C. Péron (France). Attended by 44 participants from 13 Members with 37 papers considered

(ii) Working Group on Ecosystem Monitoring and Management (WG-EMM), 24 June to 5 July 2019, Concarneau, France (Annex 5). Convened by Dr C. Cárdenas (Chile) and attended by 61 participants from 17 Members with 84 papers considered

(iii) Subgroup on Acoustic Survey and Analysis Methods (SG-ASAM), 26 to 30 August 2019, Bergen, Norway (Annex 6). Convened by Dr X. Zhao (China) and attended by 20 participants from 8 Members with 10 papers considered

(iv) Working Group on Fish Stock Assessment (WG-FSA), 7 to 18 October 2019, Headquarters, Hobart (Annex 7). Convened by Dr D. Welsford (Australia) and attended by 44 participants from 14 Members with 81 papers considered.

1.11 Dr Belchier noted the very large volume of intersessional work undertaken in 2019 and offered his thanks to the conveners, hosts and local organisers for their technical and logistic support. He noted this level of intersessional work demonstrated the commitment of CCAMLR scientists to progress the priority work items of the Scientific Committee.

1.12 Dr Belchier also thanked COLTO and the hosts and conveners of the COLTO–CCAMLR Toothfish Catch and Effort Data Workshop held in Cape Town, South Africa, 30 July to 1 August 2019 (COLTO–CCAMLR Workshop). This was a highly successful workshop bringing together industry, science and management expertise (WG-FSA-2019/01).

1.13 Dr Belchier thanked the Members of the Scientific Committee Bureau for their engagement through the year to plan and coordinate the work plan for meetings and expressed his gratitude for their input to the virtual bureau meetings despite the occasional inconvenience of working across 16 time zones.

1.14 Dr Belchier encouraged all participants to work together to provide scientifically based advice to the Commission. He stressed the desire of the Scientific Committee was to reach agreement on important issues, but that, where agreement cannot be found, the report should reflect the points of difference and the alternative hypotheses that they reflect.

1.15 Dr Belchier expressed his sadness at the news of the untimely death of our US colleague, Dr Adrian Dahood-Fritz, who died in the California dive boat fire accident in early September. He noted Dr Dahood's contribution to the work of CCAMLR and in particular to the fields of ecosystem modelling and spatial management as well as her role in the Women in Polar Science community. He extended the condolences of all of the Scientific Committee to Adrian's relatives, friends and colleagues.

Advances in statistics, assessments, modelling, acoustics and survey methods

Statistics, assessments and modelling

2.1 The Scientific Committee reviewed advice from WG-SAM (WG-SAM-2019 report) which was directed to WG-FSA, Members, or to the Scientific Committee.

2.2 WG-SAM is following a five-year work plan from the Scientific Committee set out in SC-CAMLR-XXXVI/BG/40 addressing three of the six themes:

(i) assessments to estimate sustainable yield in established/assessed fisheries

(ii) development of management advice consistent with Article II for fisheries with more limited data

(iii) data acquisition and management.

2.3 The Scientific Committee noted that the review of research plans and proposals again took a significant proportion of the time available at the meeting and is delaying work on WG-SAM's progress in its main objectives.

2.4 Under the theme of 'Assessments to estimate sustainable yield in established/assessed fisheries', WG-SAM (WG-SAM-2019 report, paragraphs 3.1 to 3.8) discussed refinement or development of stock assessments, including progress in estimation of natural mortality and maturity ogives, in response to the recommendations of the CCAMLR Independent Stock Assessment Review for Toothfish.

2.5 The Scientific Committee noted WG-SAM's discussions (WG-SAM-2019 report, paragraphs 3.9 to 3.11) on the use of CASAL to estimate a constant sustainable harvest rate that would lead the stock achieving 50% B_0 regardless of the initial status of the stock. This method could be used to help evaluate the yield calculations using the CCAMLR decision rules in data-poor fisheries and where unknown amounts illegal, unreported and unregulated (IUU) fishing has occurred in the past.

2.6 As recommended by the Scientific Committee (SC-CAMLR-XXXVII, paragraph 3.51), a paper was presented on the time series of biological productivity parameters for Subarea 48.3. WG-SAM (WG-SAM-2019 report, paragraphs 3.12 to 3.19) noted that when the effect of confounding factors was taken into account in analyses, there was no indication of systematic change in stock parameters that would indicate potential impacts from the fishery or impacts of climate change on toothfish length, age and sex composition.

2.7 Under the theme of 'Data acquisition and management', WG-SAM (WG-SAM-2019 report, paragraphs 4.1 to 4.13) reviewed a new method for tag linking and a new template for Fishery Reports developed by the Secretariat. The Scientific Committee welcomed the initiatives by the Secretariat, which has enabled greater transparency and improved data quality.

2.8 To address concerns raised by the Scientific Committee in 2018 (SC-CAMLR-XXXVII, paragraph 3.124), Ukraine provided a description of the reporting processes followed on some vessels, which resulted in the underestimation of catches reported in the C2 forms. Methods to account for operating conditions when estimating catch weights on board were discussed.

2.9 The Scientific Committee noted Ukraine's transparency in the provision of the details to WG-SAM (WG-SAM-2019 report, paragraphs 4.5 and 4.6) of the under-reporting of catch data and its work with the Secretariat to provide further details of the potential extent of the underestimation of catches (including by vessel, year and area) to WG-FSA in order that the implications of this on the provision of management advice could be reviewed.

2.10 The Scientific Committee agreed that the under-reporting of catches by Ukrainian vessels should be considered by the Standing Committee on Implementation and Compliance (SCIC).

2.11 Under 'Development of management advice in fisheries with more limited data', the Scientific Committee noted WG-SAM's discussions on the topic of research standardisation.

2.12 Several approaches to data standardisation were discussed: (i) the requirement for an appropriate survey design to minimise or identify vessel effects and (ii) the necessity for robust statistical analyses to account for the multiple factors that may affect catch rate, catch composition or tag recaptures (WG-SAM-2019 report, paragraphs 6.2 to 6.11).

2.13 The Scientific Committee noted that WG-SAM had developed a list of the key influential factors that should be considered in the design of research data collection and statistical analyses of results (WG-SAM-2019 report, Table 1). In addition, WG-SAM had also highlighted that power analysis was a key step in determining the likelihood of success of research designs to meet their objectives, and that an R code had been provided to run statistical power analyses to evaluate the likely success of sampling designs (appendix in WG-SAM-2019/06).

2.14 The Scientific Committee noted the WG-SAM discussions on research fishing proposed in marine protected area (MPA) zones (WG-SAM-2019 report, paragraphs 6.15 to 6.17) and agreed that a proposal should ensure it maximises scientific outputs and that robust scientific conclusions can be drawn from those outputs.

2.15 The Scientific Committee noted that in recent years the development by the Scientific Committee and its working groups of criteria for the evaluation of research proposals has considerably enhanced the evaluation process. It has enabled the proponents to link the objectives of their research to the priorities of the Scientific Committee, and for WG-SAM and WG-FSA to provide feedback on the proposals in a consistent manner, including standardisation of on-the-water research, design, analysis and reporting of research, leading to improved advice. The Scientific Committee noted that in future meetings, clarification and transparency in the decision-making process during evaluation, as to why proposals did not meet the expected criteria, was needed.

2.16 The Scientific Committee endorsed the recommendations from WG-SAM, outlined in the WG-SAM-2019 report, paragraphs 6.16 and 6.17, that research proposals that relate to MPA objectives should:

(i) identify which priority research elements are addressed

(ii) explicitly integrate core concepts of good scientific research design (replication, randomisation and reference areas) to ensure robust experimental results

(iii) explain why the proposed research or data collection cannot be conducted during the exploratory fishery

(iv) provide a detailed rationale for the choice of comparable reference areas

(v) demonstrate how participating vessels will employ robust standardised procedures, including how the vessels involved will provide high-quality and comparable data, especially with respect to toothfish tag-survival and tag detection rates

(vi) demonstrate Members' capacity to conduct high-quality and timely shore-based analyses necessary to utilise the data to inform the research and monitoring plan (RMP) evaluation process

(vii) describe the mechanism by which research fishing is coordinated with other research fishing and with any Olympic fishery, and how the research will avoid being compromised by spatial and temporal interactions

(viii) provide an environmental impact assessment for the research, and an assessment of how the research may impact the objectives of the MPA.

2.17 The Scientific Committee also endorsed the recommendations from WG-SAM, outlined in the WG-SAM-2019 report, paragraphs 6.17, that proposals that relate to MPA objectives should include design components, including:

(i) a clear rationale and approach for the definition of experimental strata

(ii) well-designed statistical approaches to standardise the results to control for variation due to operational effects (e.g. catch-rate standardisation)

(iii) removing the effects of vessel choice in fishing location through randomisation of survey station locations

(iv) the use of power analyses and simulations to ensure robust statistical comparisons

(v) ensuring that the proposed data collection requirements can be implemented by including the appropriate scientific expertise, numbers of people sampling, and/or use of scientific electronic monitoring.

2.18 The Scientific Committee noted the WG-SAM discussions (WG-SAM-2019 report, paragraph 6.19) on research in closed areas notified under Conservation Measure (CM) 24-01, which includes requirements for research plans in Annexes 24-01/A and 24-01/B. It noted that these annexes had not been reviewed for several years.

2.19 The Scientific Committee recommended that the annexes in CM 24-01 should be updated to reflect changes in the WG-SAM and WG-FSA review process, including the requirements for research within MPAs. It also noted that research targeting toothfish should not undermine the other objectives that MPAs are designed to achieve for CCAMLR.

2.20 The Scientific Committee noted that WG-SAM had reviewed and commented on all research plans and research results submitted to the meeting. The process had followed the research proposal template agreed by SC-CAMLR-XXXVII, Annex 13.

2.21 Progress against milestones was evaluated and advice provided by WG-SAM to improve research plans or analyses of existing data. Summary tables of the proposal assessments were updated for consideration by WG-FSA. Most of the advice was to Members, the Secretariat or to WG-FSA.

2.22 The Scientific Committee noted that WG-SAM (WG-SAM-2019 report, paragraph 6.38) had reported that the tag-overlap statistic for the Ukrainian survey in Subarea 48.1 reported in WG-SAM-2019/33 was lower than the 60% threshold specified by CM 41-01 while the number of fish tagged was greater than the 30 minimum for the threshold to apply. WG-SAM recommend the failure to achieve the statistic be reviewed by SCIC. The low overlap percentage resulted from a low number of large fish in the tagged fish length distribution compared to the catch. However, the Scientific Committee also noted that WG-FSA had reported a mistake in WG-SAM-2019/33 and a recalculated value for the survey was above the required threshold, therefore this was not referred to SCIC.

2.23 The Scientific Committee noted that under 'Other Business', WG-SAM had discussed several topics related to vulnerable marine ecosystem (VME) risk area estimation, skate ageing and satellite tagging deployments (WG-SAM-2019 report, paragraphs 8.1 to 8.8). In addition, a proposal for a new fishery for crabs in Subareas 88.2 and 88.3 was presented, but this proposal was not reviewed because consideration of new fisheries was considered to be outside the remit of WG-SAM (WG-SAM-2019 report, paragraphs 8.7 and 8.8).

2.24 The Scientific Committee noted that under 'Future Work', WG-SAM (WG-SAM-2019 report, paragraph 7.7) requested the Scientific Committee consider the prioritisation of the following tasks for WG-SAM:

(i) the Strategic Plan was last updated in 2016, and the current five-year work plan could be updated to help prioritise and frame the workload for the WG-SAM in the next few years

(ii) the Scientific Committee consider developing an overarching strategic direction for the work plan to more clearly define the role of the Working Group, noting that cross-links with WG-ASAM and WG-EMM could create opportunities for sharing of scientific expertise on high-priority quantitative work areas

(iii) given recent advice by the Commission and the Scientific Committee, a timeline is required to effectively monitor, strategically align, and clarify the review process for each research plan.

2.25 The Scientific Committee discussed the heavy workload of WG-FSA and WG-SAM, as has been discussed at previous meetings, particularly in relation to the review of research proposals. The Scientific Committee agreed that work plans and review timelines would be considered intersessionally by the Scientific Committee Bureau for consideration by the working groups.

Acoustic survey and analysis methods

2.26 The Scientific Committee approved the results from the report of the meeting of SG-ASAM (held in Bergen, Norway, 26 to 30 August 2019) (SG-ASAM-2019 report), which advised that the krill biomass estimate from the 2019 Area 48 Survey was 62.6 million tonnes with a coefficient of variation (CV) of 13%. Smaller-scaled surveys were also conducted under the same overarching survey effort and data were analysed during the meeting. These are contributions to the ongoing timeseries of krill density estimates from Subareas 48.1, 48.2 and 48.3. The analysis procedures included recommendations and issues raised during WG-EMM-2019, including a review of the application of methods for cross-checking and quality control.

2.27 The Scientific Committee endorsed the advice from SG-ASAM that the estimated krill biomass from the 2019 Area 48 Survey was 62.6 million tonnes.

2.28 The Scientific Committee welcomed the successful completion of the field work for the 2019 Area 48 Survey and the presented analyses of data. It noted the coordination efforts by Norway and recognised that this project was a significant undertaking amongst multiple Members and the fishing industry and that this was realised after a short planning period and thanked all participants for their contributions.

2.29 The survey demonstrated that fishing vessels can be utilised as platforms for collecting large-scale scientific information on krill and that the successful cooperation between scientists and the fishing industry provides considerable benefits for developing scientific advice for management.

2.30 The Scientific Committee looked forward to seeing further outcomes from the survey objectives on krill biology, population characteristics, other taxa and analyses of environmental data collected during the survey. The Scientific Committee also encouraged the initiation of planning for the next large-scale survey.

2.31 Russia highlighted the efforts undertaken by SG-ASAM-2019 to provide data analysis of the 2019 Area 48 Survey taking into account any issues raised during WG-EMM (WG-EMM-2019 report, paragraph 2.48). It was noted that the collection and analysis of survey data is consistent with the equipment of the six vessels that participated. However, it was stressed that the analysis presented in SG-ASAM-2019 confirms that the main uncertainties in biomass estimates from the 2019 Area 48 Survey are associated with effects of: (i) the method used to identify krill targets in the acoustic data, namely, using the swarms-based and the dB window method for krill identification; (ii) using non-standardised krill sampling gear, including commercial fishing and research trawls on board different vessels. Russia also noted that clarity regarding methodical aspects will, to a large degree, determine understanding the practical implementation of the 2019 survey results. It was proposed to accompany survey result with krill length and biology data.

2.32 SC-CAMLR-38/BG/26 described the focus in SG-ASAM on investigating the potential and development of using fishing-vessel-based acoustic data to provide qualitative and quantifiable information on the distribution and abundance of Antarctic krill (*Euphausia superba*).

2.33 The Scientific Committee recognised the huge potential for collection of valuable data for management purposes and encouraged further development of sampling design and analysis methods and welcomed the storage of acoustic data at the Secretariat. The Scientific Committee noted that the Data Services Advisory Group (DSAG) could also offer guidance and facilitate data management.

2.34 The Scientific Committee welcomed the Japanese krill biomass survey in Division 58.4.1 in 2018/19 which reported a preliminary biomass estimate which was comparable with the estimate from 1996 BROKE survey. The Scientific Committee noted the significant contribution of this survey to achieve CCAMLR's objectives and looked forward to receiving a full report with an estimate of krill biomass and CV to update the Division 58.4.1 krill fishery conservation measure (CM 51-02).

2.35 The Scientific Committee noted the developments in SG-ASAM over the years, and that the Subgroup's workload had increased and also noted that acoustic surveys were planned across the Convention Area. The Scientific Committee recommended that SG-ASAM become a full Working Group – WG-ASAM and reviewed and agreed its terms of reference during the meeting (Annex 8).

2.36 The Scientific Committee noted that Dr Zhao had been the Convener of SG-ASAM for four years. The Scientific Committee thanked him for his leadership and his ability to develop SG-ASAM in a positive direction, as reflected in the change from SG-ASAM to WG-ASAM, during these years. The Scientific Committee welcomed Dr S. Fielding (UK) and Dr X. Wang (China) as the new Co-conveners for WG-ASAM.

Harvested species

Krill resources

Status and trends

Fishing activity

3.1 The Scientific Committee reviewed krill fishing activities for 2017/18 and 2018/19 (SC-CAMLR-38/BG/01 Rev. 1). The Scientific Committee noted that:

(i) in 2017/18 (1 December 2017 to 30 November 2018), 10 vessels fished in Subareas 48.1, 48.2, 48.3 and Division 58.4.2, and the total catch of krill reported was 312 991 tonnes of which 151 691 tonnes, 137 879 tonnes 23 175 tonnes and 246 tonnes were taken from Subareas 48.1, 48.2, 48.3 and Division 58.4.2 respectively

(ii) in 2018/19 (to 13 September 2019), 11 vessels fished in Subareas 48.1, 48.2, 48.3, and Division 58.4.2, and the total catch of krill reported in catch and effort reports was 381 934 tonnes of which 155 907 tonnes, 162 416 tonnes, 63 599 tonnes and 12 tonnes were taken from Subareas 48.1, 48.2, 48.3 and Division 58.4.2 respectively. Subarea 48.1 was closed on 13 July 2019.

3.2 The Scientific Committee advised the Commission that the catch in 2019 up to 13 September is the highest catch since the early 1990s. The Scientific Committee noted that this season's catch in Area 48 (381 922 tonnes) is the third-highest in history (the highest was 425 871 tonnes in 1986). The catch in Subarea 48.2 has, for first time, exceeded 50% of the catch limit for this subarea.

3.3 The Scientific Committee noted the current data reporting requirements are for monthly catch and effort reporting for Subarea 48.2 until catch once reaches 80% of its trigger limit, at which point five-day reporting is required. The Scientific Committee welcomed the current, voluntary, provision of five-day reports in all krill fisheries and advised the Commission that, to improve fisheries closure forecasting, this should be reflected in a change to CM 23-06.

3.4 The Scientific Committee requested that the Secretariat review the data that has been submitted for estimating the green weight of krill, for each of the methods specified in CM 21-03, Annex 21-03/B, and present this to the next meeting of WG-EMM.

STATLANT data

3.5 The Scientific Committee noted that SC-CAMLR-38/BG/01 Rev. 1 contained data from aggregated catch data used in within-season monitoring, summarised haul-by-haul catch data and verified landing data as published in the *Statistical Bulletin* (referred to as STATLANT data). The Scientific Committee requested that a reconciliation of any discrepancies between the different catch reporting formats be included in the summary of catches in the Convention Area as presented in SC-CAMLR-38/BG/01 Rev. 1 in future.

3.6 The Secretariat clarified that STATLANT data contains information on annual catches by species, subareas, country and year globally managed by FAO and that this is the data that is used in the public domain publication of CCAMLR catch data in the *Statistical Bulletin*.

3.7 The Scientific Committee noted the limitations in finding this data on the CCAMLR website and requested the Secretariat to explore improved formats for the presentation of the historical catch data and to prepare a paper on how to improve the presentation and discoverability of CCAMLR catch data for consideration at next year's Scientific Committee meeting.

3.8 The Scientific Committee also requested the Secretariat to review the need for using STATLANT data in the *Statistical Bulletin*, including the requirement for reformatting existing catch data, and to examine the potential for using the haul-by-haul catch data as the definitive source of catch data published on the CCAMLR website.

Continuous trawl catch recording by Norway

3.9 The Scientific Committee noted WG-EMM discussions on continuous trawl catch reporting and its request for further explanation on how the reporting is done (WG-EMM-2019 report, paragraphs 3.16 to 3.21).

3.10 SC-CAMLR-38/19 provided details of the procedure currently used to derive two-hour catches on all Norwegian vessels using the continuous trawling system in the krill fishery. The paper also proposed that the procedure used be added amongst already established procedures provided in CM 21-03 (Annex 21-03/B).

3.11 The Scientific Committee found that the procedure was appropriate for distributing the catch into two-hour periods. While rather technical, based on an improved description (Annex 9) the method could be understood and potentially applied by other vessels using the continuous trawling system.

3.12 The Scientific Committee reviewed the procedure for estimating two-hour catches during continuous trawl fishing for krill using daily flow-scale records split according to the distribution of two-hour catches derived from holding tank volume monitoring (Annex 9) and made the following comments:

(i) the method to assign coordinates for each catch location is now consistent with catch reporting from traditional trawl fisheries

(ii) the inclusion of all ancillary data in the reporting of catches from vessels using the method described in Annex 9, such as records of changes in filling levels of the krill tanks, the distributions used to split the daily catch, and the measures of drip loss 12 times a day, should be provided to the Secretariat in the interim of the specification of any changed reporting requirements on the C1 form

(iii) data reporting format for submission of these data. An appropriate format would be developed in correspondence between operators, Norway and the Secretariat.

Norway stated that detailed daily records specified in paragraph 3.12(iii) are kept and would be made available to the Secretariat.

3.13 The Scientific Committee recommended that for the purposes of CM 21-03 (Annex 21-03/B) the current method outlined in Annex 9 be considered as ‘Other’ and the specification of the method should include a cross reference to Annex 9.

Krill ageing workshop

3.14 The Scientific Committee noted the WG-EMM discussions on the proposed Krill Ageing Inter-laboratory Calibration Workshop in 2020 (WG-EMM-2019 report, paragraphs 4.26 to 4.29).

3.15 The Scientific Committee noted the proposal in SC-CAMLR-38/17 for an allocation of AU$20 000 from CCAMLR to support the expense to hold a Krill Ageing Inter-laboratory Calibration Workshop in 2020 (WG-EMM-2019 report, paragraphs 4.26 to 4.29) during the July–August period in Hobart, Australia.

Krill management work plan

3.16 The Scientific Committee noted WG-EMM discussions on a work program to implement a revised management strategy that would incorporate contemporary information across a range of spatial and temporal scales to improve the likelihood of achieving CCAMLR's conservation objective (WG-EMM-2019 report, paragraph 2.59) for the krill fishery.

3.17 SC-CAMLR-38/17 highlighted the challenges in securing resources and capacity to coordinate a work plan for the working groups over the next two years to facilitate the work required to progress the preferred management strategy outlined in Tables 1 to 8 of the WG-EMM-2019 report, which requires a high degree of expertise as well as strategic oversight.

3.18 In considering the issues highlighted in SC-CAMLR-38/17, the Scientific Committee developed plans outlining the timescale of the proposed work plan needed to implement the adopted krill management strategy (Tables 1 to 4). The Scientific Committee noted the need to move forward by ensuring relevant data and expertise were available. The Scientific Committee therefore encouraged Members to consider Tables 1 to 4, in order to identify the data and work that they can contribute, or which could be supported by the General Science Capacity Fund.

3.19 The Scientific Committee recognised that some Members may wish to apply for support from the General Science Capacity Fund (paragraphs 11.1 to 11.8) and encouraged them to develop proposals in collaboration with those Members that have the necessary skills to guide the work plan. The Scientific Committee noted that the timescales were such that General Science Capacity Fund support would need to facilitate work in time for intersessional meetings in 2020.

3.20 The Scientific Committee noted SC-CAMLR-38/BG/19 which presented a preliminary proposal by the USA for a multinational research effort to quantify krill flux into, out of, and within the Bransfield Strait using a Super SWeet ARray of Moorings (SuperSWARM). The project aims to collaboratively quantify krill flux through the Bransfield Strait and across the continental shelf surrounding Astrolabe Island. The Scientific Committee welcomed this initiative and looked forward to seeing a full proposal at next year's Scientific Committee meeting.

SCAR Krill Action Group (SKAG)

3.21 The Scientific Committee noted SC-CAMLR-38/BG/06 which reported the outcome of the second annual meeting of the SCAR Krill Action Group (SKAG) (WG-EMM-2019 report, paragraphs 4.4 to 4.7).

3.22 The Scientific Committee noted 'krill recruitment' and 'krill's plasticity to climate change' as major knowledge gaps in improving mechanistic understanding of krill abundance, distribution behaviour and movement. The Scientific Committee further drew its attention to an important opportunity for testing the theory of intraspecific competition for food as a main driver of krill population dynamics (Ryabov et al., 2017).

ARK

3.23 The Scientific Committee noted SC-CAMLR-38/BG/09 by ARK which outlined its activities in the 2018/19 season, including implementation of voluntary restricted zones (VRZs) in Subarea 48.1, participation in the 2019 Area 48 Survey and co-hosting of a krill fishery management workshop.

3.24 In relation to VRZs, the Scientific Committee noted the importance of analysing how fishery dynamics might be affected to better understand their possible implications to other areas.

3.25 The Scientific Committee thanked ARK for its strong commitment to work with CCAMLR to achieve the CCAMLR objectives.

Ad-hoc Workshop on Krill-fishery Management for Subareas 48.1 and 48.2

3.26 The Scientific Committee welcomed the work carried out at the ad-hoc Workshop on Krill-fishery Management for Subareas 48.1 and 48.2 co-funded by ARK, the Pew Charitable Trusts and the World Wide Fund for Nature (WWF) (SC-CAMLR-38/16). Following the recommendation of WG-EMM, the Scientific Committee endorsed the Workshop recommendations as below:

(i) the development of a krill stock assessment was an urgent priority to achieve the objective of the Convention

(ii) the development of the proposed Domain 1 MPA (D1MPA) and feedback management (FBM) strategies for the krill fishery could be progressed independently

(iii) the need to support and improve working collaborations among Members. In particular, the Scientific Committee noted the discussions of the Workshop on the need to develop a strategy to better fund and share the burden for research needed to manage the krill fishery.

3.27 In addition, the Scientific Committee endorsed the overall vision shared by all workshop participants and which describes future aspirations for the krill-centric ecosystem as follows, 'A healthy Antarctic marine ecosystem in the context of climate change and fisheries for Antarctic krill, maintained by application of best practices in science and management informed by common goals, enhanced communication, collaboration, understanding, and commitments by all stakeholders'.

3.28 ASOC made the following statement:

'*ASOC introduced CCAMLR-38/BG/22 providing an update on the krill fishery and recommendations related to its management. ASOC highlighted the recent positive developments towards the establishment of a precautionary ecosystem-based management system for the krill fishery, including the new synoptic survey for krill in the South Atlantic sector of the Southern Ocean and the krill workshop in Concarneau, France, in June that resulted in a collective vision for the krill fishery.*

ASOC stated that the detailed and timed action plan for the management of the krill fishery agreed by WG-EMM is fundamental to prescribe science priorities that are needed to advance beyond CM 51-07 in time for its expiration in 2021, especially in the context of increasingly concentrated fishing pressure and growing climate change impacts.

ASOC emphasised the need for SC-CAMLR to endorse the work plan proposed by the Working Group and to prioritise its implementation. In addition, ASOC called SC-CAMLR to agree on the need to conduct subarea- or finer-scale stock assessments on a regular basis, and to address differences in the methodology used in the 2000 and 2019 surveys.

Based on current challenges with krill catch and by-catch reporting, ASOC recommended that SC-CAMLR develops methods to accurately report catches despite differences in greenweight reporting methods across vessels which may lead to underestimating fishery impacts on krill and the ecosystem. In addition, ASOC recognised the importance that SC-CAMLR ensures that guides for finfish larvae and ice krill are provided to the Scheme of International Scientific Observation (SISO) observers and the need to ensure a method for quantitative by-catch reporting at two-hour intervals in the continuous trawl fishing method. ASOC also highlighted the need to update CM 21-03 to incorporate the WG-EMM-agreed method for reporting catches at two-hour intervals for continuous midwater trawl fishing gear.

Finally, ASOC called the attention to the need to expand the CCAMLR Ecosystem Monitoring Program to monitor the status of additional krill-dependent predators by incorporating additional datasets on cetaceans, pack-ice seals and penguin demographic groups other than adults. The CCAMLR Ecosystem Monitoring Program (CEMP) in Area 48 will also need to be adapted to provide necessary data to satisfy the future needs for management of the krill fishery and for monitoring the proposed D1MPA. Therefore, ASOC recommended that SC-CAMLR organises a technical workshop to undertake a comprehensive review of CEMP to satisfy the growing ecosystem monitoring requirements of CCAMLR.'

Ecosystem effects of krill fishing

3.29 The Scientific Committee reviewed the recommendations of WG-EMM-2019 on developing the preferred management strategy for the krill fishery (WG-EMM-2019 report, paragraphs 2.20 to 2.38). It endorsed the detailed work plan (WG-EMM-2019 report, Tables 1 to 8 and Figure 1), recognising that its development was a direct result of collaborative efforts across all CCAMLR Members and represented a major step forward in modernising the management of the krill fishery.

3.30 The Scientific Committee noted that the preferred management strategy comprised prioritising the development of three key elements:

(i) a stock assessment to estimate precautionary harvest rates

(ii) regular updates of biomass estimates, initially at the subarea scale, but potentially at multiple scales

(iii) a risk assessment framework to inform the spatial allocation of catch.

3.31 The Scientific Committee agreed that expediting the development of these three elements before the expiration of CM 51-07 at the end of the 2020/21 season would require, inter alia, focus topics during future working group meetings.

3.32 The Scientific Committee recognised that successfully implementing the preferred management strategy within the current lifetime of CM 51-07 will be a significant challenge. It noted that CM 51-07 represents a precautionary safeguard whose status should be revisited during CCAMLR-40, at which time detailed consideration of its revision or replacement can be undertaken.

3.33 The Scientific Committee recommended that the Commission approve the advancement of the preferred management strategy as described.

3.34 The Scientific Committee outlined a work plan and schedule for implementing the adopted strategy for krill management (Tables 1 and 2). It agreed that the work plan would require a range of expertise and that this might best be achieved by holding joint sessions of particular working groups, or through dedicated workshops.

3.35 Russia noted that work plan and schedule for implementing the adopted strategy for krill management based on ecosystem and precautionary approaches will require development of scientifically based criteria and diagnostics to assess the possible ecosystem impact of the fishery, taking into account the mixed effects of fishing, environmental variability (or climatic changes) and the competitive relationship between predator species.

3.36 The Scientific Committee noted that the risk assessment has the potential to integrate a large number of data layers. However, it recognised a number of priority data layers that would be particularly important to incorporate. It agreed that provision of these layers should be considered for support under the General Science Capacity Fund (paragraphs 11.1 to 11.8). The Scientific Committee noted that the D1MPA planning group had already collated a large number of data layers and that these might form a valuable asset for the Risk Assessment.

3.37 The Scientific Committee noted paragraphs 2.4, 2.5 and 4.41 of the WG-EMM-2019 report. The latter paragraph noted that the Working Group agreed that WG-EMM-2019/10 and 2019/11 demonstrate that krill fishing at current levels and concentration in the Bransfield and Gerlache Straits is likely to have had a negative effect on localised predator populations in years with unfavourable environmental conditions.

3.38 The Scientific Committee noted several uncertainties arising from these papers that further research may clarify:

(i) The hypothesised mechanism by which local harvest rates greater than 10% could impact predators, namely interference competition arising from swarm disruption by fishing activity, required data to evaluate. Such a mechanism would need to be considered against the high degree of natural variation in swarm characteristics and temporal trends in krill stock abundance. The Scientific Committee noted that acoustic monitoring data from fishing vessels and a better estimation of krill flux could be helpful in this regard.

(ii) Published analyses of concurrent overlap of penguin tracking data and fisheries operations (Hinke et al., 2017) demonstrate species-specific patterns of overlap.

These patterns indicate that gentoo penguins (*Pygoscelis papua*) have the greatest overlap with the fishery. The Scientific Committee noted that the analysis of WG-EMM-2019/11 suggested, however, that chinstrap penguins (*P. antarctica*) were most affected by fishing activity. The Scientific Committee noted that this apparent contradiction should be explored more fully.

(iii) Species-specific functional relationships that define predator responses to spatial and temporal variation in krill density would help frame expectations of fishery impacts on predator species. The Scientific Committee again noted that acoustic monitoring data from fishing vessels and a better estimation of krill flux could be helpful in this regard.

(iv) A SCAR project, led by Dr Lowther, is currently developing a work plan to link functional to demographic responses of predators in collaboration with the SCAR Expert Group on Birds and Marine Mammals (EG-BAMM) and the Expert Group on Antarctic Biodiversity Informatics (EG-ABI).

(v) There is no agreement for how a demonstration of an impact by a fishery on a single, or multiple, predator species could be used to inform conservation measures or adjust fishing activities.

3.39 The Scientific Committee considered SC-CAMLR-38/BG/13 which reported on the use of time-lapse cameras to study the behaviour of gentoo penguins at Galindez Island in the 2018/19 season. The Scientific Committee noted that the paper had been discussed at WG-EMM-2019 (WG-EMM-2019 report, paragraphs 5.13 to 5.15) and recalled that this work highlighted the value of the CEMP Fund to support novel research.

3.40 ASOC introduced SC-CAMLR-38/BG/24 on the need to increase the consideration of cetaceans in science and management of the Southern Ocean. ASOC noted that there have been significant advancements in the understanding of the status of whales and their role in ecosystem structure and function. As CCAMLR works to progress management of the krill fishery and develops a network of MPAs, ASOC urges that it is crucial to incorporate information on whale ecology, including foraging distribution, abundance and behaviour into Scientific Committee advice and CCAMLR conservation measures.

3.41 ASOC recommended a number of steps to incorporate information on whale ecology into Scientific Committee advice and CCAMLR conservation measures, including considering foraging needs of baleen whales in krill fisheries management and MPA design; inviting the International Whaling Commission Southern Ocean Research Partnership (IWC-SORP) participation in Scientific Committee meetings; assisting in data collection and analysis to inform ship strike mitigation measures; and conducting a joint CCAMLR–IWC workshop with the goal of including whales in CEMP.

3.42 The Scientific Committee recalled the increase in consideration of cetaceans in the work of WG-EMM (WG-EMM-2019 report, paragraphs 4.49 to 4.52). It noted the importance of including cetacean abundance data in the risk assessment of the preferred krill fishery management strategy to more fully embrace an ecosystem approach.

3.43 The Scientific Committee endorsed the request of WG-EMM (WG-EMM-2019 report, paragraph 4.52) to: (i) contact existing organisations with pre-existing datasets and ongoing work that may provide natural collaborations or analytical advice such as IWC-SORP or the Scientific Committee of the IWC (IWC-SC), and (ii) appeal to appropriate SCAR bodies that could potentially provide both data and scientific advice directly to WG-EMM such as EG-BAMM and the important marine mammal areas (IMMAs) program (WG-EMM-2019/80).

Fish resources

General issues in the assessed fisheries

3.44 SC-CAMLR-38/BG/01 Rev. 1 provided an update of catches in 2017/18 and for 2018/19 up to 13 September 2019. This paper also included a map of the Convention Area showing all areas for which a catch limit is in place.

3.45 The Scientific Committee noted the WG-FSA-2019 report, paragraphs 2.18 and 2.19, describing the work of the Secretariat to ensure that a single consistent source of taxonomic reference data is used. The Scientific Committee welcomed the work and encouraged the Secretariat to work with interested Members to avoid duplication of effort.

Status and trends

Champsocephalus gunnari

C. gunnari in Subarea 48.3

3.46 The fishery for mackerel icefish (*Champsocephalus gunnari*) in Subarea 48.3 operated in accordance with CM 42-01 and associated measures. In 2018/19, the catch limit for *C. gunnari* was 3 269 tonnes. Details of this fishery and the stock assessment of *C. gunnari* are contained in the Fishery Report (www.ccamlr.org/node/75667).

3.47 The Scientific Committee noted that in recent years low amounts of fishing effort were being deployed in Subarea 48.3 and that this has resulted in very low catch uptake by the fishery.

3.48 The Scientific Committee noted that an assessment of *C. gunnari* in Subarea 48.3 based on the random stratified bottom trawl survey estimated the median demersal biomass at 53 124 tonnes, with a one-sided lower 95% confidence interval of 32 399 tonnes. A catch limit of 3 225 tonnes for 2019/20 and 2 132 tonnes for 2020/21 would ensure at least 75% biomass escapement after a two-year projection period.

Management advice

3.49 The Scientific Committee recommended that the catch limit for *C. gunnari* should be set at 3 225 tonnes for 2019/20 and 2 132 tonnes for 2020/21 in Subarea 48.3.

C. gunnari at Heard Island (Division 58.5.2)

3.50 The fishery for *C. gunnari* in Division 58.5.2 operated in accordance with CM 42-02 and associated measures. In 2018/19, the catch limit for *C. gunnari* was 443 tonnes. Fishing was conducted by one vessel and the total reported catch up to 28 September 2019 was 443 tonnes. Details of this fishery and the stock assessment of *C. gunnari* are contained in the Fishery Report (www.ccamlr.org/node/75667).

3.51 The Scientific Committee noted that an assessment for *C. gunnari* using the generalised yield model (GYM) had been conducted based on a random stratified trawl survey in Division 58.5.2 undertaken in April 2019. The one-sided bootstrap lower 95% confidence bound of total biomass of age 1+ to 3+ fish from the 2019 survey and fixed model parameters was estimated at 3 724 tonnes. Estimates of yield indicate that a catch limit of 527 tonnes of *C. gunnari* in 2019/20 and 406 tonnes in 2020/21 would satisfy the CCAMLR decision rules.

Management advice

3.52 The Scientific Committee recommended that the catch limit for *C. gunnari* should be set at 527 tonnes for 2019/20 and 406 tonnes for 2020/21 in Division 58.5.2.

Dissostichus spp.

General issues applicable to *Dissostichus* spp. assessments

3.53 CCAMLR-38/BG/11 presented a data comparison between the Catch Documentation Scheme for *Dissostichus* spp. (CDS) and the fine-scale catch and effort data for the 2017/18 and 2018/19 fishing seasons. Overall, the comparison indicated that, in both seasons, the total toothfish catches reported from the Convention Area in the CDS and from catch data differed by less than 1%. Specific issues were identified in the reporting of subarea and species in *Dissostichus* Catch Documents (DCDs) which the Secretariat is working with Members to resolve.

3.54 The Scientific Committee noted the comments of WG-FSA (WG-FSA-2019 report, paragraphs 2.7 to 2.15) that:

(i) the Secretariat is requested to update the work annually

(ii) an assessment of the impact of these catches on the management of the Ross Sea region be presented to WG-SAM-2020

(iii) following changes in practices, there were no discrepancies in the 2018/19 data submitted by Ukraine

(iv) the requirements to report landings from subareas or divisions in CM 10-05 rather than the management areas specified in CM 41-09 (for Subarea 88.1 and small-scale research units (SSRUs) 882A–B) mean that it is currently not possible to use the CDS and fine-scale catch and effort data reconciliation process as a data quality input into the integrated assessment for toothfish in the Ross Sea region.

3.55 The Scientific Committee further noted that fish depredated by sea lice may not have been included so far within the reconciliation of C2 and CDS data, and recommended that Ukraine provide information to WG-SAM-2020 on this.

3.56 The Scientific Committee endorsed the recommendation of WG-FSA that all data collected on the *Calipso*, *Koreiz* and *Simeiz* from 2015 to 2018 be quarantined by the Secretariat, pending the outcomes of any evaluation by WG-SAM of the methods used to re-estimate the C2 data and the Working Group's advice on the implications of those revisions on the work of the Scientific Committee.

3.57 The Scientific Committee recalled the proposal in CCAMLR-XXXVII/22 to move the boundary between Subareas 88.1 and 88.2 from 170°W to 150°W in order to align the Subarea 88.1 with the boundary of the exploratory fishery. The Scientific Committee requested that the Commission consider this proposal in order to make the C2–CDS reconciliation possible in this area, as noted in paragraph 2.10 of the WG-FSA-2019 report.

3.58 The Scientific Committee recalled the recommendations of the Independent Stock Assessment Review (SC-CAMLR-XXXVII, Annex 5) and welcomed the considerable progress made by Members towards addressing these recommendations (WG-FSA-2019 report, Table 3) and encouraged further work to address the remaining recommendations.

3.59 The Scientific Committee endorsed the recommendation of WG-FSA (WG-FSA-2019 report, paragraph 3.13) that a bridging analysis be used in all stock assessments to explore the effects of changes in the stock assessment due to updated data, revised parameter estimates and changes to model approaches since the last assessment model which has been used to provide catch advice.

3.60 The Scientific Committee noted the progress made by the Secretariat and Members in developing standard Fishery Report documents (WG-FSA-2019 report, paragraphs 2.31 to 2.33). The Scientific Committee recommended that Members continue development of a common format for our public domain documentation of these fisheries.

3.61 The Scientific Committee noted that WG-FSA-2019 had discussed SC-CAMLR-38/15 (WG-FSA-2019 report, paragraphs 3.15 to 3.21). The Scientific Committee noted that:

(i) the decision rule is highly precautionary compared to many other harvest control rules used to manage non-CCAMLR fisheries

(ii) the decision rule remains precautionary if the productivity of the stock decreases

(iii) further refinement of the decision rule would ensure that it is robust in cases where the productivity of the stock increases, or to provide advice in the case where the initial biomass (B_0) is unknown

(iv) decision rules based on a constant harvest rate, rather than a constant catch, can reduce the fluctuations in stock size in the long term

(v) any refinements of the CCAMLR decision rule would require thorough testing with simulations to ensure that it remains consistent with achieving the objectives of Article II of the Convention.

3.62 The Scientific Committee noted that catches permitted by the decision rule depend on, inter alia, the length distribution of the catch, the growth rates and maturity rates. The permitted catch is chosen to remain precautionary in each fishery despite the differences in these parameters between areas and fisheries. The variation of these parameters over time is accounted for by updating these parameters in the assessment as required.

3.63 The Scientific Committee noted that WG-FSA (WG-FSA-2019 report, paragraphs 3.31 to 3.39) had performed analyses demonstrating that the CCAMLR decision rules result in similar trajectories for different fish stocks, independent of stock-specific characteristics such as different growth and maturity rates across two species, or different fishery characteristics such as area and depth-specific selection patterns.

3.64 The Scientific Committee noted that the 35-year projection period of the decision rule and the target of 50% of B_0 have been chosen to allow the stock to recover to near-virgin levels if there is no fishing.

3.65 The Scientific Committee endorsed the recommendation of WG-FSA to task WG-SAM with investigating potential refinements of the CCAMLR decision rules to increase their robustness in specific circumstances, such as using target and limit exploitation rates, through management strategy evaluations.

Dissostichus eleginoides in Subarea 48.3

3.66 The fishery for Patagonian toothfish (*D. eleginoides*) in Subarea 48.3 operated in accordance with CM 41-02 and associated measures. In 2018/19, the catch limit for *D. eleginoides* was 2 600 tonnes and the total reported removal was 2 172 tonnes. Fishing in the current season finished on 30 September 2019 (www.ccamlr.org/node/75667).

3.67 The Scientific Committee noted the discussion in WG-FSA (WG-FSA-2019 report, paragraphs 3.49 to 3.68), concerning toothfish in Subarea 48.3.

3.68 Dr S. Kasatkina (Russia) recalled the discussions held at WG-FSA on WG-FSA-2019/40 and recalled concerns with regard to whether the current approach to fisheries in Subarea 48.3 was in line with rational use of the *D. eleginoides* population. At the same time, it was noted that additional work 'on the margins' of the Scientific Committee meeting with interested delegations enabled delegations to look at other options alternative to the initially proposed closure of fisheries and 0 catch limit, namely the reduction of the catch limit or the period of the program (from two years to one year with subsequent assessment). It was noted that these options could be used to address her concerns for the time being.

3.69 Dr Darby also recalled the discussions during WG-FSA-2019 and that the stock assessment calculations for Subarea 48.3 and the application of the CCAMLR decision rule were in line with CCAMLR procedures, demonstrating there are no differences in characteristics between Subarea 48.3 and all other CCAMLR stock assessment areas. Given the 'on the margins' discussions, he noted that the catch allocation referenced by WG-FSA-2019 in the WG-FSA-2019 report, paragraph 3.60, did not include an adjustment for whale depredation. He also noted that such consideration would be science-based and consistent with the approach taken in some other CCAMLR regions.

3.70 The Scientific Committee considered the advice from WG-FSA (WG-FSA-2019 report, paragraphs 3.39 and 3.62). The assessment of Subarea 48.3 (*D. eleginoides*) contained in WG-FSA-2019/38 includes a depredation correction factor applied to catches in each year. The average of this factor since 2010 is 4%. The Committee proposed adjusting the recommendation for the long-term catch limit to take into account depredation and, therefore, it recommended a total catch limit of 2 327 tonnes for the 2019/20 and 2020/21 seasons.

Management advice

3.71 The Scientific Committee recommended that the catch limit for *D. eleginoides* in Subarea 48.3 be set at 2 327 tonnes for 2019/20 and 2020/21 based on the results of this assessment.

Dissostichus spp. in Subarea 48.4

3.72 The fishery for *D. eleginoides* in Subarea 48.4 operated in accordance with CM 41-03 and associated measures. The catch limit for *D. eleginoides* in Subarea 48.4 in 2018/19 was 26 tonnes and 17 tonnes were taken (www.ccamlr.org/node/75667).

3.73 The Scientific Committee noted that WG-FSA-2019/29 presented an updated CASAL assessment model for *D. eleginoides* in Subarea 48.4. The assessment data were updated with observations for the 2017/18 season and the data weighting method revised to be consistent with those applied in other CCAMLR assessment models. The model estimated that the stock was at 67% of B_0 in 2018/19 and that a yield of 27 tonnes in 2019/20 and 2020/21 was consistent with the application of the CCAMLR decision rules.

Management advice

3.74 The Scientific Committee recommended that the catch limit for *D. eleginoides* in Subarea 48.4 be set at 27 tonnes for 2019/20 and 2020/21 based on the results of this assessment.

D. mawsoni in Subarea 48.4

3.75 The fishery for Antarctic toothfish (*D. mawsoni*) in Subarea 48.4 operated in accordance with CM 41-03 and associated measures. The catch limit for *D. mawsoni* in Subarea 48.4 in 2018/19 was 37 tonnes of which 33 tonnes were taken in the fishery (www.ccamlr.org/node/75667).

Management advice

3.76 The Scientific Committee recommended that the catch limit for *D. mawsoni* in Subarea 48.4 be set at 45 tonnes for 2019/20 based on the results of this assessment.

D. eleginoides in Division 58.5.1

3.77 The fishery for *D. eleginoides* in Division 58.5.1 is conducted in the French exclusive economic zone (EEZ). Details of the fishery and the stock assessment are contained in the Fishery Report (www.ccamlr.org/node/75667).

3.78 The Scientific Committee welcomed the substantial development of the stock assessment of *D. eleginoides* in Division 58.5.1. It noted the WG-FSA-2019 report, paragraphs 3.79 to 3.84, describing the development of two integrated CASAL assessment models for Division 58.5.1, and that the catch limit of 5 200 tonnes for 2019/20, that accounts for depredation, was consistent with the CCAMLR decision rule for the model runs presented.

3.79 Dr Péron thanked WG-FSA for the valuable advice on the development of the assessment model in Division 58.5.1 over the last 10 years and underlined the importance of CCAMLR working groups for developing and applying state-of-the-art methods. She asked the Scientific Committee to consider this essential aspect when setting the priorities for WG-SAM and WG-FSA.

Management advice

3.80 No new information was available on the state of fish stocks in Division 58.5.1 outside areas of national jurisdiction. The Scientific Committee therefore endorsed the recommendation of WG-FSA that the prohibition of directed fishing for *D. eleginoides*, described in CM 32-02, remain in force in 2019/20.

D. eleginoides in Division 58.5.2

3.81 The fishery for *D. eleginoides* in Division 58.5.2 operated in accordance with CM 41-08 and associated measures. Details of the fishery and the stock assessment are contained in the Fishery Report (www.ccamlr.org/node/75667).

3.82 The Scientific Committee noted the WG-FSA-2019 report, paragraphs 3.85 to 3.91, describing the updated stock assessment for Division 58.5.2, and that:

(i) the stock was currently estimated to be at 51% of B_0

(ii) due to recent weak year classes and the effect of changing from trawl to longline fishery, the stock is forecast to decline to below 50% of B_0

(iii) the assumption of average recruitment in the future would allow the stock to rebuild to 50% B_0 at the end of the 35-year projection period

(iv) if the future year classes are at a similarly low level to those seen since 1998, the stock will not rebuild to 50% B_0 by the end of the 35-year projection period

(v) the estimated stock status at the time of the next assessment in 2021, irrespective of the assumption of future year-class strength, was expected to be about 46% of B_0.

3.83 The Scientific Committee recommended an update on stock parameters, including recruitment indices from the trawl survey, and age-frequency data and tag-recapture data from the fishery be presented in 2020 to WG-FSA to evaluate whether recruitment and the stock trajectory were consistent with those estimated by this assessment.

3.84 The Scientific Committee tasked WG-SAM with developing advice on alternative harvest strategies that may provide a more precautionary approach for stocks that fluctuate around, or are below, the target level and for stocks where recent patterns of weak year classes were apparent in the fishery.

Management advice

3.85 The Scientific Committee recommended that the catch limit for *D. eleginoides* in Division 58.5.2 be set at 3 030 tonnes for 2019/20 and 2020/21 based on the results of this assessment.

3.86 No new information was available on the state of fish stocks in Division 58.5.2 outside areas of national jurisdiction. Therefore, the Scientific Committee endorsed the recommendation of the WG-FSA, that the prohibition of directed fishing for *D. eleginoides*, described in CM 32-02, remain in force in 2019/20.

D. eleginoides in Subarea 58.6

3.87 The fishery for *D. eleginoides* at Crozet Islands is conducted within the French EEZ and includes parts of Subarea 58.6 and Area 51 outside the Convention Area. Details of this fishery and the stock assessment are contained in the Fishery Report (www.ccamlr.org/node/75667).

3.88 The Scientific Committee noted the WG-FSA-2019 report, paragraphs 3.95 to 3.99, describing the updated stock assessment for Subarea 58.6, and noted that the assessment included updated data, revised growth curves and catches from outside the Convention Area. The Scientific Committee noted that the catch limit of 800 tonnes for 2019/20 that accounts for depredation was consistent with the CCAMLR decision rule for the model runs presented.

Management advice

3.89 No new information was available on the state of fish stocks in Subarea 58.6 outside areas of national jurisdiction. Therefore, the Scientific Committee endorsed the recommendation of the WG-FSA, that the prohibition of directed fishing for *D. eleginoides*, described in CM 32-02, remain in force in 2019/20.

D. mawsoni in the Ross Sea region

3.90 The exploratory fishery for *Dissostichus* spp. in Subarea 88.1 operated in accordance with CM 41-09 and associated measures. In 2018/19, the catch limit for *Dissostichus* spp. was 3 157 tonnes, including 65 tonnes set aside for the Ross Sea shelf survey. Fishing was conducted by 19 longline vessels and the total reported catch was 2 988 tonnes. Details of this fishery and the stock assessment are contained in the Fishery Report (ww.ccamlr.org/node/75667).

3.91 The Scientific Committee noted the WG-FSA-2019 report, paragraphs 3.100 to 3.109, describing the updated stock assessment and that:

(i) the Ross Sea region MPA (RSRMPA) had led to some concentration of fishing effort on the slope South of 70°S

(ii) growth and length–weight parameters used in the assessment were updated

(iii) further work should be carried out to investigate the differences in growth between different parts of the Ross Sea region

(iv) the assessment is consistent with the assessments presented previously for this area.

Management advice

3.92 The Scientific Committee recommended that the catch limit be set at 45 tonnes for the 2019/20 shelf survey and 65 tonnes for the 2020/21 shelf survey.

3.93 The Scientific Committee recalled that the catch for the winter survey conducted in 2018/19 should be included in the RSR North 70 catch limit for the 2019/20 season (CCAMLR-XXXVII, paragraph 5.48) and, therefore, this catch would need to be taken into account in the management of the fishery in the 2019/20 season.

3.94 The Scientific Committee recommended that following the procedure outlined in CM 91-05, the catch limit for the Ross Sea region (Subarea 88.1 and SSRUs 882A–B) in the 2019/20 and 2020/21 seasons be 3 140 tonnes, see paragraphs 3.136 and 4.40 for potential catch allocation methods between management areas.

New and exploratory finfish fisheries

General issues

3.95 The Scientific Committee recalled its recommendation that Members provide their digital toothfish ageing reference sets to the Secretariat in order that the Secretariat can create a digital repository on the CCAMLR website containing otolith ageing and calibration instruction manuals, digital reference collections and a record of the locations of physical reference material. The Scientific Committee further recalled that a centralised ageing database would facilitate the increasing number or multi-Member ageing programs and recalled that this was discussed at WG-FSA-2012 (WG-FSA-2012 report, paragraphs 10.18 and 10.19).

3.96 The Scientific Committee recalled that in 2018 the Commission agreed that all continuing research in exploratory fisheries be reviewed every second year at WG-FSA (CCAMLR-XXXVII, paragraph 5.30). The Scientific Committee requested that the Commission consider reflecting this agreement in CM 21-02. The Scientific Committee noted that there was a low risk associated with reviewing continuing research in exploratory fisheries every second year as opposed to annually, given the processes it had developed over the last few years to review research and setting catch limits.

Area 48

Subarea 48.6

3.97 The Scientific Committee noted the discussion at WG-FSA (WG-FSA-2019 report, paragraphs 4.59 to 4.80) on research results and the proposal by Japan, South Africa and Spain to continue the longline research survey for *D. mawsoni* in Subarea 48.6. The Scientific Committee noted the review of the research proposal using the revised criteria set out in the WG-FSA-2019 report, Table 8.

3.98 The Scientific Committee noted that several papers had been presented at WG-SAM-2019 and WG-FSA-2019 to address research questions and requests from previous working group and Scientific Committee meetings. The Scientific Committee noted that these addressed research findings related to age readings, tagging data, a satellite tagging experiment, microchemistry of otoliths, sea-surface temperature anomalies with sea-ice concentration and a preliminary CASAL integrated stock assessment. It noted the importance of the assessment area reflecting the stock for an integrated assessment and recommended further work to reflect this in future models.

3.99 The Scientific Committee noted that some of the research block biomass estimates had declined in Subarea 48.6, resulting in declining catch limit calculated for research block 486_2. Research block 486_2 displayed a strong decline in the Chapman estimate between 2018 and 2019 with a high number of tag recaptures following a period of relative stability. The Scientific Committee noted that this suggested that there may be some concerns about the status of the stock in this research block.

3.100 The Scientific Committee recommended that this exploratory fishery should proceed and the catch limits given in Table 5 should apply in Subarea 48.6.

3.101 The Scientific Committee noted that, should CM 21-02 be updated as recommended in paragraphs 3.96 and 4.15, this research plan would not need to be reviewed until WG-FSA-2021. However, results and milestones relevant to 2020 as specified in WG-FSA-2019/23 should still be reported next year.

Area 58

Divisions 58.4.1 and 58.4.2

3.102 The Scientific Committee noted the discussion at WG-FSA (WG-FSA-2019 report, paragraphs 4.81 to 4.88) on research results for *D. mawsoni* in Divisions 58.4.1 and 58.4.2.

3.103 The Scientific Committee recalled that Dr Kasatkina had expressed concerns in 2018 on the likelihood of success of the Multi-Member proposal by Australia, France, Japan, Korea and Spain (SC-CAMLR-XXXVII, paragraphs 3.135 to 3.145). Dr Kasatkina had concerns about use of multiple gear types and that the stratified sampling design was not for all of the sampling.

3.104 The Scientific Committee noted that the same sampling design in the initial multi-Member research proposal had been agreed in 2016 by the Scientific Committee (SC-CAMLR-XXXV, paragraphs 3.238 to 3.247).

3.105 The Scientific Committee recalled that as there was no consensus on the subject of gear standardisation in 2018, this exploratory fishery had only operated in Division 58.4.2 in 2018/19 (CCAMLR-XXXVII, paragraphs 9.23 and 9.24).

3.106 The Scientific Committee expressed its concerns that the loss of a season of data from Division 58.4.1 has resulted in a break in the time series of the data collected in that division. The Scientific Committee highlighted that this had caused a delay to the further development of a stock assessment and the ability of the Scientific Committee to provide advice to the Commission for the area.

3.107 The Scientific Committee noted the extensive discussions and a focus topic on gear and sampling design standardisation at WG-SAM (WG-SAM-2019 report, paragraphs 6.1 to 6.20), including discussing statistical methods for accounting for gear/vessel effects *a posteriori* which are commonly used in the scientific literature (WG-FSA-2019 report, paragraph 4.99).

3.108 Dr Kasatkina noted that she upheld her view on the importance of gear standardisation for research plans conducted under CM 21-02 and as discussed in WG-FSA-2019 report, paragraphs 4.89 to 4.114.

3.109 The Scientific Committee noted that two research plan proposals for *D. mawsoni* in Division 58.4.1 and 58.4.2 had been submitted and extensively discussed at WG-SAM (WG-SAM-2019 report, paragraphs 6.52 to 7.72) and WG-FSA (WG-FSA-2019 report, paragraphs 4.89 to 4.114).

3.110 The Scientific Committee noted the proposal for the continuation of a multi-Member research plan by Australia, France, Japan, Korea and Spain in Divisions 58.4.1 and 58.4.2 (WG-FSA-2019/44).

3.111 The Scientific Committee noted that WG-FSA-2019 had evaluated this ongoing multi-Member research proposal against the standard criteria and format for research proposals (WG-FSA-2019 report, Table 9) and noted the high scientific merit of the proposal.

3.112 The Scientific Committee noted a new proposal by Russia for a multi-Member research program in Divisions 58.4.1 and 58.4.2 (WG-FSA-2019/52).

3.113 The Scientific Committee noted that WG-FSA had evaluated the research proposal against the standard criteria and format for research proposals as shown in the Area 58 research proposal assessment table (WG-FSA-2019 report, Table 9).

3.114 The Scientific Committee noted that the research plan could not be completed without collaboration with other Members. Some Members considered that the proponent has limited off-water research capacity (only one researcher was listed in the proposal section 5a).

3.115 The Scientific Committee noted that the tagging performance of the proposed vessels are poor or unknown; one vessel had consistently poor tagging detection and a tagging survival of zero (*Palmer*) and the other (*Volk Arktiki*) had a good tagging detection rate but unknown tag-survival rate.

3.116 The Scientific Committee noted that WG-FSA-2019 had been unable to reach consensus on the requirement for the use of multiple types of longline gears when implementing research plans in exploratory fisheries. This point was reflected in the Area 58 research proposal assessment table noting that different gears are used in both research plans (WG-FSA-2019 report, Table 1).

3.117 The Scientific Committee recalled its previous advice and the CCAMLR Performance Review, requiring proponents of new research to collaborate with Members who are currently participating in established research programs within the same area.

3.118 The Scientific Committee recalled the WG-SAM-2019 report, paragraph 6.72, outlining the commitment to work intersessionally to develop a joint research proposal for Divisions 58.4.1 and 58.4.2 for consideration by WG-FSA-2019. It noted that no joint proposal had been submitted to WG-FSA-2019 and that there was no agreement between the two research proposal proponents on a joint research proposal despite extensive discussions in the intersessional period, during WG-FSA and at the Scientific Committee.

3.119 The Scientific Committee noted that the main reason for the difficulty in achieving consensus in the discussions to achieve a collaborative research plan was on the use of standardised autoline gear. The Scientific Committee noted that there was the intention from the proponents of the existing research plan to find a solution to improve the sampling design of the research proposal.

3.120 The Scientific Committee recalled that the research plan required in Divisions 58.4.1 and 58.4.2 is for an exploratory fishery similar to Subarea 48.6 and Division 58.4.3a, and not a survey under CM 24-01 in a closed area.

3.121 Some Members noted that there is no requirement for the exclusive use of one gear type in an exploratory fishery. They further recalled that there are six research plans in the WG-FSA-2019 report, Tables 8, 9 and 10, which involve multi-gear research programs and would be concerned by this debated gear standardisation issue (WG-FSA-2019 report, point 2.2 in Tables 8, 9 and 10).

3.122 As Scientific Committee was unable to resolve this issue during its session, the Scientific Committee recommended that both plans be considered.

3.123 The Scientific Committee recommended the catch limits for Divisions 58.4.1 and 58.4.2 using the trend analysis rules (WG-FSA-2017 report, paragraph 4.33) as shown in Table 5.

Area 88

Forecast closures and capacity

3.124 The Scientific Committee considered SC-CAMLR-38/02 which discussed the procedures of monitoring catches and fishing effort across the Ross Sea area, particularly during or after the issue of a notification closure, and the lack of clarity regarding the redistribution of allowable catch between areas north and south of 70°S. The paper noted that:

(i) once closure notifications are sent out, the catches hauled on lines that were set prior to the closure date but hauled after the closure date are not reported in the catch reporting summaries to Members

(ii) the redistribution of allowable catch between fishing grounds to the north and south of 70°S (RSR North 70 and RSR South 70) in the 2018/19 season are not in accordance with CM 41-09 (paragraph 2i)

(iii) information about catch landed after the fishery was closed was not included in any circular letters of any Flag State whose vessels could not haul their gear in time

(iv) the catch recorded at the time the fishery was closed was not changed in subsequent fishery monitoring catch reports submitted by the Secretariat.

3.125 The Scientific Committee noted that the catch monitoring reports from the Secretariat should be updated with data as it becomes available, so if a catch is recorded after a fishery is closed, this would need to be reported in the following reports.

3.126 The Secretariat clarified that while daily report updates to fishing Members may not immediately reflect catches taken on lines that are removed after a fishery closure has taken effect, the total catches as reported in SC-CAMLR-38/BG/01 are complete, including catch on those lines that may have been hauled after the fishery closure.

3.127 The Scientific Committee noted that all catches are taken into account in the stock assessment conducted for this region and underpinning the Scientific Committee advice, including those that may have been reported after the closure date.

3.128 The Scientific Committee recommended that CM 41-09 be clarified to better state the transfer of catch allocation from RSR North 70 to RSR South 70, as well as from south of 70°S to north of 70°S should an area have an under- or over-catch, as directed in paragraph 5.46 of CCAMLR-XXXVII.

3.129 The Secretariat presented CCAMLR-38/BG/12, providing summary advice to the Commission on the Secretariat's interpretation and application of procedures to monitor and forecast closures in CCAMLR fisheries in the 2018/19 season. Key issues in applying the procedures, and specific instances which resulted in catch over-runs and under-runs in certain circumstances, were presented.

3.130 The Scientific Committee noted the update on capacity and capacity utilisation within Subareas 88.1 and 88.2 in WG-FSA-2019/06 and the following discussions at WG-FSA (WG-FSA-2019 report, paragraphs 4.133 to 4.135). The analyses showed similar patterns to previous years and did not indicate excess of capacity in the fishery, although the Scientific Committee noted that while there was no evidence of excess of capacity at overall regional level of Subareas 88.1 and 88.2, CCAMLR-38/BG/12 considered capacity issues in this fishery at the same spatial scale at which catch limits and fishery closures are implemented.

3.131 The Scientific Committee recommended that in future, capacity analysis updates for Subareas 88.1 and 88.2 should be applied at the same spatial scales as catch limits are set to better reflect the operational capacity issues in the fishery, and to also include a measure of hooks set and retrieved each day during the season, to investigate factors influencing gear loss rates.

Toothfish biology and ageing

3.132 The Scientific Committee noted the studies on diet of *D. mawsoni* in Areas 58 and 88 (WG-FSA-2019/37) using metabarcoding analysis of stomach content samples. The Scientific Committee noted that results showed distinct differences in prey species between the two regions, highlighting differences between structures of the ecosystem between the two areas.

3.133 The Scientific Committee further noted work progressing on comparing otolith readings for *D. mawsoni* between two laboratories, one by Korea and one from New Zealand (WG-FSA-2019/35), and recognised the homogeneity of the readings, highlighting good overlap between the laboratories. The Scientific Committee noted the importance of ageing tagged fish to improve growth-curve accuracy and understanding individual variability of growth, as well as to understand migration.

Subarea 88.1 and SSRUs 882A–B

3.134 SC-CAMLR-38/12 addressed the allocation of research catch limits in the RSRMPA, considering that one of the main aims of this MPA is protection and conservation of the toothfish resource. The authors considered that the catch limit for any research in the RSRMPA should not be deducted from catch limits for exploratory fishing outside the MPA and proposed that CM 91-05 contain an appendix to include recommendations on the procedures for allocating catch limit to carry out research inside the MPA.

3.135 The Scientific Committee recalled the considerable discussion on this issue during WG-FSA (WG-FSA-2019 report, paragraphs 4.141 to 4.150).

3.136 The Scientific Committee noted that WG-FSA had proposed three options (WG-FSA-2019 report, Table 6) for allocating catch within the MPA for the survey, as consensus had not been reached. Of those, one option was not further supported by the Scientific Committee and thus the options proposed to the Commission area:

(i) allocation as applied in 2018/19, where the shelf survey catch is removed from the entire Ross Sea region limit before the allocation of catch to the three management areas (RSR North 70, RSR South 70 and the special research zone (SRZ))

(ii) allocation as suggested by Dr Kasatkina, where the shelf survey catch limit is allocated from the SRZ catch limit.

3.137 The Scientific Committee noted that in all the proposed scenarios, the overall catch limit for Subarea 88.1 and SSRUs 882A–B was the same and highlighted that whichever option is chosen, it would need to be consistent with CM 91-05 (Table 6).

3.138 Most Members favoured the first option as this was consistent with previous recommendations of the Scientific Committee (SC-CAMLR-XXXVII, paragraph 3.168).

Subarea 88.2

3.139 The Scientific Committee noted discussions of WG-FSA (WG-FSA-2019 report, paragraphs 4.171 to 4.176) on the data-limited exploratory fishery in Subarea 88.2 which also includes SSRUs 882C–H, in the Amundsen Sea region. The Scientific Committee noted that while this region used to be assessed with an integrated stock assessment, it now only has sufficient tag-recapture data to perform a Chapman estimate of biomass in one research block, likely as a result of low overlap of effort in research blocks 882_1 to 882_4 and SSRU 882H.

3.140 The Scientific Committee noted that currently CM 21-02, paragraph 6(iii), (notifications for participation in exploratory fisheries for *Dissostichus* spp.) included the data-limited exploratory fisheries and recommended the areas covered by SSRUs 882C–H be included here for future notifications.

3.141 The Scientific Committee endorsed the catch limits derived from trend analysis rules for Subarea 88.2 as shown in Table 5.

Scientific research exemption

4.1 The Scientific Committee noted the discussion of WG-FSA (WG-FSA-2019 report, paragraphs 4.4 to 4.8) on toothfish conversion factors and that a workshop or focus topic in a working group to address factors which may influence conversion factors is planned for the intersessional period. The Scientific Committee recalled the importance of conversion factors for calculating green weight used when conducting integrated assessments and setting of catch limits based on catch per unit effort (CPUE).

4.2 The Scientific Committee recommended the Secretariat conduct a Member survey similar to that of the tagging survey (paragraph 4.6) on how conversion factors are calculated and applied for each vessel, and provide the results of this survey to WG-SAM.

4.3 The Scientific Committee noted WG-FSA discussions on stock identification and connectivity papers (WG-FSA-2019 report, paragraphs 4.9 to 4.20). The Scientific Committee noted the large amount of collaboration in these studies between Members and encouraged these kinds of collaborations in the future.

4.4 Mr Maschette thanked all Members who had collaborated and contributed samples to the multi-area toothfish genetics study (WG-FSA-2019/P01), noting this work will be expanded to include a peer-reviewed publication in the near future.

4.5 Dr G. Zhu (China) thanked the Members who contributed samples to the circumpolar *D. mawsoni* otolith microchemistry study (WG-FSA-2019/59 and 2019/61) to enhance the international collaborative project, noting this work will be expanded to include peer-reviewed publications in the near future.

4.6 The Scientific Committee noted the results of the tagging study (WG-FSA-2019 report, paragraphs 4.21 to 4.25) which highlighted the variable nature of tagging operations across the fishing fleet, and that 12 of the 17 vessels who responded to the survey rely on observers for all tagging duties, with no crew trained in tagging procedures. It was further noted that only 75% of the fleet considered tagging to be a Flag State responsibility.

4.7 The Scientific Committee viewed a brief video clip showing tagging and release practices aboard Ukrainian-flagged vessels. Ukraine noted that 100% of tagging operations are now recorded with video monitoring, in the hope of reviewing and improving tagging operations on the vessels.

4.8 The Scientific Committee endorsed the recommendation for a joint COLTO–CCAMLR Workshop on tagging procedures and noted this could be combined with discussions on conversion factors (paragraph 4.1).

4.9 The Scientific Committee noted that conversion factors would be considered intersessionally at WG-SAM, and that there may be an opportunity to progress this work at the joint COLTO–CCAMLR Workshop, if required.

4.10 COLTO made the following statement:

> '*We agree that tagging is an important area given that tag data holds such a high value in toothfish assessments, and as such COLTO would be pleased to assist in a similar fashion to this year's toothfish C2 data workshop in the intersessional period*.'

4.11 The Scientific Committee thanked COLTO for offering to host this tagging workshop, and developed a set of objectives, agenda topics and other details for this workshop. The workshop will be co-convened by Dr Parker and Mr R. Arangio (COLTO). Further details are provided in Annex 10.

4.12 Noting the low rate of responses to the tagging survey and that many of the questions can be answered whilst in port, the Scientific Committee recommended that Members notifying vessels under CMs 21-02 and 24-01 in 2020 be required to complete the tagging questionnaire as part of the notification process. This will allow greater clarity on the variability in tagging procedures between toothfish vessels.

4.13 The Scientific Committee further discussed technological advances in tagging processes, noting the development of post-capture survival indicators used in sharks which uses blood lactate sampling to assess the viability of the specimen for tagging, as well as the further development of pop-up satellite archival tags (PSATs). The Scientific Committee encouraged Members to further develop these methods and present them to Scientific Committee working groups in the future.

Research plan assessments

4.14 The Scientific Committee noted the discussions in WG-FSA on the review of research plans (WG-FSA-2019 report, paragraphs 4.26 to 4.28) which included a proposed revision to the tables used for evaluating research plans, and that these revised tables were used in the WG-FSA report. The Scientific Committee endorsed the new tables, noting the greater clarity compared to the previous version of table, and recommended they be used to assess future research plans.

4.15 The Scientific Committee noted the large amount of time spent at both WG-SAM and WG-FSA assessing research plans, limiting the ability to focus on other areas of research. The Scientific Committee recommended that proponents provide a self-assessment of their research plan and submit this with their research plan for evaluation by WG-SAM and WG-FSA. This would involve answering the questions shown in the WG-FSA-2019 report, Tables 8 to 10, with an additional column providing specific reference to the sections in the research plan which address the question being asked, if applicable. The self-assessments would provide the working groups with a guide for evaluating whether research plans are consistent with CCAMLR's objectives.

4.16 The Scientific Committee recalled the advice of the Commission (CCAMLR-XXXVII, paragraph 5.30) that new research proposals under CM 24-01 be limited to a maximum duration of three years (SC-CAMLR-XXXVII, paragraphs 3.107 to 3.109). Also noted was that all new research proposals shall be reviewed by WG-SAM and WG-FSA, all continuing research in closed areas shall be reviewed annually at WG-FSA and continuing research in exploratory fisheries be reviewed every second year at WG-FSA.

4.17 The Scientific Committee discussed that there are many tools used by various Members whilst developing research plans, and the development of a 'tool box' which contains analytical tools for use by all Members in the development of research plans. These tools may include:

(i) mapping tools or tutorials

(ii) scripts for statistical power analysis with detailed tutorials adapted to the question asked and the type of data available

(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

(vi) scripts for comparative analysis of vessel tagging performance.

4.18 The Scientific Committee further noted that in addition to the development of a tool box for building research plans, training the scientists in the use of these tools is just as important. The Scientific Committee also noted that the need for training applies not just to development of research plans but also other tasks of the working groups such as the development of CASAL models. Training such as this could be achieved either at a working group meeting with special time allocated for training, through a special workshop before or after a working group meeting or through a web-based meeting.

Fishery status and the regulatory framework

4.19 The Scientific Committee noted the discussion and recommendations provided by WG-FSA that aimed to reduce confusion and better align toothfish fishery status with the CCAMLR regulatory framework. In many cases, the five types of toothfish fishery status designations (new, exploratory, established, lapsed and closed) has become increasingly disconnected in some toothfish fisheries in the Convention Area.

4.20 The Scientific Committee agreed that the current status designation of several toothfish fisheries has been a source of confusion. To reduce some aspects of this confusion, the Scientific Committee agreed to forward the following advice to the Commission for consideration:

(i) Subarea 88.1 and SSRUs 882A–B (Ross Sea region toothfish fishery): Remove the term 'exploratory' in CM 41-09, but retain all elements required by Members to participate in the fishery in the conservation measure

(ii) Division 58.4.4: This toothfish fishery, currently closed in accordance with CM 32-02, be reclassified as an exploratory fishery in accordance with CM 21-02, with a new CM 41-XX established for this exploratory fishery

(iii) Division 58.4.3b: Change the current status of the exploratory toothfish fishery as set out in CM 41-07 to a status of 'lapsed'

(iv) in relation to (iii), it was recommended that the Commission consider toothfish fisheries that have had no fishing or research activities for 3–5 years classified as a lapsed fishery.

4.21 The Scientific Committee highlighted that if the Commission were to endorse (i), there would be the need to ensure that all relevant and related conservation measures that currently apply to CM 41-09 would still apply.

4.22 The Scientific Committee agreed that it would benefit from a clear strategy from the Commission as to how the regulatory framework can be interpreted in order to better define the status of a toothfish fishery at its current stage of development, and requested that the Commission consider how to progress this. Such a strategy would assist the Scientific Committee in developing scientific advice for toothfish fisheries.

Map data

4.23 The Scientific Committee noted the discussion at WG-FSA (WG-FSA-2019 report, paragraph 4.34), regarding the use of a standard map projection as specified within the CCAMLR GIS, or providing the projection used in the map. Additionally, the Scientific Committee recommended that maps within papers provide references for data layers used (e.g. bathymetry). This would allow the recreation and analysis of maps/research design within working groups, should that be required.

Scientific research exemption

D. mawsoni in Subarea 48.1

4.24 The Scientific Committee noted a proposal by Ukraine to carry out a scientific survey of *Dissostichus* spp. by bottom longline in the northeastern part of the Antarctic Peninsula region of Subarea 48.1 under CM 24-01.

4.25 The Scientific Committee noted that the previous survey had been restricted by sea-ice. The Scientific Committee further noted the large amount of collaboration in the previous survey in the analysis of samples and encouraged continuing collaboration.

4.26 The Scientific Committee recommended that this research could proceed as a fixed-effort survey for one year, with nine longline sets positioned in research block 481_ 1 (northern block) and 20 sets in research block 481_2 (southern block) following coordinates set out in WG-FSA-2019/17, Table 1, with a focus to be given to the southern research block. Results from this research will be presented intersessionally at WG-FSA. The maximum catch limit for the fixed-effort survey is 43 tonnes.

4.27 The Scientific Committee noted that this research proposal was evaluated against the criteria outlined in WG-FSA-2019 report, Table 8, and endorsed that this research fishing proceed (Table 5).

4.28 The Scientific Committee agreed that by-catch limits for this research fishing should be set at 16% of the research catch limit for *D. mawsoni* in this subarea (Table 5).

D. mawsoni in Subarea 48.2

4.29 The Scientific Committee noted the discussion at WG-FSA (WG-FSA-2019 report, paragraphs 4.48 to 4.55) on the final year of research fishing by Ukraine in Subarea 48.2. The Scientific Committee noted the large amounts of collaboration on analysis in this area.

4.30 The Scientific Committee noted that a member of the Ukrainian research team, Illia Slypko, is a CCAMLR scholarship recipient who spent one week at the Australian Antarctic Division (Kingston, Australia) with the team led by his mentor (Dr Welsford) prior to WG-FSA this year, working on ageing of *Dissostichus* spp. with Australian colleagues.

D. mawsoni in Subareas 48.2 and 48.4

4.31 The Scientific Committee noted the discussion at WG-FSA (WG-FSA-2019 report, paragraphs 4.56 and 4.57) on the preliminary results of the connectivity of toothfish between Subareas 48.2 and 48.4. The Scientific Committee welcomed the preliminary results, recalling that all on-water activities have concluded, and this research plan is now in the two-year analysis phase.

D. eleginoides in Division 58.4.4b

4.32 The Scientific Committee noted the discussion at WG-FSA (WG-FSA-2019 report, paragraphs 4.115 to 4.132) on the research plan within Division 58.4.4b. The Scientific Committee noted the large amount of work that has been done over the intersessional period, that all milestones have been completed and that a preliminary CASAL assessment has been produced for research block 5844b_1.

4.33 The Scientific Committee noted the modification of the research plan to avoid areas with high densities of sea pens and skates in the eastern region of research block 5844b_2. It requested that further analysis be presented to the working groups on the distribution and abundance of these fauna.

4.34 The Scientific Committee noted the progress made in the stock assessment model in this division, and that the level of the estimated yields consistent with the CCAMLR decision rules would allow a yield substantially higher than the catch limit set using the Chapman estimate of biomass (WG-FSA-2019 report, Table 7). The Scientific Committee agreed that a 20% increase from the existing catch limit in research block 5844b_1 to 23 tonnes would be consistent with the trend analysis procedure.

4.35 The Scientific Committee noted this research proposal was evaluated against the criteria outlined in WG-FSA-2019 report, Table 9, and endorsed that this research fishing proceed.

4.36 The Scientific Committee recommended that catch limits for Division 58.4.4b be set using the trend analysis rules and CASAL model (WG-FSA-2017 report, paragraph 4.33) as shown in Table 5.

4.37 The Scientific Committee agreed that by-catch limits for this research fishing should be set at 16% of the research catch limit for *D. eleginoides* in this subarea.

4.38 The Scientific Committee requested that discussions on fishery status and the regulatory framework in relation to the status of this division changing from a closed area under CM 32-02 to an exploratory fishery (paragraph 4.18) be considered by the Commission with this advice.

D. mawsoni in Subareas 88.1 and 88.2

Research plans in the MPA

4.39 The Scientific Committee considered Tables 10 and 11 of the WG-FSA-2019 report, summarising research proposals in MPAs reviewed against criteria outlined in WG-FSA-2019/55 and WG-SAM-2019 report, paragraph 6.16.

Shelf survey

4.40 The Scientific Committee recalled the importance of this time series of surveys for the Ross Sea region stock assessment in delivering a long-term time series of recruitment, as highlighted by the Independent Review (WG-FSA-2018 report, paragraph 4.148). The

Scientific Committee welcomed the participation of a CCAMLR scholarship recipient (Illia Slypko) to the 2019/20 survey and highlighted the value of the CCAMLR scholarship program in exchanging experience and knowledge between CCAMLR Members.

4.41 The Scientific Committee recalled that the survey is effort limited with a core strata sampled every year and strata sampled in alternate years (i.e. McMurdo and Terra Nova; WG-FSA-2017 report, paragraph 3.83). The McMurdo strata will be sampled in the 2019/20 season.

4.42 The Scientific Committee agreed to endorse the proposal for the Shelf Survey with a recommended catch limit of 45 tonnes for the 2019/20 season.

4.43 The Scientific Committee recalled SC-CAMLR-XXXVI, paragraph 3.166, a recommendation that the catch for the winter survey conducted in 2018/19 should be deducted from the Ross Sea northern catch limit for the 2019/20 season.

Special research zone

4.44 The Scientific Committee considered the proposal for a research program from 2019 to 2022 in the SRZ to investigate the life cycle, distribution and movement, biological parameters and stock structure of toothfish species in the eastern part of the Ross Sea over the shelf and continental slope. The Scientific Committee noted the additional work carried out by WG-FSA collectively to address some of the points related to research designs and capacity as described in Table 10 of the WG-FSA-2019 report.

4.45 The Scientific Committee noted that the research was proposed to be carried out by two vessels, one of which had consistently poor tagging detection rates and a tagging survival of zero (*Palmer*). The other vessel (*Volk Arktiki*) had a good tag detection rate, but as it had only operated for one season previously, its tag survival rate was yet unknown.

4.46 The Scientific Committee highlighted the links of this proposal to the Ross Sea region RMP and the science needed to evaluate whether the MPA objectives would be met.

4.47 The Scientific Committee noted that each research plan has two parts, the on-water data collection, and the off-water data analysis, and sought clarification whether there was sufficient research capacity available for off-water analysis and whether the survey could be carried out with one vessel only. It further noted that although great improvements had been made to the proposal taking much of the previous feedback into consideration, there was little information on analytical methods proposed or considered for analysing data coming from the survey.

4.48 The Scientific Committee raised concerns around the very poor tagging performance of the *Palmer*, asking for assurances that the tagging performance would improve substantially should this research proposal go ahead.

4.49 The proponents thanked the Scientific Committee for all comments and noted that as the comparison between two different vessels using the same gear type was one key objective of the survey, it would not be possible to carry it out with one vessel only. The proponents further clarified that analyses will be carried out by VNIRO, to be presented in 2020.

4.50 The Scientific Committee recommended that, if the survey was to go ahead, electronic monitoring should be conducted on both vessels to understand what procedures are causing the failure of released tags to be detected by adjacent fishing vessels, and that the survey used the strata and allocation given in the WG-FSA-2019 report, paragraphs 4.160 and 4.161 and Figure 8.

4.51 The Scientific Committee further requested that the research be reviewed at WG-FSA-2020 as a new research proposal.

4.52 The Scientific Committee recommended that, should the research plan be approved, the research plan consist of two research blocks with overlapping distributions of haul stations between the two vessels, in each research block, and the two vessels should operate in such a way as to maximise the overlap in sampling stations actually fished within each research block. The Scientific Committee also recommended priority be given to research block one, as it contained the greatest ice accessibility.

4.53 The Scientific Committee further requested that, should the research plan be approved, sampled stations shall be a selection of the stations shown in WG-FSA-2019 report, Figure 8.

4.54 The Scientific Committee noted that objective 1 contained a stock assessment and that the toothfish within the SRZ are already assessed as part of the Ross Sea region stock assessment (WG-FSA-2019/08). The development of time series of local trends in abundance and CPUE would be desirable for this area in order to compare them to trends outside the RSRMPA and within the RSRMPA general protection zone (GPZ).

4.55 The Scientific Committee recalled advice to other research plans that the proposed sampling rate of 10 fish per by-catch species, per line, was insufficient to collect enough data for the analysis planned (WG-FSA-2018 report, paragraph 4.47).

4.56 The Scientific Committee noted the calculations of an upper catch limit for the effort-limited survey proposed in the SRZ which resulted in a maximum catch limit of 140 tonnes. It also noted data from the most recent two seasons are now available and should be accounted in future calculations.

4.57 The Scientific Committee recommended that should this research be approved, a catch limit of 140 tonnes for this effort-limited survey should be applied.

D. mawsoni in Subarea 88.3

4.58 The Scientific Committee noted a multi-Member research proposal for *D. mawsoni* in Subarea 88.3 by Korea, New Zealand and Ukraine, and that it was in its final year. It noted that the main objective of this research was to determine the abundance and distribution of *D. mawsoni* in Subarea 88.3, understand stock structure of toothfish in Area 88, carry out calibration trials among vessels, collect data on the spatial and depth distributions of by-catch species and trial scientific electronic monitoring technologies.

4.59 The Scientific Committee noted this research proposal was evaluated against the criteria outlined in the WG-FSA-2019 report, Table 10, and recommended that this research fishing proceed.

4.60 The Scientific Committee recommended that research catch limits for Subarea 88.3 be set using the trend analysis rules (WG-FSA-2017 report, paragraph 4.33), as shown in Table 5.

4.61 The Scientific Committee agreed that by-catch limits for this research fishing should be set at 16% of the research catch limit for *D. mawsoni* in this subarea.

Crabs in Subareas 88.2 and 88.3

4.62 The Scientific Committee noted the results of research on crabs in accordance with CM 24-01 undertaken by Russia in Subareas 88.2 and 88.3 during March 2019. It was noted that there had been considerable discussion of the results of this research at WG-SAM (WG-SAM-2019 report, paragraphs 6.101 to 6.106) and that the research had been severely constrained by ice conditions. It was further noted that the continental shelf region had been inaccessible in Subarea 88.2 and the research effort was restricted to a region of offshore seamounts. It was noted that Russia will be undertaking future analysis of this crab data and that these analyses will be provided to WG-FSA next year.

4.63 Given the limited success of the research, the Scientific Committee concluded that there is likely no scope for a viable fishery for crabs on seamounts in Subarea 88.2.

4.64 The Scientific Committee was requested by WG-FSA to consider whether future potential research on crabs in Subareas 88.2 and 88.3 should be conducted under CM 24-01, or considered as a new fishery under CM 21-01, given the limited results and low spatial coverage of the research conducted to date.

4.65 The Scientific Committee recalled that the process of undertaking structured research in accordance with CM 24-01 prior to opening a new fishery has been valuable. Some Members recommended that the limited success of the research on crabs indicated that any future research activities on crabs in this region should continue to be conducted in accordance with CM 24-01.

4.66 Dr Kasatkina noted that the crab research this year was a pilot study and that the vessel endeavoured to complete as much of the research as was logistically feasible. She noted that this research provided useful data on crab stocks in this region and provided data that can be used for planning future research fishing for crabs in Subareas 88.2 and 88.3. In her opinion, future research fishing should be conducted as new a fishery in accordance with CM 21-01.

4.67 The Scientific Committee requested that the Commission consider this issue.

Other research

4.68 The Scientific Committee noted the discussion in WG-FSA on other research being conducted (WG-FSA-2019 report, paragraphs 7.6 and 7.7) which includes the quadrennial POKER survey within Division 58.5.1 in 2021, and the annual random stratified trawl survey within Division 58.5.2 in 2020.

Non-target catch and ecosystem impacts of fishing operations

Fish and invertebrate by-catch

5.1 The Scientific Committee noted research presented at WG-FSA (WG-FSA-2019 report, paragraphs 6.1 to 6.3) using molecular tools to identify specimens of softnose skates (*Bathyraja* spp.) from Subarea 48.3, using a method similar to that applied in 2018 to resolve the taxonomic uncertainty of *Amblyraja* skates. Results indicated a single population of *B. meridionalis* in this region with low genetic diversity.

5.2 The Scientific Committee noted that high levels of skate by-catch had been reported from Division 58.4.3a for fishing activities between 2008 and 2018. Analyses of by-catch composition, distribution and biological characteristics during this time period indicated that key factors determining the by-catch of *A. taaf* appeared to be bathymetry and location, although the study also noted that *A. taaf* were caught more frequently on lines set by a vessel using integrated weight autolines. Of the 133 *A. taaf* tagged and released since 2009, none have been recaptured to date. The Scientific Committee noted that the observed differences in size and quantity of skates between vessels would warrant further exploration, standardising data used in the analysis for vessel effects, gear effects, or geographical attributes such as depth, as analyses from other areas had shown that vessel effects appear to be a more significant factor explaining by-catch levels than gear type.

5.3 Dr Péron highlighted to the Scientific Committee that the results revealed extremely high systematic catches of skates when French longliners were operating in the area, and that these high rates appear to be linked to fishing practice, such as gear type, fishing depth, bait type and high densities of skates on this seamount system. She informed the Scientific Committee that in view of these results and the declining toothfish CPUE in recent years, France has decided to terminate the operational part of this research plan at-sea. Dr Péron stressed France's commitment to continue to study, in collaboration with Japanese colleagues, the population structure and connectivity at the Area 58 level to improve our understanding of stock dynamics on a larger scale.

5.4 The Scientific Committee noted that information on post-release survivorship was important to understanding the likely impact of by-catch of skates. The Scientific Committee noted that no notification for fishing activities (CM 41-06) and no fisheries research plan proposals were submitted for this division for the 2019/20 season.

5.5 The Scientific Committee recommended that a focused skate tagging program be conducted in 2019/20 and 2020/21 in the Ross Sea region. The intent is to tag all live skates caught, up to 15 live skates per line as specified in CM 41-01, Annex 41-01/C. During this tagging program vessels may tag more than 15 skates per line, and may also tag skates with a low probability of survival, on the provision that the condition of the skate is recorded along with the tag number.

Incidental mortality of seabirds and marine mammals associated with fisheries

5.6 The Scientific Committee noted WG-EMM-2019/16 that described the outcomes of trials with a net monitoring cable aimed at developing real-time monitoring of the fishing gear on the *Saga Sea* that were first presented in WG-EMM-16/06. A derogation from the prohibition on the use of net monitoring cables in CM 25-03 was provided for this trial. Because the trials on the *Saga Sea* were unsuccessful with the existing rigging configuration, the vessel introduced the same trawl rigging as used on the *Antarctic Sea* and has also introduced the same operating approach for the net monitoring cable, with it closely paired to the trawl cable.

5.7 The Scientific Committee noted that in 2016 a one-year derogation on the prohibition of the use of a net monitoring cable was given on the basis of the trial described in WG-EMM-16/06 (SC-CAMLR-XXXV, paragraphs 4.10 to 4.13; SC-CAMLR-XXXVI, paragraphs 3.10 and 3.11), this was extended in 2017 but was apparently no longer in place when the trial was conducted (SC-CAMLR-XXXVII, paragraphs 3.14 and 3.15).

5.8 The Scientific Committee recalled comments provided by Dr O.A. Bergstad (Norway) (WG-EMM-2019 report, paragraph 3.13) which clarified that the suggestion in WG-EMM-2019/16 that the trials had continued into the 2018/19 season was incorrect; the experiments on the *Saga Sea* were conducted in 2016/17 and 2017/18.

5.9 The Scientific Committee noted the report from Norway (SC-CAMLR-38/18) that emphasised the need for cabled communication with net sensors. There is currently no other practical alternative providing the broadband net monitoring and power supply needed for safe and efficient operating of the trawls. Net monitoring with acoustics is a substantial benefit to science, and it is required for the continued development of catch estimation from trawl density measurements. The report also provided detail about the challenges faced during the two-year trials on the *Saga Sea* which were conducted within the derogation period. The experiments essentially failed, leading to the vessel abandoning its trawl rigging with the beam at the base of the trawl mouth. It also detailed the use of the net monitoring cables paired with the trawl cable, on the *Antarctic Sea* since 2011, and on the *Antarctic Endurance* since the 2018/19 season. The paper confirmed that all three Norwegian vessels, including the *Saga Sea* as of the 2018/19 season have used the same trawl rigging and the paired warp and net monitoring cable arrangement that had been assumed not to violate CM 25-03 and that none of the vessels have ever used the classical free-flying net monitoring cable. The paper maintained that CM 25-03 (Article 1) prohibits net monitoring cables without technical specifications on what a net monitoring cable is, how it is rigged or used. SC-CAMLR-38/18 proposed a change to CM 25-03 facilitating use of cabled connections between the vessel and trawl if it can be demonstrated that it would not violate the main objective of the conservation measure.

5.10 The Secretariat provided a summary of the warp strike data collected by SISO observers on krill trawl vessels. As instructed in the Observer Krill Trawl Logbook Instructions, observers record occurrence of heavy strikes during 15-minute observation periods (www.ccamlr.org/node/74769). Over the previous two years, 21 strikes were observed from 1 708 observation periods on continuous trawlers, and zero strikes observed from 3 157 observations from non-continuous trawl vessels. The Scientific Committee noted that further analyses of these data, as well as observer data from previous years for both conventional and continuous trawlers, would be needed to provide a more thorough understanding and to assess the potential implications for seabird populations.

5.11 ACAP made the following statement:

'The use of net monitoring cables has been prohibited by CCAMLR ever since the 1994/95 season (CM 25-03) as it was recognised these cables pose a severe danger to seabirds; and ACAP observed that CCAMLR's record in rapidly and substantially reducing seabird by-catch in its fisheries was a major success story and an example to others.

- *ACAP's position on the use of net monitoring cables is that:*

  - *Net monitoring cables* ***should not be used****. Where this is impractical:*

    - *deploy bird scaring lines specifically positioned to deter birds away from net monitoring cables while fishing*

    - *install a snatch block at the stern of a vessel to draw the net monitoring cable close to the water and thus reduce its aerial extent.*

ACAP pointed to some recent studies conducted in both Argentina and Chile, presented to ACAP's most recent meeting of its SBWG (in May 2019), which reported far higher rates of seabird mortality in trawl fisheries using a net monitoring cable than for vessels using alternative net monitoring devices.

Given the risks associated with net monitoring cables, ACAP considers that any proposal to lift, or weaken, CCAMLR's prohibition (CM 25-03) of the use of net monitoring cables should be done in a precautionary manner, and based on evidence that the proposed configuration of the net monitoring gear is of negligible risk to seabirds (and other taxa).'

5.12 The Scientific Committee noted that the particular issue in question refers to the continuous trawling system used by Norway only, in which each beam trawl net used is towed by a single warp where the net monitoring cable is aligned in parallel and very close to the warp.

5.13 The Scientific Committee recommended that a one-season trial be carried out in the 2019/20 season with the net monitoring cables paired with the trawl warp (as described in SC-CAMLR-38/18) on all krill vessels conducting continuous trawling, and that results of these trials be reported to WG-FSA to further evaluate the risks that this rigging poses to seabirds.

5.14 The Scientific Committee agreed that during continuous krill trawling operations the following conditions are required during the trial, in order to monitor and mitigate potential interactions with seabirds:

(i) 100% observer coverage for any vessel included in the trial

(ii) the use of a camera or video monitoring system (able to operate in low light conditions) that continuously records the full aerial length of the net monitoring cable and the seaward entry point

(iii) the observer(s) conduct observations on incidental mortality arising from fishing (IMAF) on the net monitoring cable and trawl warp at least twice daily, following the current standard warp strike observer protocols outlined in the SISO krill logbook instructions

(iv) the mandatory use of effective mitigation limiting seabird access to the area where warp cables and net monitoring cables are deployed. Mitigation should be consistent with specifications relevant to trawlers (e.g. ACAP best-practice advice for trawlers)[1].

5.15 Norway confirmed that the vessels conducting continuous krill trawling already have 100% observer coverage, and that the observers follow the instructions mentioned in paragraph 5.14(iii) at least twice daily. Camera monitoring has also been conducted, although not continuously.

5.16 The Scientific Committee noted the update from the Secretariat on incidental mortality of seabirds and marine mammals in CCAMLR fisheries during 2018/19 (WG-FSA-2019/16). The paper summarised IMAF activities collected in scientific observer and vessel data during 2018/19 as received by the Secretariat up to 8 October 2019, and included a short report, as requested by the Scientific Committee (SC-CAMLR-XXXVII, paragraph 5.22), providing details on multiple Antarctic fur seal (*Arctocephalus gazella*) mortalities that occurred during the 2017/18 season.

5.17 The Scientific Committee noted that the extrapolated total of 103 seabirds killed in the 2018/19 season was the third-lowest mortality figure on record, and that there were two seal mortalities reported in 2018/19 CCAMLR longline fisheries.

5.18 The Scientific Committee noted that in CCAMLR trawl fisheries there had been three seabirds and three seals killed through interactions with fishing gear. The Scientific Committee thanked the Secretariat for the report on the 19 Antarctic fur seal mortalities in the krill fishery in 2017/18. The report stated that an ineffectively attached marine mammal exclusion device may have contributed to the issue.

5.19 The Scientific Committee noted SC-CAMLR-38/BG/20 which described interactions of marine mammals with krill midwater trawl nets in Subarea 48.3 from observations using underwater cameras and sea-surface observations by observers. While large numbers of Antarctic fur seal were observed around the vessel during fishing, no seals were observed inside the trawl net from the underwater video operations. The paper noted that when krill swarms were distributed deeper, this usually resulted in more aggressive behaviour as seals chased a krill-filled trawl net. It is speculated that this behaviour of fur seals may be a foraging-related phenomenon.

5.20 The Scientific Committee appreciated the initiation of this work noting that temperature recording on the trawl net may also be useful to understand the relationship between the vertical distribution of krill swarms and water temperatures, and encouraged this research to continue along with any similar research to increase understanding of marine mammal interactions with trawl gear and the krill swarm they feed on.

[1] Noting that streamer lines in CM 25-02, Annex 25-02/A, paragraph 1, are designed for longline application.

5.21 The Scientific Committee noted WG-FSA-2019/31 which presented a final report on fishing effort and seabird interactions during three season-extension trials (1–14 April, 1−14 November and 15–30 November) in the longline fishery for *D. eleginoides* in Division 58.5.2. Due to the application of effective seabird by-catch mitigation by participating fishing vessels, the overall risk of seabird mortality in this fishery was low with 20 mortalities in total reported between 2003 and 2018. The rate of seabird mortality in the core fishing season and the existing post-season extension from 15 September to 31 October was less than 0.0001 birds per thousand hooks (or less than 0.1 birds per million hooks). The rates of seabird mortality for the pre-season and two post-season extension trials were comparable to that during the existing pre-season extension from 15 to 30 April.

5.22 The Scientific Committee noted that in the last three years all seabird mortalities occurred during the season extensions while seabird mortalities had occurred prior to that during the core season. It was unclear whether there was a temporal trend or pattern in seabird mortalities during the core season due to the rare nature of these mortality events.

5.23 The Scientific Committee noted the conclusion of the three season-extension trials, with seabird mortality risk in the trial periods being highly uncertain but similar to one of the existing season-extension periods.

5.24 The Scientific Committee recommended that the specifications of the longline fishing season in CM 41-08 (CM 41-08, paragraph 3) remain unchanged.

5.25 The Scientific Committee recommended that the requirement for any vessel to demonstrate full compliance with CM 25-02 in the previous season be removed from CM 41-08 (CM 41-08, paragraph 3) since there is already effective seabird by-catch mitigation by fishing vessels in this fishery both in the specification and application of seabird mortality mitigation measures. The Scientific Committee noted the requirement to record data on seabird mortality by new vessels, so that this approach can be reviewed in future.

5.26 ACAP noted that season extensions into times of the year when seabirds are at colonies should always be undertaken with caution. As the by-catch events are not consistent over time, consideration should be given to continued review and monitoring of the season extensions.

Bottom fishing and vulnerable marine ecosystems

5.27 The Scientific Committee considered the WG-EMM-2019 report, paragraphs 6.39 and 6.40, that listed four points to be considered during WG-FSA-2019 as a focus topic on VMEs.

5.28 The Scientific Committee noted that the VME focus topic was discussed and reflected in the WG-FSA-2019 report, paragraphs 6.25 to 6.42, as well as in Table 12 of that report.

5.29 The Scientific Committee noted that revision of CMs 22-06 and 22-07 were long overdue despite being priorities of the Scientific Committee.

5.30 The Scientific Committee identified a range of topics that should be considered as part of a review on CCAMLR VME protocols and bottom fishing impacts and these are set out in Table 12 of the WG-FSA-2019 report and recommended that the table was considered as a basis for a VME work plan for Members. The Scientific Committee requested that these topics be arranged in order of priority with an associated timeline.

5.31 The Scientific Committee highlighted that new approaches such as video camera observations of fishing gear on the seabed and during hauling, should be considered as a relatively cheap and practical approach to VME impact assessment.

5.32 The Scientific Committee noted that taxonomic and benthic experts from outside CCAMLR would be needed to assist with VME identification, and that the editors of the Register of Antarctic Marine Species, a subregister of the World Register of Marine Species (WoRMS) under the auspice of SCAR, could be a useful starting point.

5.33 The Scientific Committee recommended the establishment of an e-group to facilitate the implementation of the VME work plan outlined in Table 12 of the WG-FSA-2019 report and, in particular, to identify analyses that could be undertaken by the Secretariat. Subsequently, the e-group could be tasked with developing the details for each element of the work plan described in Table 12 of the WG-FSA-2019 report and the best forum (workshop, working group, etc.) for undertaking each element of the work plan.

5.34 The Scientific Committee recommended that a focus topic on non-target species that would include VME questions should be considered by WG-FSA in 2020.

Marine debris

5.35 The Scientific Committee considered the advice of WG-FSA regarding marine debris (WG-FSA-2019 report, paragraphs 6.43 to 6.52) and endorsed the recommendations that:

(i) with respect to gear loss reporting, a description of the circumstances that led to a line being lost should be provided along with the C2 data when they are submitted to the Secretariat, in order to evaluate the information requirements for a text field to be included in the future C2 form to enable routine reporting of causes of gear loss (WG-FSA-2019 report, paragraph 6.45)

(ii) to establish an intersessional correspondence group on marine debris (ICG-MD) (WG-FSA-2019 report, paragraphs 6.52).

5.36 The Scientific Committee considered SC-CAMLR-38/09 which reviewed the CCAMLR marine debris program, current methodology and data submission procedures, and emerging issues and current knowledge of marine debris levels in the Southern Ocean. The paper highlighted the difficulty in quantifying and monitoring marine debris levels, trends and associated impacts across the Convention Area due to the spatial scale at which data is currently collected and considered ways in which the program could be modernised.

5.37 Based on Scientific Committee discussions in 2018 (SC-CAMLR-XXXVII, paragraph 5.41), the Secretariat developed a new data e-form for the submission of opportunistic marine debris data (SC-CAMLR-38/09, Appendix 2). The Scientific Committee noted that the collection of marine debris data using the new data e-form will increase engagement with other international organisations collecting similar data, such as the SCAR Plastic in Polar Environments Action Group, as well as being relevant to the CEP.

5.38 The Scientific Committee noted the recommendation in SC-CAMLR-38/09, and supported at WG-FSA-2019 (WG-FSA-2019 report, paragraph 6.52), to establish the ICG-MD to review and further develop the CCAMLR marine debris program, which could include defining its objectives, developing program materials and methodology and developing an analytical approach that would allow for quantification of marine debris levels across the Convention Area. Terms of reference for the ICG-MD are contained in Annex 11.

5.39 The Scientific Committee thanked Dr Söffker for her agreement to chair the ICG-MD and looked forward to broad participation in this group given the increased awareness of the potential impacts of marine debris on marine ecosystems.

5.40 The IAATO Observer thanked the CCAMLR Secretariat for the revised e-form for reporting opportunistic marine debris, which is now included in IAATO's Field Operations Manual as part of its wider strategy to understand and reduce plastics across its operations. The Scientific Committee noted that IAATO is working closely with stakeholders, such as SCAR's Plastic in Polar Environments Action Group, as part of its commitment to the UN Environment's Clean Seas campaign. The Scientific Committee noted the request from IAATO to contribute to the proposed ICG-MD.

5.41 SC-CAMLR-38/BG/28 outlined the marine debris, entanglements and hydrocarbon soiling at Bird Island and King Edward Point, South Georgia, Signy Island, South Orkney Islands and Goudier Island, Antarctic Peninsula, in 2018/19. The Scientific Committee noted that marine debris, entanglements and oiling are below the average for most species and records in the last reporting year.

5.42 The Scientific Committee recommended that the ICG-MD be established.

5.43 The Scientific Committee recommended that the marine debris program form part of the WG-EMM agenda.

Spatial management of impacts on the Antarctic ecosystem

Antarctic Specially Protected Areas

Rosenthal Islands

6.1 The Scientific Committee noted that WG-EMM reviewed a draft management plan, submitted by the USA, for an Antarctic Specially Protected Area (ASPA) in the Rosenthal Islands, which is within the existing Southwest Anvers Island Antarctic Specially Managed Area (ASMA) and includes the Palmer long-term ecological research (LTER) study area. The Rosenthal Islands are important as a minimally impacted reference area of exceptional scientific interest (WG-EMM-2019 report, paragraphs 6.1 to 6.6).

6.2 It was noted that, until recently, the Rosenthal Islands have mostly been inaccessible to humans. Thus, future data collection will be used to characterise baseline conditions in the area, including in the marine environment.

6.3 The Scientific Committee advised the Commission that that there is currently no harvesting in the Rosenthal Islands and the area is not of interest for harvesting activities. It recommended approval of the draft management plan for a new ASPA in this area.

Inexpressible Island

6.4 SC-CAMLR-38/14, submitted by China, Italy and Korea, presented the draft management plan for a proposed ASPA on Inexpressible Island, which is in the Ross Sea and within the GPZ of the RSRMPA. There are a large breeding colony of Adélie penguins and an important south polar skua (*Catharacta maccormicki*) nesting site on Inexpressible Island, and the island is an area of particular interest to ongoing and planned research and monitoring.

6.5 The Scientific Committee noted that the marine area in the ASPA has interesting ice regime characteristics that can serve for comparing coastal shallow water benthic communities around the continent.

6.6 It was noted that the proposed ASPA might be the first ASPA established within a CCAMLR MPA and some Members noted that the proposal is complementary to the RSRMPA. As such, some Members suggested that the proponents aim to link research conducted within the ASPA to that in the RSRMPA. The research and monitoring that is envisioned within the ASPA can be integrated into the RSRMPA RMP, including by observing or measuring the same indicators in both protected areas.

6.7 The proponents expressed their willingness to share the scientific data generated in the ASPA, including using the data for the RSRMPA RMP.

6.8 Mr L. Yang (China) noted that the size of proposed ASPA was small and has crowded Adélie penguins in the shore area, which need to use the channel for foraging activities in the sea. The small marine area contained in the proposed ASPA is based on a clear protection needs and takes into account of the needs for scientific study, logistics operation, historic site or monument protection and tourism management. No other more ambitious aims are discussed or pursued during the development of the management plan, including in the two workshops attended by experts from other Members.

6.9 The Scientific Committee advised the Commission to approve the draft management plan for a new ASPA in this area.

6.10 Some Members also recommended that the Commission request the ATCM and CEP, during regular and ongoing reviews of ASMAs and ASPAs, harmonise, as relevant, the management plans of managed or protected areas that occur within CCAMLR MPAs with the provisions and RMPs of those MPAs.

Argentine Islands

6.11 SC-CAMLR-38/BG/21, submitted by Ukraine, summarised plans to design and establish an ASPA in the Argentine Islands, adjacent islands of the Wilhelm Archipelago, and the nearby Graham Coast of the Antarctic Peninsula. This area, on the western coast of the Antarctic Peninsula, is of interest to ongoing and planned research and includes CEMP sites around Vernadsky Station where Adélie and gentoo penguins breed. Data collected at these CEMP sites are annually contributed to CCAMLR.

6.12 The Scientific Committee encouraged Ukraine to continue its work on establishing an ASPA in the Argentine Islands and appreciated that the proponents intend to harmonise the ASPA with the D1MPA.

Special Areas for Scientific Study

6.13 The Scientific Committee considered CCAMLR-38/20, submitted by the EU and its member States, which proposes to designate a newly exposed marine area adjacent to the Pine Island Glacier as a stage 2 Special Area for Scientific Study in accordance with CM 24-04. The paper provided information on the extent and characteristics of the proposed Special Area for Scientific Study, which is in Subarea 88.3. In May 2019, the UK notified all Members that the area of the Pine Island Glacier has reduced by 15.1% since 2017, thus meeting the criteria for designation of a Special Area for Scientific Study set out in paragraph 2 of CM 24-04 (COMM CIRC 19/53 and 19/58). The stage 1 area entered into force on 1 June 2019.

6.14 Dr Zhao indicated that the maximum scientific value of the newly exposed area due to iceberg calving resides in the beginning years. It has already been two years since the first major iceberg calving of the Pine Island Glacier, and still no research survey has been scheduled to obtain baseline data for the area; therefore the best time window available for obtaining the maximum scientific benefit in relation to the study of local ecosystem succession can thus be missed.

6.15 Some Members agreed that there is value in early access to newly exposed marine areas for the purpose of research on ecological succession but noted that there is no time limit on such research. Furthermore, ecological succession is not the only potential research interest in this dynamic and scientifically interesting area, and studies relating to oceanography (e.g. installation of moorings planned by German researchers), geomorphology and past climate are also likely to be undertaken.

6.16 The proponents of the proposal in CCAMLR-38/20 noted that planning to undertake research in the newly exposed area adjacent to the Pine Island Glacier is underway, and that advancement to stage 2 will ensure that the area is protected until such time as research can be conducted, as well as encouraging and facilitating collaborative research activities.

6.17 The Scientific Committee noted that a substantial area of new seabed has been exposed by the recent ice loss at the Pine Island Glacier and agreed that this is an area of significant scientific value for research on benthic ecology and evolution, past climate, bathymetric controls on glacier calving events, and oceanographic drivers of ice loss. It encouraged Members to plan and conduct research in the area adjacent to the Pine Island Glacier as soon as possible.

6.18 Dr Kasatkina noted that in line with CM 24-04, paragraph 6, following the designation of a stage 1 Special Area for Scientific Study, Members shall submit detailed information on the extent and characteristics of the Special Area for review by the Scientific Committee and its working groups. Taking into account the lack of a research plan for stage 1, as well as the significant risk that expeditionary research will be undertaken in the Special Area due to ice conditions, Dr Kasatkina still considered that the Special Area for Scientific Study adjacent to the Pine Island Glacier (Subarea 88.3) cannot be deemed designated until there is clarification regarding the volume and quality of existing information required prior to the designation of stage 1. Dr Kasatkina highlighted that this appears to be justified, considering the lack of implementational procedures regarding the designation of a stage 2 Special Area for Scientific Study based on the results of stage 1.

6.19 Dr Grant recalled that the intention of CM 24-04 is to facilitate the development of research in response to ice loss events such as has occurred at Pine Island Glacier. There is no requirement in CM 24-04 for a research plan to be implemented before a stage 2 Special Area is adopted, and the 10-year stage 2 designation period is considered to be the minimum time needed for scientific activities in Antarctica to be designed, organised and funded. The UK has provided all of the information required under the provisions of CM 24-04 for this area to proceed to a stage 2 designation. In addition, ice conditions in the region mean that access to the area is logistically feasible, so there is a high probability of research being undertaken.

6.20 SC-CAMLR-38/BG/30 described outcomes from the EU-H2020 Project 'Mesopelagic Southern Ocean Prey and Predators (MESOPP)'. This program is managed through a cooperation between Europe and Australia and aims to improve data sharing and promote international coordination on several topics to better characterise the mesopelagic domain, including:

(i) taxonomic characteristics of the mesopelagic fish

(ii) habitats and assemblages of mesopelagic species and couplings with their predators

(iii) advances in the use of acoustic methods to study mesopelagic species, including progress on the identification of acoustic targets

(iv) micronekton modelling.

Marine protected areas (MPAs)

South Orkney Islands southern shelf MPA

6.21 CCAMLR-38/22 presented information on the review of the South Orkney Islands southern shelf (SOISS) MPA, which is due to be undertaken in 2019 under the provisions of CM 91-03. The review is informed by the results of research and monitoring, and assessments presented in CCAMLR-38/BG/20 (MPA Report). The proponents consider that the scientific basis for protection of the SOISS MPA remains as described in CM 91-03 at the time of its designation. Furthermore, the research and monitoring requirements set out in the updated RMP (CCAMLR-38/24) also indicate the value of this area for ongoing scientific study in the context of wider research needs in the Scotia Sea region. It is therefore proposed that CM 91-03 is maintained in its current form.

6.22 The Scientific Committee welcomed the increasing amount of research undertaken in and around the SOISS MPA. It noted that while research and monitoring activities outside the MPA are useful in providing relevant data and regional context, further research within the MPA will be important, particularly in increasing understanding and monitoring of biodiversity and change. The Scientific Committee further noted that this is a CCAMLR MPA, and the responsibility for research and monitoring is therefore shared by all Members.

6.23 Dr Kasatkina noted that after a 10-year period of the SOISS MPA's existence, this MPA still does not have a research monitoring plan approved by the Scientific Committee and the Commission. Therefore, the assessment of the effectiveness of the SOISS MPA and the achievement of MPA goals does not seem to be legitimate. She also noted that the scientific and legal issues of the SOISS MPA implementation should be brought into line with CM 91-04.

6.24 Mr Yang noted the following considerations in relation to the review of the SOISS MPA, which are also relevant to the development of the RMP:

(i) understanding the nature of change in the region will be important for future reviews and requires assessments of ecosystem status, however, the timescales of change may be longer than the MPA review period

(ii) reports informing MPA reviews should be structured to reflect the extent to which the specific MPA objectives are achieved

(iii) more ecosystem indicators could be further monitored to evaluate the MPA in relation to conservation objectives.

6.25 CCAMLR-38/24 presented an updated draft RMP for the SOISS MPA. This update takes account of recent general discussions on the development of RMPs and aims to address the research and monitoring requirements of CM 91-04. The draft plan outlines research and monitoring topics relevant to the MPA objectives. It also includes a project list, and information on datasets (including baseline data) relevant to the designation and review of the MPA.

6.26 The Scientific Committee noted the updates to this RMP in response to advice from WG-EMM on the inclusion of baseline data and ecosystem indicators. Some Member noted that the SOISS MPA RMP is similar in intent, content and format to the RSRMPA RMP.

Review of scientific analysis relevant to existing MPAs, including the scientific requirements for research and monitoring plans for MPAs

6.27 The Scientific Committee considered a number of papers on the development of RMPs, addressing both general principles and issues specific to RMPs under development.

6.28 SC-CAMLR-38/20 presented the critical elements for the development of RMPs for CCAMLR MPAs previously raised by China (CCAMLR-XXXVII/32), with the aim to ensure the transparency of all RMPs and to provide a guiding framework of all Members participating in the RMPs and future reviews on scientific basis. The paper identified critical elements including, inter alia: (i) baseline data be collated from the very beginning of elaboration of MPAs and presented; (ii) broadly stated objectives be translated into specific, measurable, achievable, relevant or realistic and time-bound (SMART) management objectives; (iii) indicators and their parameters be identified; (iv) data collected be standardised. It recommended that the Scientific Committee recognise the importance of these critical elements in the development of RMPs for CCAMLR MPAs, and use it as a foundation to facilitate further cooperation on this important matter.

6.29 The Scientific Committee recalled that there had been constructive consideration of the technical aspects of RMPs and baseline data at the 2018 Workshop on Spatial Management

(WS-SM-2018). However, it noted that there was a need to find time for further discussion in the intersessional period to further enhance mutual understanding of research and monitoring, as highlighted in SC-CAMLR-38/20.

6.30 The Scientific Committee, therefore, agreed that opportunities for further discussion should be scheduled in 2020.

6.31 Some Members believed that an extraordinary meeting of the Scientific Committee is necessary.

6.32 Other Members recommended that the following be considered:

(i) WG-EMM should add a one-day focus topic to the agenda of its 2020 meeting to discuss scientific details of RMPs (this focus topic should fit within the regular schedule of WG-EMM)

(ii) the Scientific Committee should add a one-day focus topic to the agenda of its 2020 meeting to continue such discussions (this focus topic should be added to the regular schedule of the Scientific Committee)

(iii) if necessary and relevant, WG-FSA could also be asked to consider scientific details regarding the implementation of RMPs. This could be determined at the request of WG-EMM, after concluding its focused discussion.

6.33 The Scientific Committee requested that the Commission consider this issue.

6.34 Some Members supported the request by the EU and its member States and Norway that the agenda of WG-EMM in 2020 includes an item on Spatial Management, including RMPs, according to Item 7 of the Rules of Procedure of the Scientific Committee as applied to its subsidiary bodies. Those Members noted that Item 7(b) of the Rules of Procedure specifies that the provisional agenda shall include all items the inclusion of which is requested by any Member of the Scientific Committee.

6.35 Some Members noted that the focused discussions outlined in paragraphs 6.28 to 6.30 should not preclude adoption of the RMPs for the SOISS MPA and RSRMPA by the Commission, as RMPs are flexible, living documents that may require periodic revision.

6.36 SC-CAMLR-38/11 Rev. 1 presented proposals on the requirements for developing RMPs for MPAs. These proposals reflect Russia's position regarding the establishment of MPAs put forward at CCAMLR meetings (SC-CAMLR-XXXVII/18; SC-CAMLR-XXXVII/19; WS-SM-18/10) and included the development of a unified approach to the development and operation of RMPs as an annex to CM 91-04.

6.37 Dr Kasatkina noted that the development of a unified approach to the formulation of a scientifically based RMP requires the adoption of procedural and implementation measures aimed at ensuring the effective operation of the RMP. This could be done in conservation measures in the form of an annex to CM 91-04. The development and approval of a unified approach to the formulation of an RMP must precede the establishment of new MPAs and form the basis for the revision of existing RMPs. Dr Kasatkina emphasised that some elements should be taken into account to develop RMPs for MPAs, namely:

(i) an MPA is created by the Commission approving the entire set of required documents accompanying the establishment of the MPA. An integral part of this set of documents is the MPA RMP

(ii) addition of the following paragraph to CM 91-04: RMPs shall be developed based on ‘the best available data which must be adequate to ensure a unified approach to the development of scientifically based RMPs for specific MPAs’

(iii) baseline data, essential for the development of RMPs, must include the qualitative and quantitative characteristics of marine ecosystems and biodiversity, as well as the oceanographic and climate history of the region

(iv) RMPs should include provisions governing procedures and sources for establishing the values of the allowable catch in order to provide resource support for the implementation of the RMP

(v) RMPs should be broken down into reporting periods, both in respect of planned research and monitoring, as well as information that must be obtained. The first reporting period should specify by whom, when and how RMPs will be carried out. Information about who will perform the activity should be approved prior to each subsequent reporting period.

6.38 Dr E. Marschoff (Argentina) noted that the system established in CM 91-04 allows full participation in the administration, research and monitoring within MPAs which are created within the Antarctic Treaty System and, as such, are not a region segregated from the multilateral system. He noted that requiring the adoption of a complete RMP before the establishment of an MPA contradicts CM 91-04 and is a topic that must be addressed by the Commission. The preamble of CM 91-04 states that the basic objective of the system is the conservation of biodiversity and acknowledges the opportunity offered by MPAs for research and monitoring of natural resources. Out of the six objectives indicated in CM 91-04, five start with the word ‘protection’ and the sixth refers to reference areas for research and monitoring.

6.39 Dr Marschoff further indicated that the adoption of RMPs has gained greater weight than the MPA objectives themselves and has entangled the Scientific Committee in protracted discussions about data quality and amount. It has never been seen throughout the history of CCAMLR that something similar to this level of information was required to proceed with the exploitation of a resource. Instead, fisheries have been conducted in an absolute vacuum of information, even applying the density of one species in Subarea 48.3 to estimate catch limits for a different species in Area 88. He indicated that the requirements proposed as the starting dataset for MPAs are excessive, requiring not only the collation of huge amounts of data but also impossible achievements, such as a description of the dynamics of the ecosystem which will pose intractable mathematical problems and run the risk of blocking the establishment of any MPA. Finally, he noted that RMPs should not become one more management tool but have been conceived to determine whether the MPA objectives are being achieved, for example to monitor the effects on the ecosystem that occur as a result of climate change and human activity.

6.40 Many Members agreed with the views expressed by Dr Marschoff. and noted that any requirement to adopt a complete RMP before the establishment of an MPA would contradict the provisions of CM 91-04.

6.41 Mr S. Leonidchenko (Russia) noted that there may be a need in rethinking regarding the approach as to how CCAMLR addresses MPAs. With regard to quotations from the preamble of CM 91-04 containing the word ‘conservation’ it was suggested to turn to the document of the higher order – one forming the basis of Commission’s work – namely the Convention, and its respective provisions (Article II points 1 and 2), whereby the term ‘conservation’ includes the notion of ‘rational use’. He further underlined that nothing in the Convention prioritises conservation over rational use – these are identified as equally important goals. Mr Leonidchenko also reiterated his disagreement with the approach suggesting that management considerations should not be considered as part of an MPA design and should instead go directly to the Commission. With regard to claims that RMPs may establish thresholds for scientific data that are too high – Mr Leonidchenko underscored that the thresholds that prove too high for individual Members can be met if all Members unite their efforts – it was suggested to think about launching in the future a large-scale scientific collaboration exercise, involving as many Members as possible, as an alternative to current ‘competition’ between individual MPA proposals. In this regard Mr Leonidchenko fully agreed with the previous speaker who noted that MPAs cannot be regarded as a ‘region segregated from the multilateral system’. Finally, it was considered important to allocate time to focused consideration of the RMP topic in order to try to bridge the gaps in views on this matter. In this regard Mr Leonidchenko recalled the Russian proposal at the last session of the Scientific Committee to launch an intersessional contact e-group as an open platform to exchange views specifically on the matter in question, which unfortunately, was blocked by one Member.

6.42 The Scientific Committee agreed that scientific aspects of the views expressed in SC-CAMLR-38/11 Rev. 1 could be considered during the focused discussions on implementing RMPs planned for 2020 and summarised in paragraphs 6.28 to 6.30. SC-CAMLR-38/BG/05 also included proposals to improve the draft RMP for the Ross Sea region, following the principles outlined by Russia in SC-CAMLR-38/11 Rev. 1.

6.43 SC-CAMLR-38/21 presented China’s proposals to improve the draft RMP for the RSRMPA in accordance with the requirements of CMs 91-04 and 91-05 on research and monitoring, and the minimum needs for successful review: bringing the geographical terms in line with zones defined; translating broadly stated objectives into SMART objectives; identifying measurable criteria and indicators; clarifying the relationship between the research topics to the specific objectives of each zone; establishing monitoring framework to evaluate the extent to which these objectives are being achieved; standardising methods, protocols and/or formats for data collection and analysis; establishing baseline data before the commencement of the RSRMPA; developing rules and procedures for updating the draft RMP.

6.44 The Scientific Committee noted that it has already endorsed the RSRMPA RMP, but acknowledged that it is a living document that may be updated. Many of the issues raised in SC-CAMLR-38/21 have already been addressed in the RMP. Other, general principles will be considered during the focused discussions on implementing RMPs planned for 2020 and summarised in paragraphs 6.38 to 6.30.

6.45 SC-CAMLR-38/BG/25 Rev. 1 presented research and monitoring by New Zealand and Italy in support of the RSRMPA. Considerable progress has been made on topics outlined in the RMP and activities have benefited substantially from collaboration with international colleagues. Dr M. Vacchi (Italy) also acknowledged the support of the CCAMLR scholarship program in facilitating some of the work undertaken by Italy.

6.46 Korean scientists are also conducting research and monitoring work in the Ross Sea region. These efforts are described in SC-CAMLR-XXXVI/BG/17.

6.47 The Scientific Committee welcomed the extensive research and monitoring work in the Ross Sea region, which has involved a large number of projects and international efforts and demonstrates the scientific value of the RSRMPA. It looked forward to seeing further outcomes from all Members' efforts.

6.48 The Secretariat presented SC-CAMLR-38/BG/04 reporting on the phases of development for the CCAMLR MPA Information Repository (CMIR), noting that the project's overall aim is to develop infrastructure that will support submission, hosting, analysis and reporting of MPA project data. Outcomes from phase 1 of the CMIR include the deployment of the CMIR host server, an operative project submission portal, and a developed workflow, with infrastructure to support the submission and hosting of MPA project data. Phase 2 will further develop the CMIR with a focus on user interaction, exploration of RMP projects, and server design, and will include an established CMIR host server, as well as the development of a search portal and tools to support MPA reporting. The Secretariat informed the Scientific Committee that phase 1 had been completed with phase 2 to commence in 2020 and invited Members to provide feedback on the design and content of the initial CMIR, and to begin entering project data with the support of the Secretariat.

6.49 The Scientific Committee thanked the Secretariat for the considerable progress made on development of the CMIR and agreed that this is a valuable resource that will facilitate reporting on RMP activities and increase transparency and data accessibility, particularly as further information is generated through new and ongoing research and monitoring activities.

Review of the scientific elements of proposals for new MPAs

D1MPA

6.50 Argentina and Chile introduced the revised version of the D1MPA proposal (CCAMLR-38/25 Rev. 1 and SC-CAMLR-38/BG/03). The proponents introduced the changes that have been made based on work carried out during the intersessional period. The simplification of the 2019 model compared to last year is related to three aspects: (i) the evolution of the krill fisheries management strategy in Subareas 48.1 and 48.2, (ii) the dynamics of the fishing fleet, and (iii) the outstanding issued mentioned in the 2018 meeting of the Scientific Committee.

6.51 The new model includes two zones with different regulations for fishing. The GPZs, where directed fishing is not allowed, and the krill fishing zones where directed fishing is allowed (CCAMLR-38/25 Rev. 1 and 38/BG/22). In the northwest Antarctic Peninsula (NWAP) and South Orkney Islands (SOI) regions, this represents a unification of the former krill fishery research zones and the special fishery management zone to allow the application of current and future krill fishing management strategies. Further modifications, as a reduction of GPZ in the NWAP and the consolidation of a GPZ in the southwest Antarctic Peninsula (SWAP) were made to achieve compliance with the conservation objectives of the MPA proposal. In summary, this new model protects important components of the ecosystem, provides a safeguard to comply with Article II of the Convention, while allowing a redistribution of fisheries (catch allocation), and seeks to reduce the concentration of the krill fishery in time and space.

6.52 Dr T. Ichii (Japan) welcomed the reduction in the NWAP while requesting further explanation about the expansion of the GPZs in the SWAP. He noted that, in his opinion, this region is not especially important for early stages of krill, based on Perry et al., 2019, and that the dynamic food-web model (SC-CAMLR-XXXVII/BG/04) which suggests the benefit of protecting a large portion of the SWAP is based on a questionable assumption of krill distribution. Furthermore, he noted that if the extensive SWAP is fully closed for fishery, we will lose a valuable source of future scientific information about krill.

6.53 Dr K. Demianenko (Ukraine) confirmed Ukraine's commitment to the work of the Commission to create a system of MPAs in the Antarctic. He expressed gratitude to the proponents of the D1MPA project for the great work done during the intersessional period, and also noted the great progress achieved by the proposal of the D1MPA He also confirmed Ukraine's interest in integrating the marine component of the ASPA project being developed by Ukraine into the D1MPA project. At the same time, Dr Demianenko drew attention to the fact that there are still some gaps in the project, in particular, the issue of the distribution of fishing efforts within the areas open for fishing under the MPA regime is not fully disclosed, and the prospects for fishing after the establishment of the MPA regime are not entirely clear. Taking this into account, Dr Demianenko expressed Ukraine's willingness to cooperate for the quickest completion, adoption and implementation of the D1MPA project.

6.54 Dr Kasatkina welcomed the revised version of the MPA proposal for Domain 1 and advancement of its proposal over the years. However, she noted the need for further consideration associated with research questions on existing and future management of krill fishery in the region with special attention to developing criteria for assessing the possible impact of the fishery on krill resources and dependent predators taking into account the mixed effects of fishing, environmental variability (or climatic changes), and the competitive relationship between predator species.

6.55 The proponents noted the conclusion from WG-EMM-2019 regarding the need for a more precautionary approach as the concentration of catches may potentially impact penguins during years with particular environmental conditions (WG-EMM-2019 report, paragraph 4.41). Therefore, WG-EMM agreed on a strategy for a preferred option to manage the krill fishery, understanding the necessity of a more precautionary approach.

6.56 The proponents also highlighted that the indicator species listed as priority data layers to progress the risk assessment in Area 48 (WG-EMM-2019 report, Table 7) will be used as indicator species for the D1MPA. The developing krill fishery management strategy does not include a monitoring plan to assess whether or not the decisions taken affect marine living resources. However, by incorporating conservation objective 10 'ensuring the sustainable development of the Antarctic krill fishery in a manner consistent with the objectives of Article II of the Convention', the D1MPA RMP can evolve with this strategy and monitor its effectiveness.

6.57 Dr Zhao thanked the proponents for addressing the concerns previously raised by China and welcomed the simplification of the model. Dr Zhao stated that, in his opinion, although it might be a Commission matter, he does not think it is appropriate to use MPA to manage the fishery. Dr Zhao further indicated that he believed that there is some misinterpretation in the accompanying background paper describing the rationale of the modification. He indicated he will talk with proponents in the margin for the interest of time.

6.58 The Scientific Committee welcomed the simplification of the D1MPA model 2019. Some Members noted that it is now a mature proposal, based on open and collaborative efforts and strong science and agreed that the management of the fishery within the MPA should be further considered by the Commission.

6.59 The Scientific Committee welcomed the efforts of the proponents to pursue a goal of ensuring that the new model incorporates Members' interests, as well as allowing the fishery to progress, in particular intersessional discussions and the Workshop on Krill Fishery Management held in Concarneau, France (10 to 14 June 2019). The Scientific Committee also noted that the development of the proposed D1MPA and FBM strategies for the krill fishery could be progressed independently as endorsed by WG-EMM (WG-EMM-2019, paragraph 2.2).

East Antarctica

6.60 SC-CAMLR-38/BG/53 outlined China's plan for marine investigation and assessment in the East Antarctic sector. This sector is recognised as a data-poor region with a paucity of time series data that can be used to describe the structure and process of the ecosystem. China has enhanced its capacity for research and monitoring in Antarctica with its second Icebreaker *Xue Long 2* and welcomes cooperation with Members to increase the understanding and conservation of the marine living resources in this sector and the marine ecosystem on which it depends.

6.61 The Scientific Committee welcomed the collaborative research proposed by China which will increase understanding of the East Antarctic region, noting that there are already extensive research efforts in the region, including long-term studies on Adélie and emperor penguins (*Aptenodytes forsteri*), Antarctic fulmars (*Fulmarus glacialoides*), snow petrels (*Pagodroma nivea*), Weddell seals (*Leptonychotes weddellii*), plankton monitoring and krill surveys, conducted by Australia, France, Japan and others for decades, some of these studies having started in the 1950s. The Southern Ocean Observing System (SOOS) also aims to coordinate international research efforts in this region.

6.62 In response to the additional issues raised on the East Antarctic MPA (EAMPA) proposal in SC-CAMLR-38/BG/53, Prof. P. Koubbi (EU) recalled that baseline information in the form of GIS data layers has been introduced to the Scientific Committee since 2011 and is available on the CCAMLR website.

6.63 Some Members also requested clarification on the research programs and development of a new MPA scenario mentioned in the document. They noted the implementation of such activities and the submission of a new MPA project in East Antarctica could contribute towards the establishment of a representative system of MPAs. They further noted this development should not delay in any way the discussions by the Commission to adopt the EAMPA proposal by Australia and the EU and its member States.

Weddell Sea

6.64 CCAMLR-38/BG/14 reported on progress towards the scientific data compilation and analyses in support of the planning of a potential MPA east of the zero meridian in the Weddell

Sea. The report highlighted work undertaken during the intersessional period by Norway, the EU and its member States to further enhance the existing Weddell Sea MPA (WSMPA) proposal, and to implement a two-phase approach. Phase 1 is focused on the establishment of MPAs in Domain 3 and the western parts of Domain 4, based on a slightly modified WSMPA proposal submitted by the EU and its member States and Norway (CCAMLR-38/23). Phase 2 is focused on the establishment of MPAs in the subarea of Domain 4 east of the prime meridian with a view to present targeted measures for the MPA designation in this area to the Commission by 2022/23.

6.65 The Scientific Committee welcomed the progress made on collaboratively developing this work during the past year, in particular the international expert workshop held in Tromsø, Norway, (13 to 14 May 2019) and reported to WG-EMM in 2019 (WG-EMM-2019 report, paragraphs 6.17 to 6.19).

6.66 Some Members noted that the establishment of an MPA in this region would make a substantial contribution to the development of a representative system of MPAs in the Convention Area.

6.67 Mr Leonidchenko disagreed with the terminology used in the WSMPA proposal, noting that terms ‘phase 1’ and ‘phase 2’ could create an impression that a degree of automatism exists in how the Scientific Committee treats the respective parts of the proposal. It was underlined that each of the parts is to be studied separately by the Scientific Committee based on their merits and scientific basis.

6.68 Dr Zhao questioned the scientific justification of dividing an integral ecosystem by the prime meridian.

6.69 Some Members agreed that while the adoption of phase 1 does not necessarily lead to the adoption of phase 2, the aim is for conservation and management to be consistent across the region as a whole ecosystem.

6.70 Some Members noted that issues relating to potential or future fishing resources are management considerations and are, therefore, not part of the scientific process being undertaken at this stage. They further recalled the conclusions of the 2018 Workshop for the Development of a *D. mawsoni* Population Hypothesis for Area 48 (WS-DmPH-18) that the alternative stock hypotheses developed for *D. mawsoni* in Area 48 should not hinder progress towards spatial management in this region.

6.71 The Scientific Committee welcomed the extensive work undertaken during this workshop, building on the outcomes from a previous technical workshop (WG-EMM-12/33). It noted that the focus on connectivity across pelagic ecosystems is particularly important, and that further development of this work would contribute substantially to the achievement of a representative system of MPAs.

6.72 SC-CAMLR-38/BG/15 set out observations and comments on the scientific basis and draft RMP of the WSMPA proposal, recalled issues identified by the Scientific Committee, and reiterated points previously raised by China regarding outstanding scientific issues to be addressed in the WSMPA proposal, indicating further work is still needed to be done in the Scientific Committee.

6.73 ASOC introduced CCAMLR-38/BG/44, highlighting the global climate and biodiversity crisis, and that MPAs were a proven solution to address these challenges. ASOC called on CCAMLR and all its Members to complete the representative system of MPAs by 2020 and recommended that CCAMLR acknowledges the climate and biodiversity crisis and commits to adopting MPAs with no duration and significant no-take zones; that CCAMLR adopts the current MPA proposals, with the D1MPA including the extension of no-take zones to all areas previously identified as critical for conservation; and that CCAMLR develops MPAs in un-represented regions of the Convention Area, including Domain 9.

6.74 Mr Leonidchenko referred to the use of the word 'recommended' in the above statement and in this regard wished to clarify that Russia as a Member of the Scientific Committee did not request advice or recommendations according to the Rules of Procedure.

Eastern sub-Antarctic region (Domains 4, 5 and 6)

6.75 SC-CAMLR-38/BG/29 reported on the Expert Workshop on Pelagic Spatial Planning for the eastern sub-Antarctic region (Domains 4, 5 and 6) held in Cape Town (South Africa), 26 to 30 August 2019. The Workshop Co-conveners (Dr A. Makhado (South Africa), Dr Lowther and Prof. Koubbi) acknowledged the support of the CCAMLR MPA Special Fund and the Pew Charitable Trusts in facilitating the Workshop and thanked all of the participants for their contribution.

6.76 The Workshop report included a scientific work plan outlining the delivery of work packages on ecoregionalisation, connectivity between ecoregions, forecasting trends in ecoregions, long-term and short-term variability, human dimensions, and education and outreach, over the next five years. This work will lead to a regional (pan-sub-Antarctic) overview of ecosystem structure and function, that can be used in future spatial conservation planning or risk assessments in this dynamic pelagic environment. The Workshop also included a videoconference with the Indian Ocean Tuna Commission (IOTC) workshop on pelagic ecoregionalisation.

6.77 At the time of report adoption, Dr Kasatkina noted that eastern sub-Antarctic region (Domains 4, 5 and 6) will include potential fishing grounds for krill and a number of fish species. Therefore, MPA design should include allocation of fishing and protected areas of managed by different conservation measures.

IUU fishing in the Convention Area

7.1 The Scientific Committee welcomed an update from the Secretariat on IUU fishing activity and trends (CCAMLR-38/12 Rev. 1) that contained no reports of IUU vessel sightings in the Convention Area over the last two years.

7.2 The Scientific Committee noted in the report of WG-FSA (WG-FSA-2019 report, paragraph 2.3) the request that the Secretariat review the current requirements for gear marking by CCAMLR vessels against the FAO Voluntary Guidelines on the Marking of Fishing Gear.

CCAMLR Scheme of International Scientific Observation

8.1 The Scientific Committee considered the advice of WG-EMM (WG-EMM-2019 report, paragraphs 3.29 to 3.39) and WG-FSA (WG-FSA-2019 report, paragraphs 5.1 to 5.6) in relation to SISO.

8.2 The WG-EMM-2019 report, paragraphs 3.29 to 3.39, summarised the discussion in WG-EMM-2019 in relation to SISO. It outlined (WG-EMM-2019 report, paragraph 3.28) the timeliness of a krill workshop to review information on krill sampling.

8.3 SC-CAMLR-38/22 outlined the proposal by China to host a three-day krill fishery observer workshop in Shanghai in 2020, to improve krill sampling protocols and priorities for data collection. Terms of reference and a draft budget were summarised. The intention is for scientific observers, technical coordinators, managers, relevant researchers and the Secretariat to attend the workshop.

8.4 The Scientific Committee endorsed the proposed workshop and thanked China for the initiative.

8.5 The Scientific Committee also noted the utility of ARK attending the workshop to provide practical input, based on the success of the recent COLTO–CCAMLR workshop.

8.6 The Scientific Committee recommended that outcomes from WS-SISO-17 (SC-CAMLR-XXXVI/08) be reviewed and could form useful materials for the preparation for this workshop.

8.7 The Scientific Committee thanked the Secretariat and observers for their hard work in the development of new krill and finfish manuals. The Scientific Committee noted minor changes were required to the conservation measures outlined below to reference the correct manuals:

(i) CM 22-06
(ii) CM 41-01
(iii) CM 51-04
(iv) CM 51-06.

8.8 Results from the vessel tagging survey highlighted that observers are doing large amounts of tagging, and the Scientific Committee noted that this reinforces the need for an observer tagging training program.

8.9 The Scientific Committee noted that the identification of observer names in papers presented to its working groups may result in personal data confidentiality issues. The Scientific Committee reflected that some observers may wish to be identified for recognition of working in CCAMLR fisheries and suggested that permission for identifying the observer could be specified in the bilateral arrangement between Designating and Receiving Members and communicated to the Secretariat when submitting the observer deployment notification. The Scientific Committee noted that whilst bilateral agreements are between Members, if there is a wider problem, then the Secretariat needs to be aware and this issue may need to be passed up to the Commission.

8.10 SC-CAMLR-38/01 reported on the regular Workshop for Training National and International Scientific Observers and Inspectors, including CCAMLR Scientific Observers, held at the Atlantic branch of VNIRO (AtlantNIRO) in Kaliningrad, Russia, from 19 to 23 August 2019. Forty-one specialists from marine research institutes operating under the auspices of the Federal Agency for Fisheries and from a number of fishing companies took part in the workshop.

8.11 The Scientific Committee thanked Russia for sharing valuable information on observer training. It was noted that WG-FSA-2018 advised developing procedures to share training information between Members. The Scientific Committee re-endorsed the text from SC-CAMLR-XXXVII, paragraphs 8.1 and 8.2, and recognised the importance of standardising observer output across Members.

8.12 The Scientific Committee noted that a previously suggested accredited observer program was not endorsed but could be built upon, and there is also the potential for creation/use of online courses which could harmonise the information observers receive to improve consistency notwithstanding nationality.

8.13 The Scientific Committee noted that the Secretariat Observer Scheme Program Coordinator has been engaged in outreach with many Members to facilitate common understanding across observer training and suggested that he could be invited to attend the next Russian training workshop with an interpreter.

Climate change

9.1 The Scientific Committee noted that there were considerations of climate change throughout its deliberations (SC-CAMLR-38/15 and 38/BG/30), however, more substantive discussions focused on the role of krill in global and regional biogeochemical models, fish stock productivity parameters and emperor penguins.

9.2 The Scientific Committee noted discussion at WG-EMM (WG-EMM-2019 report, paragraphs 4.18 and 4.19) concerning a model of the potential flux of particulate organic carbon originating from Antarctic krill in the marginal ice zone. Krill swarming behaviour could result in carbon export to depth through their rapid exploitation of phytoplankton blooms and bulk egestion of rapidly sinking faecal pellets. The model results (Belcher et al., 2019) suggested a seasonal export flux of 0.039 giga-tonnes of carbon across the Southern Ocean marginal ice zone, corresponding to 17–61% of current satellite-derived export estimates for this zone. Thus, krill may be important contributors to the Southern Ocean carbon sink.

9.3 The Scientific Committee recognised that such studies (Belcher et al., 2019; Cavan et al., 2019) emphasise the role of krill in global and regional biogeochemical models, and thus the critical role of CCAMLR in helping mitigate climate change at the global scale.

9.4 The Scientific Committee recalled that changes in fish stock productivity parameters may impact assessment estimates and consequently management advice, and that these changes may be related to long-term environmental change (WG-FSA-2018 report, paragraphs 2.28 to 2.31). WG-FSA-2018 had, therefore, recommended that key assessment parameters be reviewed and that changes in the fishery dynamics that would impact their estimation be explored.

9.5 The Scientific Committee noted that biological productivity parameters in the Subarea 48.3 toothfish stock had been analysed for variation across time (WG-SAM-2019/32). When the effects of confounding factors, such as depth, were included in the analysis, there was no indication of systematic change in the proportion of females in the catch, maturity at length, and length–weight relationships that would indicate potential impacts from external influences such as the fishery or climate change.

9.6 The Scientific Committee recalled its advice (SC-CAMLR-XXXVII, paragraph 3.51) that a section in Fishery Reports on changes in model parameters and productivity assumptions could be a useful way to highlight issues related to climate change and requested that these sections be included in updated CCAMLR's Fishery Reports.

9.7 SCAR introduced SC-CAMLR-38/BG/10 which reported on the work of an international group of scientists, including the majority of those holding long-term data and having experience of working with emperor penguins, to review the dependence and vulnerability of emperor penguins to ongoing and projected climate change (Trathan et al., 2019). The outcomes of this work will have relevance to the ATCM, CEP and possibly CCAMLR, because of their implications for species-related conservation decision-making and conservation planning. SC-CAMLR-38/BG/10 noted that emperor penguins are highly sensitive to climate change, given their critical reliance on sea-ice during breeding. They are also exposed to climate change, given their current circumpolar distribution, which includes areas of regional warming, coupled with the fact that most climate models agree that future global climate change will lead to reductions in sea-ice areas of close to 30% (or 40%) over the 21st century following medium (or high) greenhouse gas emission scenarios. As such, the international group of scientists have concluded that emperor penguins are highly vulnerable to climate change. The Scientific Committee, therefore, noted that the next steps for SCAR will be to:

(i) liaise with the IUCN Species Survival Commission Penguin Specialist Group and BirdLife International to inform SCAR's evaluation of the threat status of emperor penguins and to report back to SC-CAMLR in 2020

(ii) should an assessment of the emperor penguins' conservation status, in accordance with the Guidelines for CEP Consideration of Proposals for New and Revised Designations of Antarctic Specially Protected Species under Annex II to the Protocol, determine that the species is at significant risk (e.g. the conservation status is determined to be 'Vulnerable' or higher), seek Antarctic Protected Species Status for the species. A draft species Action Plan would then be developed collaboratively amongst interested Parties, led through the appropriate SCAR Expert Group.

9.8 The Scientific Committee noted that the work by the international group of scientists provided an excellent summary of the known threats to emperor penguins and therefore nominated Dr Trathan to engage in the SCAR process identified above.

9.9 IAATO informed the Scientific Committee that it has a working group that provides guidelines about how tourists are managed at emperor penguin colonies. It therefore welcomed the initiative by SCAR and noted that it would also be happy to contribute to the development of an Action Plan, should the ATCM/CEP agree to designate the emperor penguin as an Antarctic Specially Protected Species.

9.10 ASOC introduced CCAMLR-38/BG/56 and highlighted the recent Intergovernmental Panel on Climate Change's (IPCC) Special Report on the Ocean and Cryosphere in a Changing Climate (SROCC) which contained important findings relevant to the work of SC-CAMLR, such as the fact that the Antarctic food web has already been affected by climate change, and that ocean acidification will be widespread throughout the Southern Ocean by 2090 under high greenhouse gas emission scenarios. Nevertheless, ASOC emphasised that CCAMLR can take steps to reduce these impacts and recommended that CCAMLR complete the planned system of MPAs, agree to a climate response plan, and commit to continued climate-related research so that the Scientific Committee can fully take climate change into account when developing scientific advice.

Cooperation with other organisations

10.1 The Convener of WG-EMM, Dr Cárdenas, noted two paragraphs from the WG-EMM-2019 report of relevance to CCAMLR's cooperation with other organisations. Paragraph 4.52 indicated the need for collaboration with organisations that could provide data relating to krill predators such as the IWC-SORP, the IWC-SC and the SCAR EG-BAMM. Paragraph 7.8 indicated the importance of the collaboration with Integrating Climate and Ecosystem Dynamics in the Southern Ocean (ICED) towards the development of a krill fisheries management strategy, and welcomed the continuing collaboration between ICED and SKAG, while minimising the duplication of work between the two groups.

10.2 The Convener of WG-FSA, Dr Welsford, noted paragraphs 8.15 and 8.19 of the WG-FSA-2019 report discussing scientific activities relating to toothfish and whales linking the Convention Area to areas within SIOFA.

10.3 Dr L. Newman (SCOR) provided an overview (SC-CAMLR-38/BG/27) of recent activities of SOOS, highlighting in particular the work of the Regional Working Groups to quantify observational requirements, the online data discovery tool (SOOS map) and the outcomes of a recent project funded by the Second Institute of Oceanography, China, as a joint product of the SOOS Observing System Design and Southern Ocean Fluxes working groups. Additionally, SCOR requested that the four recommendations made by the Scientific Committee last year (SC-CAMLR-XXXVII, paragraph 10.9), be considered for endorsement by the Commission this year, so that action can be progressed.

10.4 The Scientific Committee noted that many Members collect observations in research blocks, but that there is not a clear understanding of required data formats, or pathways for data submission to SOOS.

10.5 The Scientific Committee proposed that DSAG would collaborate with SOOS and SCAR data management committees to provide a concise document outlining best practice for data submission to appropriate repositories.

Cooperation within the Antarctic Treaty System

CEP

10.6 The CEP Observer to SC-CAMLR (Dr P. Penhale) informed the Scientific Committee that the 21st meeting of the CEP was held from 1 to 15 July 2019 in Prague, Czech Republic. Several topics of mutual interest to both the CEP and the Scientific Committee were presented in the CEP 2018 Annual Report to the Scientific Committee (SC-CAMLR-38/BG/07).

10.7 Under the joint topic of Climate Change, the CEP noted the importance of considering regional variations in climate change and emphasised the need for a better understanding of the impacts of combined pressures of human activities and climate. The CEP discussed progress made on the Climate Change Response Work Program and noted that future work will prioritise climate change related research topics within the overall CEP five-year work plan. The CEP also considered a UK paper which synthesised scientific information on how a 1.5°C global average temperature increase scenario could impact the Antarctic Peninsula and noted that it was important to remain informed about climate change research. It should be noted that a similar paper was submitted to CCAMLR (CCAMLR-38/01).

10.8 Under the topic of Biodiversity and Non-native Species, a Non-native Species Response Protocol was endorsed by the CEP; the Protocol is intended to help decision-making when a suspected non-native species is discovered within the Treaty area. The CEP welcomed an update of checklists for supply chain managers for reducing risk of transfer of non-native species by the Council of Managers of National Antarctic Programs (COMNAP) and SCAR.

10.9 The joint topic of Species Requiring Special Protection focused on the vulnerability of the emperor penguin to climate change. This topic was also brought to the attention of the Scientific Committee (SC-CAMLR-38/BG/10). It was suggested that species-related management options could be developed in order to reduce other anthropogenic stressors and thereby improve the resilience of emperor penguins.

10.10 Discussion on the topic of Ecosystem and Environmental Monitoring was guided by recommendations which arose from the Antarctic Tourism Workshop. The CEP agreed to invite SCAR, in consultation with other interested bodies and parties, to provide advice regarding a potential design for an environmental monitoring program to assess the impacts of tourism.

10.11 The CEP work on the joint topic of Spatial Management and Area Protection was conducted through informal intersessional discussions led by New Zealand held in response to Resolution 5 (2017) ‘to consider any appropriate actions within the Antarctic Treaty Consultative Meeting’s competence to contribute to the achievement of the specific objectives set forth in CCAMLR Conservation Measure 91-05’. The intersessional work focused on drafting a list of general complementary actions that could support connectivity between land and ocean and strengthen marine protection initiatives. The importance of not duplicating work of the CEP and the Scientific Committee was acknowledged. New Zealand will continue to lead discussions during the 2019/20 intersessional period. A Joint SCAR–CEP Workshop on Further Developing the Antarctic Protected Area System was held prior to the CEP.

SCAR

10.12 Dr M. Lea presented the SCAR Annual Report (SC-CAMLR-38/BG/16), highlighting activities that may be of interest to CCAMLR. These included the retrospective analysis of animal tracking data, the Southern Ocean diet database and an assessment of progress made against the questions raised by the 2014 SCAR Horizon Scan. SCAR further provided updates on key affiliated initiatives, including SKAG, and announced the forthcoming SCAR Open Science Conference (OSC) meeting in Hobart (31 July to 11 August 2020) which will include a CCAMLR-focused session on the role of fish in the Southern Ocean. SCAR welcomed CCAMLR attendees to the OSC.

10.13 The Scientific Committee thanked SCAR for this summary and indicated that it looked forward, in particular, to the predator tracking analysis given its importance for our understanding of krill population dynamics.

10.14 Dr C. Brooks presented SCAR’s update on the Antarctic Climate Change and the Environment Expert (ACCE) Group (SC-CAMLR-38/BG/17). Key updates included: the increasing evidence of human-driven contribution to changes in the Antarctic atmosphere and the Southern Ocean; the increasing loss of ice from the Antarctic ice sheet as well as decreases in sea-ice; and the demonstrated value of ice cores for understanding long-term changes. SCAR further provided updates on impacts related to the biological environment, highlighting potential impacts on seabirds, krill and lanternfish. SCAR also presented recent evidence from the IPCC SROCC which is in agreement with the information presented in the ACCE update. SCAR highlighted the panel’s finding that governance arrangements (e.g. MPAs) are often too fragmented to provide integrated responses to the increasing risks from climate-related changes and that the capacity of polar governance systems is not sufficient to adequately respond to, and address, the scale of increasing projected risks.

10.15 Dr Brooks informed the Scientific Committee that during the intersessional period, SCAR will be conducting a substantial decadal review of the original 2009 ACCE report, which it will bring to the Scientific Committee in 2020.

10.16 ASOC welcomed the timeliness of this report which stressed the need for CCAMLR to urgently adopt measures to protect the Antarctic ecosystem as it is being impacted by climate change.

Reports of observers from other international organisations

IAATO

10.17 The IAATO observer (Ms A. Lynnes) noted that IAATO does not promote private-sector travel to Antarctica; rather, it seeks to ensure that its practice is safe and environmentally responsible. As such, it is committed to supporting the work of the Antarctic Treaty System by exchanging information with other Antarctic stakeholders to promote the most responsible management of human activity possible.

10.18 CCAMLR-38/BG/37 presented an overview of Antarctic tourism for the past season. The paper outlined several factors contributing to the current period of tourism growth and the steps IAATO is taking to manage for that growth in order to mitigate any potential impacts on the Antarctic environment, working closely with Antarctic Treaty Parties and other stakeholders.

10.19 IAATO welcomed the work being done through CCAMLR and other Antarctic stakeholders to advance understanding of cetacean distribution, abundance and behaviour that will help IAATO plan its activities. IAATO noted its newly adopted mandatory rules for avoiding whales.

10.20 IAATO has implemented a mandatory observer scheme to assure itself and others that members comply with IAATO and Antarctic Treaty System policies and procedures. IAATO and its northern sister association, the Association of Arctic Expedition Cruise Operators, are working together to eliminate plastics from its operations, adding the CCAMLR marine debris form and ATCM Resolution 5 (2019) on reducing plastic pollution in Antarctica and the Southern Ocean to its Field Operations Manual, and creating new guidelines for visitors about reducing waste while travelling.

10.21 SCAR and IAATO continue to advance their Systematic Conservation Plan for the Antarctic Peninsula, currently forming a liaison group to provide advice, data and input. The CCAMLR D1MPA Expert Group e-group has been notified and Members invited to join.

ASOC

10.22 Dr R. Werner (ASOC) presented CCAMLR-38/BG/43, noting that CCAMLR has a clear role to play in responding to global threats to the ocean. ASOC submitted seven background papers relevant to the work of the Scientific Committee and discussed ASOC's key priorities and activities. These included MPAs, krill fisheries management, climate change, vessel safety, transhipment and toothfish fisheries. In particular, ASOC highlighted that the climate crisis is a matter of global urgency and deserves consideration in all relevant areas of CCAMLR's work. The designation of MPAs and the implementation of highly precautionary, ecosystem-based approaches to fisheries management are vital to ensuring the resilience of Antarctic marine ecosystems in a changing climate. ASOC noted that it is important for CCAMLR to ensure that climate science is considered in all decisions.

10.23 ASOC and its member groups have been involved in different scientific initiatives of relevance to the Scientific Committee. Representatives of ASOC and WWF participated actively in the discussions of the D1MPA Expert Group e-group. The Pew Charitable Trusts supported a range of scientific research projects related to the development of MPAs on penguins, crabeater seals, killer whales, krill, VMEs, climate change and modelling. Greenpeace released its 30 by 30 report, which articulates an ambitious vision for 30% of all the world's oceans, including the Southern Ocean, to be protected. The WWF has supported conservation science projects on krill, baleen whales, penguins and seals throughout the Antarctic, and has produced a new report highlighting the impacts of climate change within the Antarctic.

10.24 To support the work of the Scientific Committee in developing management measures for the krill fisheries, the Pew Charitable Trusts and WWF (in conjunction with ARK) supported a krill workshop in Concarneau, France, in June 2019. This workshop united stakeholders from industry, science, and non-governmental organisations (NGOs) to discuss possible approaches to the future management of the krill fishery. ASOC, in conjunction with several member organisations, hosted MPA science workshops in Seoul, Korea and Qingdao, China.

10.25 The Antarctic Wildlife Research Fund (AWR), to which ASOC is one of founding board members, selected four new projects to be supported in the upcoming year and just launched its 6th Call for Proposals. The projects cover issues which will fill information gaps identified by the Scientific Committee, including the connectivity among krill populations, re-evaluating the vertical distribution of krill, the trophic ecology of notothenid fish and the spatio–temporal and functional overlap of flying seabirds with krill hotspots.

10.26 ASOC urged the Scientific Committee to take action to improve the management of the krill fishery, including the endorsement and implementation of the work plan proposed by WG-EMM. ASOC recommended that the Scientific Committee support the designation of MPAs in East Antarctica, the Western Weddell Sea and the Antarctic Peninsula and encouraged research to underpin the development of new proposals for other planning domains.

ARK

10.27 Dr J. Arata (ARK) congratulated the scientific working groups of CCAMLR for their hard work in taking key steps for progressing the agenda on krill management. Dr Arata indicated that ARK's latest activities were outlined in SC-CAMLR-38/BG/09 and that all nine ARK vessels that participated in this fishing season complied with the VRZs around key penguin colonies during their breeding season. Furthermore, four ARK fishing vessels, plus a dedicated fishing vessel chartered by ARK, participated in the International 2019 Area 48 Survey for Krill. Dr Arata thanked the Institute of Marine Research from Norway for their dedicated labour on board the *Cabo de Hornos*, and all participants in SG-ASAM for their hard and dedicated work on reaching a new estimate of krill for Area 48, which remains at a similar level to that in the CCAMLR-2000 Survey, and with a moderate increase in biomass in Subarea 48.1. Dr Arata reported on the continuation of ARK's Annual Acoustic Transects in the Bransfield Strait.

COLTO

10.28 Mr R. Ball (COLTO) announced the winners of the 2018/19 CCAMLR toothfish tag return lottery. First place went to the Spanish-flagged vessel *Tronio*, second place went to the UK-flagged vessel *Nordic Prince* and third place went to the Japanese-flagged vessel *Shinsei Maru No. 3*. COLTO congratulated the winners and thanked all crews and scientific observers for their continued at-sea efforts.

SPRFMO

10.29 Mr C. Loveridge (SPRFMO) thanked CCAMLR Members for allowing SPRFMO to observe and the Secretariat/Chairs for facilitating an excellently run meeting. SPRFMO and its members are interested in continuing to progress the CCAMLR–SPRFMO Arrangement. Within the Arrangement, one of the main 'areas of cooperation' is the exchange of data and scientific information in support of the work and objectives of both organisations. At the recent meeting of the Scientific Committee of SPRFMO, approaches used by CCAMLR were referenced with regard to avoiding significant adverse impacts on VMEs, management/assessment of the two exploratory toothfish SPRFMO fisheries, and a new Toothfish Fishery Operation Plan which was assessed by the Scientific Committee and is expected to be put forward as a proposal to the SPRFMO Commission early next year.

Oceanites

10.30 Dr G. Humphries (Oceanites) presented the report from Oceanites (SC-CAMLR-38/BG/11), noting excellent progress over the past year in Oceanites' mission to champion science-based conservation and increased awareness of climate change and its potential impacts through the lens of penguins and Antarctica. Highlights included: Results from the 25th consecutive field season of the Antarctic Site Inventory, updates on the Mapping Application for Penguin Populations and Projected Dynamics (MAPPPD) penguin database, examination of MAPPPD by WG-EMM, assisting ARK with assessment of ARK's VRZ proposal via data available on MAPPPD, a reanalysis of gentoo penguin population trends with regard to tourism activity in the Antarctic Peninsula, assisted by visitation data supplied by IAATO, the State of Antarctic Penguins 2019 Report, updates on Oceanites' climate analyses, and, recent, notable scientific papers.

10.31 Oceanites informed Members that it looks forward to continuing to assist the Scientific Committee and its working groups with scientific data and analyses that further the work of CCAMLR in achieving its ecosystem-based conservation objectives.

Reports of representatives at meetings of other international organisations

10.32 Dr T. Okuda (Japan) was the CCAMLR observer to the Fourth Meeting of the Scientific Committee of SIOFA, held at the National Institute of Fisheries Science, Yokohama, Japan, from 25 to 29 March 2019 (SC-CAMLR-38/BG/12). The main areas of interest to CCAMLR were the discussions of VMEs, Patagonian toothfish catches and incidental mortality of seabirds. SIOFA agreed that an increased level of interaction with CCAMLR was timely and looked forward to future collaboration.

10.33 The Scientific Committee noted that the Scientific Committee of SIOFA had recommended that:

(i) SIOFA adopt a VME indicator taxa list adapted from the *CCAMLR VME Taxa Classification Guide* (CCAMLR, 2009) for use in the SIOFA area

(ii) SIOFA urgently considers adopting temporary measures to regulate toothfish fishing on the Del Cano Rise and Williams Ridge

(iii) SIOFA consider by-catch mitigation measures for areas of high risk as identified by other organisations whose areas of competence are adjacent to, or overlap with, that of SIOFA.

10.34 The Scientific Committee noted the discussion on observer data collected onboard Spanish longline vessels fishing for toothfish in the SIOFA area adjacent to the Convention Area (WG-FSA-2019 report, paragraphs 8.15 to 8.17). It welcomed the voluntary presentation of such information to CCAMLR to enable it to be considered in existing CCAMLR stock assessments while a data-sharing scheme between SIOFA and CCAMLR is being negotiated. The Scientific Committee also noted that photo identification research had identified multiple instances of the same killer and sperm whales depredating toothfish from longlines in the Del Cano Rise area and Kerguelen and Crozet fisheries. The Scientific Committee noted the importance of depredation rates in estimates of removals and management of toothfish fisheries.

Future cooperation

10.35 CCAMLR-38/19 presented a decision for adoption by the Commission, that the Secretariat will liaise with the Secretariats of regional fisheries management organisations (RFMOs) whose areas of competence are adjacent to the CAMLR Convention Area in order to promote the creation of a Southern Ocean Cooperation Platform (SOCP). The purpose of the SOCP is to provide a platform for enhanced coordination and collaboration on matters of common interest concerning species that occur both within the CAMLR Convention Area and within adjacent areas, in particular, issues related to the long-term conservation and management of those species and their ecosystems. The Scientific Committee noted the presentation but considered this a matter for the Commission.

10.36 Ms C. Christian (ASOC) presented CCAMLR-38/BG/45 which noted that despite the agreement which was in process of agreement between CCAMLR and SIOFA, fishing took place in SIOFA waters on straddling toothfish stocks between the two organisations. ASOC was concerned that this fishing was not in the spirt of the Arrangement. ASOC's recommendation included the holding of a joint CCAMLR–SIOFA technical workshop, the enactment of conservation measures be similar to those of CCAMLR for the toothfish fishery and that SIOFA adopt the CCAMLR process for setting toothfish catch limits as the basis for the catch limit of these straddling toothfish stocks in the SIOFA area.

Budget for 2019/20 and Advice to SCAF

11.1 The Scientific Committee recalled that the provision of technical and logistical support for meetings of the Scientific Committee and its working groups is part of the central role of the Secretariat and, as such, is funded from the Commission's General Fund (SC-CAMLR-XXX, paragraph 12.1).

11.2 The Chair introduced SC-CAMLR-38/08 that outlined a proposal to support financial support to the General Science Capacity Fund (GSCF) in order to maintain the success of existing capacity building initiatives for the Scientific Committee, including proposed terms of reference for the use of the GSCF (Annex 12) and a request for a transfer of A$400 000 from the current surplus of the General Fund to the GSCF.

11.3 The Scientific Committee welcomed this proposal and agreed that creating a sustainable mechanism for capacity building in the Scientific Committee should be supported and recommended that the proposal be considered by the Standing Committee on Administration and Finance (SCAF). The Scientific Committee also agreed that the request for a one-off transfer of funds from the General Fund to the GSCF should be viewed as part of a long-term strategy for the maintenance of the GSCF.

11.4 Dr Cárdenas welcomed the continued support for the funding of conveners to working groups and thanked the Commission for the support to the Convener of WG-EMM this year which had supported increased engagement in the work of WG-EMM and the Scientific Committee.

11.5 The Scientific Committee agreed that priorities for support from the GSCF would be for continued support to the CCAMLR Scientific Scholarship Scheme, extending the pilot project to fund working group conveners and to the Special Activities aimed to develop capacity in research and analytical skills between Members as agreed by the Scientific Committee according to the terms of reference of the GSCF.

11.6 The Scientific Committee recommended that applications for funding associated with Special Activities should have a focus on the inclusion of early-career scientists and collaboration between Members and should clearly indicate the relationship to the nominated Special Activities and delivery of defined outcomes. The Scientific Committee suggested that Special Activities could be facilitated by workshops, secondments and inter-laboratory exchanges and any funding of salaries would only be in relation to such activities and would be for a period of less than six months.

11.7 The Scientific Committee noted that activities supported by the GSCF should be encouraged to include contributions to increasing awareness of the work of the Scientific Committee and developing approaches that develop the effectiveness of the transfer of advice from the Scientific Committee to the Commission.

11.8 The Scientific Committee welcomed the decision by SCAF to recommend the immediate transfer of A$200 000 from the General Fund to the GSCF to support the activities outlined in SC-CAMLR-38/08 and noted the recommendation from SCAF that a further A$200 000 be transferred following further development and agreement of the terms of reference of the GSCF to ensure compatibility with ongoing discussion on the General Capacity Building Fund.

Advice to SCIC

12.1 On behalf of the Scientific Committee, the Chair transmitted the Scientific Committee's advice to SCIC on the use of net monitoring cables in trawl fisheries and the process for quarantining data where there were discrepancies between the landings and catch in the CDS and C2 data.

Scientific Committee activities

Priorities for the work of the Scientific Committee

13.1 The Scientific Committee warmly welcomed the offer from China, Japan, India, New Zealand and Australia to host intersessional workshops and meetings in 2020 and agreed to the following:

(i) Krill fishery observer workshop (Shanghai, China, April/May 2020) (Co-conveners: Drs Zhu and Kawaguchi)

(ii) WG-ASAM (Tokyo, Japan, 1 to 5 June 2020) (Co-conveners: Drs Fielding and Wang)

(iii) WG-SAM (Kochi, India, 29 June to 3 July 2020) (Co-conveners: Drs Péron and Okuda)

(iv) WG-EMM (Kochi, India, 6 July to 17 July 2020) (Convener: Dr Cárdenas)

(v) Toothfish tagging Workshop (Nelson, New Zealand, July/August 2020) (Co-conveners: Dr Parker and Mr Arangio (COLTO)).

(vi) Krill Ageing Inter-laboratory Calibration Workshop (Hobart, Australia, July/August 2020 (Convener: Dr Kawaguchi)

(vii) WG-FSA (CCAMLR Headquarters, Hobart, Australia, 12 to 23 October 2020) (Convener: Mr Somhlaba).

13.2 The Scientific Committee warmly welcomed Mr Somhlaba as Convener of WG-FSA, Dr Okuda as Co-convener of WG-SAM and Drs Fielding and Wang as Co-conveners of WG-ASAM.

13.3 The Scientific Committee requested that funds be included in budgets and plans for workshops to facilitate virtual engagement to allow the opportunity for remote attendance by those that cannot attend in person.

13.4 The Scientific Committee agreed that the priority items for the consideration of the working groups in 2020 should be as follows:

(i) WG-ASAM –

(a) subarea-scale krill biomass estimates based on repeated regional surveys

(b) survey design and CV estimation

(c) processing of acoustic data collected on nominated transects by krill fishing vessels.

(ii) WG-SAM –

(a) management strategy evaluations: refinement of harvest control rule, including F-based rules

(b) methods for calibration between vessels for tagging survival and tag detection

(c) review of re-estimation method of catch when there are inconsistencies between C2 and CDS

(d) review open-source GYM implementation for krill assessment model

(e) development of coding for toolbox for research plan review

(f) toothfish conversion factors.

(iii) WG-EMM –

(a) krill fishery management procedure (focus topic) (week 1)

(b) risk assessment procedure, data collection and implementation

(c) CEMP and other monitoring as part of risk assessment

(d) advice on review of CM 51-07

(e) one-day symposium on Indian Antarctic and marine research

(f) spatial management, including RMPs.

(iv) WG-FSA –

(a) non-target catch assessments, including the development of standardised reporting metrics and risk assessment methods, including for fish and invertebrates (VMEs)

(b) research/exploratory fishery review and advice

(c) catch limit advice

(d) krill risk assessment and management approach.

13.5 The Scientific Committee agreed that the consideration of krill-related items at WG-SAM should be taken in the later part of week to promote interaction between WG-SAM and WG-EMM on krill assessment models.

13.6 The Scientific Committee agreed that the relevant conveners would develop the individual agendas for each of the working groups and workshop.

13.7 The CCAMLR Science Manager proposed to prepare a special issue of the *CCAMLR Science* journal on management of the krill fishery. This issue could gather the extensive work conducted on krill research in the last two years and the next year during WG-ASAM and WG-EMM.

13.8 The Scientific Committee supported this excellent idea underlining that it was a good way of communicating and highlighting the research conducted within CCAMLR working groups.

13.9 The Scientific Committee suggested this special issue to be opened for submission of other documents that were not necessarily submitted to CCAMLR working groups in the recent years, despite being relevant on this topic.

13.10 It further suggested submission of documents providing historical context and background on the CCAMLR approach of krill fishery management. These documents could summarise key research conducted in the past within the CCAMLR framework on krill management.

13.11 The Scientific Committee agreed that the CCAMLR Scientific Scholarships Scheme continued to be a very successful mechanism for developing capacity in CCAMLR, both in the working groups and in the Scientific Committee.

CCAMLR Scientific Scholarship Scheme

13.12 Dr Santos announced that the CCAMLR Scientific Scholarships review panel had assessed the applications submitted to the Scientific Scholarship Scheme and that SCAF agreed on the funding of three scholarships. She announced the laureates of the 2020 scholarships:

(i) Dr Emilce Rombolá, from Instituto Antártico Argentino, who works on early euphausiid larvae in the West Antarctic Peninsula and the contribution of this region to the recruitment in the Antarctic Circumpolar Current and the Weddell Scotia Confluence. She will visit her mentor Dr B. Meyer at the Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research (AWI), Germany, and attend WG-EMM and the Scientific Committee meeting to present her results.

(ii) Dr Jilda Caccavo, from the AWI, Germany, who works on *D. mawsoni* population connectivity in the Weddell Sea with respect to their circumpolar distribution using a multidisciplinary approach combining population genetics and otolith chemistry. She will visit her mentor Dr C. Jones at the NOAA Antarctic Ecosystem Research Division, USA, and attend WG-SAM and WG-FSA to present her results.

(iii) Dr Xiaotao Yu, from the Yellow Sea Fisheries Research Institute (YSFRI), China, who works on the development of acoustic methods to estimate krill biomass (comparison of FEM-BEM and SDWBA models). He will be mentored by Dr X. Zhao (YSFRI) and attend WG-ASAM and WG-EMM to present his results.

13.13 Dr Santos informed the Scientific Committee that the budget for each applicant may be revised according to the global funding scheme and specific tasks described in those applications.

13.14 The Scientific Committee noted the progress report (SC-CAMLR-38/BG/23) by the recipient of the 2019 CCAMLR scholarship, Mr Illia Slypko (Ukraine). He visited his mentor, Dr Welsford, at the Australian Antarctic Division from 30 September to 4 October 2019. In addition, he worked on otoliths preparation and reading for Macrourid species collected in Subareas 48.1 and 48.2 and data analyses of by-catch and toothfish data collected during Ukrainian research plans.

13.15 Ukraine expressed its gratitude to the Commission for provided scholarship support, as well as to Australia and New Zealand for their great contribution to the mentorship of Illia Slypko’s research activities.

CEMP Fund

13.16 The Scientific Committee noted that the CEMP Camera network has been a successful method of expanding both the temporal and spatial scope of CEMP and the capacity of several

Members to initiate and continue to engage in CEMP (WG-EMM-2019 report, paragraphs 5.18 and 5.19). Its establishment costs have been supported by the CEMP Fund and the Scientific Committee recognised that now it is established, the network is relatively inexpensive to maintain, with maintenance requiring new batteries and other hardware replacement, costs would not be likely to exceed $A15 000 annually.

13.17 The CEMP Special Fund Management Group recommended that the Secretariat create a CEMP camera network maintenance account linked to the CEMP Fund that would allow an annual expenditure of $A15 000 from the Members engaged in the CEMP camera network. The Secretariat was requested to work with those Members to develop a request form for expenditure and report annually on the expenditure from the account.

13.18 The Scientific Committee welcomed this approach to the ongoing support to the CEMP camera network and also suggested that an overview paper on the CEMP camera network could make a valuable contribution to the proposed special issue of *CCAMLR Science* (see paragraph 13.7).

13.19 The CEMP Fund Review Panel received one proposal for funding following the call for proposals issued as SC CIRC 19/72. This multi-Member proposal is directed at developing an at-sea marine mammal and seabird monitoring program in the western Antarctic Peninsula region in collaboration with IAATO. The CEMP Fund Review Panel noted that the aims of the project were consistent with the aims of the CEMP Fund and agreed that the request for funding of $A57 600 be approved from the CEMP Fund, noting that there was in-kind support from IAATO vessel operators and institutes of $A192 000.

13.20 Dr Lowther, on behalf of the proponents of the proposal that had been accepted for CEMP Fund support, thanked the Scientific Committee and noted that this project would contribute directly to the development of data layers to the krill risk assessment process and also reflected the advice from WG-EMM and the Scientific Committee on increased importance of baleen whales as krill consumers in the work of CCAMLR.

13.21 IAATO also welcomed the funding of this proposal and was delighted to be a stakeholder in this important area of work and looked forward to further discussions with IAATO members to provide ongoing support to this marine mammal monitoring program.

13.22 Dr Santos indicated that as she was now stepping down as the Chair of the CEMP Fund Review Panel and that Dr Zhu would take on the role of Chair and Dr Schaafsma would join the panel.

13.23 On behalf of the Scientific Committee, Dr Zhu thanked Dr Santos for her excellent work supporting the CEMP Fund and increasing engagement in the work of CEMP and encouraged all Members to engage in CEMP activities.

Data Services Advisory Group (DSAG) activities

13.24 Dr A. Van de Putte (Belgium) as Co-convener for DSAG presented a verbal report about the activities and progress of DSAG. The full report can be found on the DSAG e-group. Those activities included:

(i) The creation of a DSAG e-group, which included about 40 members, has been set up by the Secretariat; the organisation of an intersessional webinar by the Secretariat proved to be an effective mechanism for engagement of Members. DSAG recommended considering using this type of approach for future meetings of DSAG at a regular interval.

(ii) The review of the needs for the CCAMLR data warehouse from an end-user perspective.

(iii) The launch of initial versions of both the Data Warehouse documentation portal (available at https://docs.ccamlr.org) and the data Warehouse (available at https://data.ccamlr.org) were set up by the Secretariat. DSAG agreed that the documentation on the Data Warehouse website can be made available publicly to allow for transparency around CCAMLR data management processes, except for confidential commercial information.

(iv) The data management workshop for the development of the warehouse during the COLTO meeting.

13.25 Given Mr Dunn will step down as Co-convener, DSAG invited all Members to consider proposing candidates to co-convene DSAG. The contribution from Mr Dunn on advancing the DSAG activities was acknowledged. As no new candidate for co-convener has come forward, an invitation will be circulated intersessionally.

13.26 The CCAMLR Science Manager informed the Scientific Committee that two new members of staff had recently joined Secretariat, in the Science and the Fishery Monitoring and Compliance sections, and these staff are part of the Secretariat's Data Centre that will work to broaden the engagement with data managers, data providers and analysts. The Scientific Committee welcomed the investment in staff associated with data management in the Secretariat and looked forward to receiving future updates.

13.27 The Scientific Committee noted that Mr Tim Jones will leave his post of Data and Information Systems (DIS) Manager in November 2019 and expressed its gratitude to him for his very hard and valuable work on data management and meeting server facilities that had contributed greatly to the work of the Scientific Committee.

13.28 The Scientific Committee noted that the Secretariat's work with DSAG has been very positive and recommended that this liaison between DSAG and the Secretariat continue, including through the DIS Manager's role.

Second Performance Review

13.29 The Scientific Committee noted CCAMLR-38/11 and the Chair recognised that the content of that paper indicated consideration of the recommendations of the second Performance Review (PR2) had not progressed as planned. However, this was a result of competing priorities, many of which did explicitly address issues consistent with the recommendations of the PR2 report.

Invitation of experts and observers to meetings of working groups

13.30 The Scientific Committee agreed that all Observers invited to the 2019 meeting would be invited to participate in SC-CAMLR-39.

Next meeting

13.31 The next meeting of the Scientific Committee will be held at the CCAMLR Headquarters building (181 Macquarie Street) in Hobart, Australia, from 26 to 30 October 2020.

Secretariat supported activities

14.1 The Scientific Committee noted the following tasks that had been requested to be undertaken by the Secretariat for the 2019/20 intersessional period, as requested by WG-SAM-2019, WG-EMM-2019, SG-ASAM-2019 and WG-FSA-2019, in addition to the routine support provided to Members.

(i) Tag linking algorithm –

(a) routinely implement the new algorithm, and provide a report back to WG-SAM-2020 on links between the currently implemented approach and the new approach to assist data users in comparisons (WG-SAM-2019 report, paragraph 4.3)

(b) provide an annual report to WG-FSA on the linking process, including identification of linking issues (WG-SAM-2019 report, paragraph 4.4)

(c) update data extracts for Members requesting tag and recapture data to include metadata identifying any known data quality issues (WG-SAM-2019 report, paragraph 4.4)

(d) investigate whether historical New Zealand tagging data can be included using the revised tag-linking process (WG-SAM-2019 report, paragraph 4.4).

(ii) Toothfish catch reporting –

(a) work with Ukraine to provide further information on the potential underestimation of catches by the *Calipso*, *Koreiz* and *Simeiz* from 2015 to 2018 (WG-SAM-2019 report, paragraphs 4.6 and 4.7)

(b) quarantine data from the *Calipso*, *Koreiz* and *Simeiz* from 2015 to 2018 (WG-FSA-2019 report, paragraph 2.15)

(c) extend data reconciliation analyses between CDS and fine-scale catch and effort data to earlier seasons (before 2018 and 2019), and correspond with Members regarding any discrepancies (WG-FSA-2019 report, paragraphs 2.7 to 2.9)

(d) develop a survey for Members to complete on calculations and applications of toothfish conversion factors provided in C forms, including how the value is estimated and provided (WG-FSA-2019 report, paragraph 4.8).

(iii) Fishery Reports –

(a) continue development of the Fishery Report prototype for all fisheries, following the same publication process as in previous years (WG-SAM-2019 report, paragraphs 4.12 and 4.13; WG-FSA-2019 report, paragraph 2.32)

(b) include relevant combined standardised indices (CSIs) in the annual Krill Fishery Report for Area 48 (WG-EMM-2019 report, paragraph 5.3).

(iv) Data infrastructure development –

(a) engage with WoRMS and the FAO Aquatic Sciences and Fisheries Information System (ASFIS) to obtain three alpha codes and AphiaIDs for Antarctic taxa which are needed by CCAMLR and are missing from WoRMS and ASFIS, and provide updates on taxonomic code corrections to relevant working groups (WG-FSA-2019 report, paragraph 2.19)

(b) incorporate 2019 bathymetry data released by GEBCO into the CCAMLR GIS, and make available for downloading by Members (WG-FSA-2019 report, paragraph 8.20)

- provide an analysis of any changes in the estimates of fishable areas used in the estimates of local biomass in exploratory fisheries (WG-FSA-2019 report, paragraph 8.20)

(c) development of an otolith digital repository on the CCAMLR website and consider development of a centralised database of ages (WG-FSA-2019 report, paragraph 4.85).

(v) C2 and SISO form development –

(a) provide any proposed changes and links to the catch and effort C2 forms and observer forms to WG-FSA (WG-FSA-2019 report, paragraph 2.11)

(b) development of an appropriate field on the C2 form for reporting number of droplines per line when using trotline gear (WG-SAM-2019 report, paragraph 6.9)

(c) continue development of the proposed C2 form and fishery data manual using the endorsed recommendations by the WG-FSA on the C2 form content and instructions (WG-FSA-2019 report, paragraph 2.22).

(vi) Fishery forecasting –

(a) provide a summary of the operation of the fishery forecasting algorithm to WG-FSA-2020, and review the algorithm for closures after implementation in the 2019/20 season to consider alternative scenarios (WG-FSA-2019 report, paragraphs 2.29 and 2.30).

(vii) Krill fishery management –

(a) generate risk profiles of overrunning catch allocations across a range of vessel capacity (or catch) and fleet sizes (WG-EMM-2019 report, paragraph 2.36)

(b) update metadata provided to Members with extracts including C1 data from continuous trawlers (WG-EMM-2018 report, paragraph 2.49)

(c) liaise with ARK to provide instructions for using a cloud-based electronic transfer method for submitting acoustic data collected by fishing vessels, and to explore a communications strategy between vessels to coordinate undertaking of nominated transects (SG-ASAM-2019 report, paragraphs 3.3 and 3.4)

(d) facilitate the submission and hosting of raw acoustic data and metadata, as well as all data that had been collected by krill fishing vessels along nominated transects (SG-ASAM-2019 report, paragraphs 3.5 and 3.6)

- review Echoexplore as a potential tool to manage acoustic data files and to add data layers on data location to add to the CCAMLR GIS (SG-ASAM-2019 report, paragraph 3.7).

(viii) Research and monitoring –

(a) work with Members and proponents of MPAs to provide links to relevant data layers and to begin entering project data in the CMIR (WG-EMM-2019 report, paragraph 6.12)

(b) update the CEMP CSI analysis to look at individual parameters by sites in addition to multivariate analysis to explore emerging temporal trends (WG-EMM-2019 report, paragraph 5.3).

(ix) Environmental impacts –

(a) review the current requirements for gear marking by CCAMLR vessels against the FAO Voluntary Guidelines on the Marking of Fishing Gear (WG-FSA-2019 report, paragraph 2.3)

(b) provide an annual report on gear loss, considering spatial trends and capacity, to WG-FSA-2020 (WG-FSA-2019 report, paragraph 6.47)

(c) undertake analysis of VME data collection practice on board vessels, and provide info on spatial and temporal trends on VME triggers to WG-FSA-2020 (WG-FSA-2019 report, paragraph 6.30).

Election of Chair and Vice-Chair

15.1 Dr Mark Belchier's second term as Chair ended with this meeting and the Scientific Committee sought nominations for a new Chair. Dr Welsford was unanimously elected to the position of Chair of the Scientific Committee for a term of two regular meetings (2020 and 2021). The Scientific Committee warmly welcomed Dr Welsford as the new Chair. He thanked the Scientific Committee for the overwhelming honour and recognised the challenge of the very large shoes that the previous chairs had left for him to fill.

15.2 Dr Santos's term as Vice-Chair ended with this meeting and the Scientific Committee sought nominations for a new Junior Vice-Chair. Dr Makhado was unanimously elected to the position for a term of two regular meetings (2020 and 2021). A very warm welcome was extended to the incoming Junior Vice-Chair who thanked the Scientific Committee for the confidence that it had placed in him and looked forward to the exciting opportunity.

15.3 The Scientific Committee thanked Dr Santos for her enthusiasm and engagement as Vice-Chair and looked forward to her continued contribution to the work of CCAMLR.

Other business

16.1 Mr Dunn requested that CCAMLR consider the scheduling of the 2020 meetings of WG-FSA, the Scientific Committee and the Commission in a way that would allow interested participants to also attend the World Fisheries Congress 2020, taking place from 11 to 15 October 2020 in Adelaide, Australia.

16.2 The Scientific Committee considered SC-CAMLR-38/BG/08 which provided feedback and first results on the CCAMLR-related work carried out in the wider Weddell Sea area by two marine scientific research expeditions of the German-flagged vessel *Polarstern* in the 2018/19 season. It was noted that the trial deployment of vertical longlines from the *Polarstern* showed that such vertical longlines can easily be deployed from research vessels. These longlines did not catch toothfish, therefore, Germany advised that it will be seeking advice from the toothfish industry regarding improvements of gear design for future deployments.

Close of the meeting

17.1 At the close of the meeting, Dr Belchier thanked all participants for their endurance and patience throughout the week. While recognising that there are some challenging items on the agenda of the Scientific Committee, he noted the tremendous progress that has been made by CCAMLR in recent years. He was pleased that the election of Dr Welsford as the incoming Chair meant that the Scientific Committee was in the safe hands of someone with a wealth of experience in CCAMLR. He thanked the Secretariat for its continuous provision of support throughout his time as Chair.

17.2 On behalf of the Scientific Committee, Drs Watters thanked Dr Belchier for his outstanding service to the Scientific Committee. Dr Watters noted that Dr Belchier was firmly established in the higher echelons of the CCAMLR community and was both liked and respected by all of participants of the Scientific Committee and its working groups.

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Table 1: Actions to combine risk assessment and biomass estimates to evaluate and revise the krill harvest strategy in Area 48. GYM – generalised yield model; AUS – Australia; CHL – Chile; CHN – China; KOR – Republic of Korea; NOR – Norway; UK – United Kingdom; USA – United States of America; UKR – Ukraine; ARK – Association of Responsible Krill harvesting companies.

Action	Inputs	Priority	Coordinating Members/groups
Recompile GYM model in open-source code	Current GYM functions	WG-SAM-2020 WG-EMM-2020	AUS, Secretariat
Collate best estimates of growth, recruitment and natural mortality, and variability at subarea scales	Existing studies of parameter estimates e.g. Atkinson et al., 2006, Constable and Kawaguchi, 2017, Kinzey et al., 2013, 2015, 2019, AMLR time series, catch and length from research and fishery hauls, productivity and source-sink relationships between subareas		AUS, CHN, NOR, UK, USA
Evaluate alternative implementation of decision rules, e.g. short-term projections with regular biomass updates	GYM or other assessment model with updated parameters		UK, USA
Update estimate(s) of gamma (γ, biomass exploitation rate) for krill in Subareas 48.1–48.4	GYM or other assessment model with updated parameters		AUS, NOR, UK, USA
Estimate of area and subarea catch limits	Subarea and area biomass estimates, subarea and area gamma estimates	WG-SAM-2021 WG-EMM-2021	NOR, UK, USA
Estimate risk associated with catch distribution scenarios	Estimate of area and subarea distribution of catches, risk assessment populated with key predator layers		AUS, UK
Canvass expectations of the fishing industry of size and variation in fishery yields	Discussions with industry stakeholders		ARK, CHN, CHL, KOR, NOR, UKR
Evaluate current fishery reporting and closure mechanisms under future harvest scenarios	Catch limit and fleet size scenarios		Secretariat

Table 2: Priority elements and timeline to progress the estimation of krill biomass for use in a stock assessment.

Action	2020	2021	2022+
Updated time series biomass estimate of krill			
Large-scale survey krill density (e.g. Area 48)	Refine biomass estimates as necessary, taking into account recommendations from SC-CAMLR-38.		Identify recommended frequency of large-scale survey Evaluate how these surveys can be made more robust.
Subarea survey krill density (e.g. Subareas 48.1, 48.2, 48.3)	New data contribution (WG-ASAM-2020).	New data contribution (WG-ASAM-2021).	New data contribution (WG-ASAM)
Transect-scale krill density by fishing vessels (data from one or more CCAMLR-nominated transect collected within a fishing season)	New data contribution (WG-ASAM-2020). Method development for inclusion in subarea stock assessment	New data contribution (WG-ASAM-2021). Analysis for subarea stock assessment	New data contribution (WG-ASAM). Implementation in subarea stock assessment
Fishing-area scale data	New data contribution (WG-ASAM-2020; WG-SAM-2020; WG-EMM-2020)	New data contribution (WG-ASAM-2021) Evaluation of the biomass estimation method and the first subarea biomass estimate (WG-ASAM-2021; WG-SAM-2021; WG-EMM-2021)	New data contribution (WG-ASAM) Method recommendation
Coherent biomass estimates (primarily based on large-scale and subarea survey scale time series biomass)	Method development and analysis for biomass estimation or a dedicated workshop on subarea biomass estimation method (WG-ASAM-2020; WG-SAM-2020; WG-EMM-2020)		

Table 3: Priority data layers (potential data providers are identified in parentheses) and time line to progress a risk assessment in Area 48. ARG – Argentina; AUS – Australia; BRA – Brazil; CHL – Chile; CHN – China; ESP – Spain; FRA – France; GER – Germany; JPN – Japan; KOR – Republic of Korea; NOR – Norway; POL – Poland; UKR – Ukraine; UK – United Kingdom; USA – United States of America; URY – Uruguay; IWC-SORP – International Whaling Commission - Southern Ocean Research Program; MEOP – Marine Mammals Exploring the Oceans Pole to Pole; RATTD – Retrospective Analysis of Antarctic Tracking Data; WG-ASAM – Working Group on Acoustic Survey and Analysis Methods; SKAG – SCAR Krill Action Group. Priority data layers for determination in 2020 are indicated; other data layers may be feasible.

Action	Comments	Priority
Risk assessment data layers		
Chinstrap penguins		
Incubation (UK, NOR, CHL, USA)	Tracking data	
Brood (UK, USA, KOR, JPN, CHL, NOR, ESP)	Tracking data	
Crèche (UK, USA, JPN, CHL, NOR)	Tracking data	
Fledging (USA, POL, ARG)	Tracking data	WG-SAM-2020; WG-EMM-2020
Winter (UK, USA, ARG, POL)	Tracking data	WG-SAM-2020; WG-EMM-2020
Adélie penguins		
Incubation (UK, USA, JPN, NOR, ESP)	Tracking data	
Brood (UK, USA, JPN, ESP, URY, NOR)	Tracking data	
Crèche (UK, USA, JPN, ARG, NOR)	Tracking data	
Non-breeders (NOR, ARG, POL)		
Fledging (USA, ARG)	Tracking data	WG-SAM-2020; WG-EMM-2020
Winter (USA, UK, ARG)	Tracking data	WG-SAM-2020; WG-EMM-2020
Gentoo penguins		
Incubation (NOR, CHL, UKR)	Tracking data	
Brood (UK, USA, KOR, JPN, NOR, UKR)	Tracking data	
Crèche (UK, USA, JPN, NOR, UKR)	Tracking data	
Fledging (USA, ARG, UKR)	Tracking data	WG-SAM-2020; WG-EMM-2020
Winter (USA, UK, ARG, POL)	Tracking data	WG-SAM-2020; WG-EMM-2020
Macaroni penguins		
Incubation (UK, JPN)	Tracking data	
Brood (UK, JPN)	Tracking data	
Crèche (UK, JPN)	Tracking data	
Fledging (UK)		
Winter (UK)	Tracking data	WG-SAM-2020; WG-EMM-2020
Pack-ice seals (UK, USA, ARG, AUS)	Tracking data, at-sea data	
Elephant seals (UK, USA, ARG, GER, AUS, FRA, MEOP, RAATD)	Tracking data	

Table 3 (continued)

Action	Comments	Priority
Antarctic fur seals		
Female (UK, USA, NOR, ESP)	Tracking data, at-sea data	
Male (UK, USA, NOR)	Tracking data, at-sea data	WG-SAM-2020; WG-EMM-2020
Humpback whales* (BRA, USA, NOR, UK, ARG, GER, AUS, IWC-SORP)	At-sea, tracking, catch history	WG-SAM-2020; WG-EMM-2020
Fin whales* (IWC-SORP, GER, AUS, ARG)	At-sea, tracking, catch history	WG-SAM-2020; WG-EMM-2020
Blue whales* (IWC)	Catch history	
Minke whale* (USA, ARG)	Tracking data, at-sea data	
Flying seabirds (USA, NOR, UK)	Tracking data, at-sea data	
Fishing fleet dynamics (Secretariat, NOR, UK, CHN, AUS, ARK, CHL)	VMS, catch data, fishing masters, environmental data	WG-SAM-2020; WG-EMM-2020
Fish (USA, ARG, GER, UKR, UK, 2019 Area 48 Survey)	Survey data, catch data, observer data	WG-SAM-2020; WG-EMM-2020; WG-FSA-2020
Euphausia species by-catch	Survey data, catch data	WG-SAM-2020; WG-EMM-2020
Fish by-catch (Secretariat, 2019 Area 48 Survey)	Survey data, catch data	WG-FSA-2020
E. superba stock		WG-ASAM-2020; WG-SAM-2020; WG-EMM-2020
E. superba spawning areas	Survey data, observer data, KRILLBASE	SKAG-2020; WG-SAM-2020; WG-EMM-2020
E. superba nursery areas	Survey data, observer data, KRILLBASE	SKAG-2020; WG-SAM-2020; WG-EMM-2020

Table 4: Tools and mechanisms required to advance the risk assessment for subdivision of the krill fishery catch in Area 48. UK – United Kingdom; TBA – to be announced; SKAG – SCAR Krill Action Group.

Action	Primary tools	Priority
Risk assessment (UK)	Compare R code implementation for the Risk Assessment	WG-EMM-2020
Fishery dynamics	Behavioural models	WG-EMM-2020
Penguins, pack-ice seals, fur seals	Compare R code for implementing models each data layer; develop standard methods, including considerations of scale and associated limitations; data quality control	WG-EMM-2020
Cetacean data layers	Consideration of appropriate cetacean layers; develop standard methods, including considerations of scale and associated limitations; data quality control	WG-EMM-2020
Fish layers	Determine relevant species	WG-FSA-2020
Krill spawning and nursery layers	TBA	SKAG-2020

Table 5: Catch limit (in tonnes) advice from the Scientific Committee for 2019/20 (the catch limits for Antarctic krill are included for completeness but were not considered during the Scientific Committee meeting). Members notifying are shown for those fisheries for which a notification is required. CM – conservation measure; A, B, C – management areas in Subarea 48.3; N – north; S – south; E – east; W – west; SSRU – small-scale research unit; N70 – north of 70°S; S70 – south of 70°S; SRZ – special research zone. [a] By-catch limits are specified in the conservation measure containing catch limit and in Conservation Measures (CMs) 33-01 (Subarea 48.3) and 33-02 (Division 58.5.2). [b] Due to the lack of consensus in the Scientific Committee, this is subject to the Commission's decision as to whether this exploratory fishery should proceed in the 2019/20 season. [c] Due to the lack of consensus in the Scientific Committee, this is subject to the Commission's decision as to whether this research should proceed in the 2019/20 season. [d] Due to the lack of consensus in the Scientific Committee, this is subject to the Commission's decision on the catch split (Table 6). [e] If approved this catch would be taken from the SRZ catch

Subarea/ division	SSRU	Area	Species	Catch limit 2018/19	Catch limit 2019/20	Notified Members	Conservation measure containing catch limit	Skates and rays by-catch catch limits (tonnes)	*Macrourus* spp. by-catch catch limits (tonnes)	Other species by-catch catch limits (tonnes)
48.3		Total	*D. eleginoides*	2 600	2 327		CM 41-02	[a]	[a]	[a]
		A (0%)		0	0		CM 41-02	[a]	[a]	[a]
		B (30%)		780	698		CM 41-02	[a]	[a]	[a]
		C (70%)		1 820	1 629		CM 41-02	[a]	[a]	[a]
48.3			*C. gunnari*	3 269	3 225		CM 42-01	[a]	[a]	[a]
48.4			*D. eleginoides*	26	27		CM 41-03	[a]	[a]	[a]
48.4			*D. mawsoni*	37	45		CM 41-03	[a]	[a]	[a]
58.5.2			*D. eleginoides*	3 525	3 030		CM 41-08	[a]	[a]	[a]
58.5.2			*C. gunnari*	443	527		CM 42-02	[a]	[a]	[a]
48.1		481_1	*D. mawsoni*	40	43	UKR	CM 24-05	2	7	7
48.6	n/a	486_2	*D. mawsoni*	175	140	JPN, ESP, ZAF	CM 41-04	7	22	22
48.6	n/a	486_3	*D. mawsoni*	32	38	JPN, ESP, ZAF	CM 41-04	2	6	6
48.6	n/a	486_4	*D. mawsoni*	144	163	JPN, ESP, ZAF	CM 41-04	8	26	26
48.6	n/a	486_5	*D. mawsoni*	274	329	JPN, ESP, ZAF	CM 41-04	16	53	53
58.4.1	C	5841_1	*D. mawsoni*	115	138[b]	AUS, FRA, JPN, KOR, ESP, RUS	CM 41-11	7	22	22
58.4.1	C	5841_2	*D. mawsoni*	116	139[b]	AUS, FRA, JPN, KOR, ESP, RUS	CM 41-11	7	22	22
58.4.1	E	5841_3	*D. mawsoni*	149	119[b]	AUS, FRA, JPN, KOR, ESP, RUS	CM 41-11	6	19	19

(continued)

Table 5 (continued)

Subarea/ division	SSRU	Area	Species	Catch limit 2018/19	Catch limit 2019/20	Notified Members	Conservation measure containing catch limit	Skates and rays by-catch catch limits (tonnes)	*Macrourus* spp. by-catch catch limits (tonnes)	Other species by-catch catch limits (tonnes)
58.4.1	E	5841_4	*D. mawsoni*	19	23[b]	AUS, FRA, JPN, KOR, ESP, RUS	CM 41-11	1	4	4
58.4.1	G	5841_5	*D. mawsoni*	50	60[b]	AUS, FRA, JPN, KOR, ESP, RUS	CM 41-11	3	10	10
58.4.1	G	5841_6	*D. mawsoni*	130	104[b]	AUS, FRA, JPN, KOR, ESP, RUS	CM 41-11	5	17	17
58.4.2	E	5842_1	*D. mawsoni*	50	60	AUS, FRA, JPN	CM 41-05	3	10	10
58.4.3a	n/a	5843a_1	*D. eleginoides*	30	24		CM 41-06	1	4	4
58.4.4b	n/a	5844b_1	*D. eleginoides*	19	23	FRA, JPN	CM 24-05	1	4	4
58.4.4b	n/a	5844b_2	*D. eleginoides*	22	18	FRA, JPN	CM 24-05	1	3	3
88.1, 88.2	n/a	Total	*D. mawsoni*	3 157	3 140	AUS, CHL, JPN, KOR, NZL, RUS, ESP, UKR, UK, URY	CM 41-09	See CM 41-09	See CM 41-09	See CM 41-09
		N70	*D. mawsoni*	587	588|597[d]	AUS, CHL, JPN, KOR, NZL, RUS, ESP, UKR, UK, URY	CM 41-09	See CM 41-09	See CM 41-09	See CM 41-09
		S70	*D. mawsoni*	2 041	2043|2072	AUS, CHL, JPN, KOR, NZL, RUS, ESP, UKR, UK, URY	CM 41-09	See CM 41-09	See CM 41-09	See CM 41-09
		SRZ	*D. mawsoni*	464	464|426	AUS, CHL, JPN, KOR, NZL, RUS, ESP, UKR, UK, URY	CM 41-09	See CM 41-09	See CM 41-09	See CM 41-09
		Shelf survey	*D. mawsoni*	65	45	NZL	CM 24-05			
88.2	n/a	SRZ	*D. mawsoni*		140[c,e]	RUS	CM 24-05	7	22	22
88.2	D, E, F, G	882_1	*D. mawsoni*	240	192	AUS, CHL, KOR, NZL, RUS, UKR, UK, URY	CM 41-10	10	31	31

(continued)

Table 5 (continued)

Subarea/ division	SSRU	Area	Species	Catch limit 2018/19	Catch limit 2019/20	Notified Members	Conservation measure containing catch limit	Skates and rays by-catch catch limits (tonnes)	*Macrourus* spp. by-catch catch limits (tonnes)	Other species by-catch catch limits (tonnes)
88.2	C, D, E, F, G	882_2	*D. mawsoni*	240	232	AUS, CHL, KOR, NZL, RUS, UKR, UK, URY	CM 41-10	12	37	37
88.2	C, D, E, F, G	882_3	*D. mawsoni*	160	182	AUS, CHL, KOR, NZL, RUS, UKR, UK, URY	CM 41-10	9	29	29
88.2	C, D, E, F, G	882_4	*D. mawsoni*	160	128	AUS, CHL, KOR, NZL, RUS, UKR, UK, URY	CM 41-10	6	20	20
88.2	H		*D. mawsoni*	200	160	AUS, CHL, KOR, NZL, RUS, UKR, UK, URY	CM 41-10	8	26	26
88.3	n/a	883_1	*D. mawsoni*	20	16	NZL, KOR, UKR	CM 24-05	1	3	3
88.3	n/a	883_2	*D. mawsoni*	25	20	NZL, KOR, UKR	CM 24-05	1	3	3
88.3	n/a	883_3	*D. mawsoni*	50	60	NZL, KOR, UKR	CM 24-05	3	10	10
88.3	n/a	883_4	*D. mawsoni*	50	60	NZL, KOR, UKR	CM 24-05	3	10	10
88.3	n/a	883_5	*D. mawsoni*	10	8	NZL, KOR, UKR	CM 24-05	1	1	1
88.3	n/a	883_6	*D. mawsoni*	30	30	NZL, KOR, UKR	CM 24-05	2	5	5
88.3	n/a	883_7	*D. mawsoni*	30	30	NZL, KOR, UKR	CM 24-05	2	5	5
88.3	n/a	883_8	*D. mawsoni*	10	10	NZL, KOR, UKR	CM 24-05	1	2	2
88.3	n/a	883_9	*D. mawsoni*	10	10	NZL, KOR, UKR	CM 24-05	1	2	2
88.3	n/a	883_10	*D. mawsoni*	10	10	NZL, KOR, UKR	CM 24-05	1	2	2
58.4.1	n/a	W	*E. superba*	277 000	277 000	CHN	CM 51-02			
58.4.1	n/a	E	*E. superba*	163 000	163 000	CHN	CM 51-02			
58.4.2	n/a	W	*E. superba*	260 000	260 000	CHN	CM 51-03			
58.4.2	n/a	E	*E. superba*	192 000	192 000	CHN	CM 51-03			
48.1	n/a		*E. superba*	155 000	155 000	CHL, CHN, KOR, NOR, UKR	CM 51-07			
48.2	n/a		*E. superba*	279 000	279 000	CHL, CHN, KOR, NOR, UKR	CM 51-07			
48.3	n/a		*E. superba*	279 000	279 000	CHL, CHN, KOR, NOR, UKR	CM 51-07			
48.4	n/a		*E. superba*	93 000	93 000	CHN	CM 51-07			

Table 6: Potential catch allocation methods for the Ross Sea Shelf Survey. Method 1 uses the method used 2012–2018 of allocating catch from the overall Ross Sea region toothfish fishery and Method 2 allocates the shelf survey catch limit from the SRZ catch limit.

Area	Percent	No Survey	Method 1	Method 2
North of 70°S	19	597	588	597
South of 70°S	66	2072	2043	2072
Special Research Zone	15	471	464	426
Shelf Survey	-	-	45	45
Total	100	3140	3140	3140

Annex 1

List of Participants

List of Participants

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Annex 2

List of Documents

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SC-CAMLR-38/02	Comments on procedures for managing the toothfish fishery: Subarea 88.1 and SSRUs 882 A–B in the 2018/19 season Delegation of the Russian Federation
SC-CAMLR-38/03	Report of the Working Group on Ecosystem Monitoring and Management (Concarneau, France, 24 June to 5 July 2019)
SC-CAMLR-38/04	Report of the Working Group on Fish Stock Assessment (Hobart, Australia, 7 to 18 October 2019)
SC-CAMLR-38/05	Report of the Working Group on Statistics, Assessments and Modelling (Concarneau, France, 17 to 21 June 2019)
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SC-CAMLR-38/07	*CCAMLR Science* – Proposal for a special volume on CCAMLR's management of the krill fishery Secretariat
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SC-CAMLR-38/11 Rev. 1	Proposals on the requirements for developing Research and monitoring plans for Marine Protected Areas Delegation of the Russian Federation
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SC-CAMLR-38/13	A proposal for a Krill Ageing Inter-laboratory Calibration Workshop Delegations of Australia, China, Japan, Norway and the USA
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SC-CAMLR-38/15	The CCAMLR Decision Rule, strengths and weaknesses Delegation of the United Kingdom
SC-CAMLR-38/16	Report from the Workshop on Krill-fishery Management for Subareas 48.1 and 48.2 (Concarneau, France, 10 to 14 June 2019) G. Watters and P. Trathan
SC-CAMLR-38/17	A Risk Assessment and ancillary approaches to facilitate the management of the krill fishery as envisaged by WG-EMM-2019 Delegations of the United Kingdom and Australia
SC-CAMLR-38/18	Net monitoring on Norwegian krill fishing vessels, recent trials, and a proposal for amendment to CM 25-03 to accommodate cabled communication between net sensors and vessel O.A. Bergstad
SC-CAMLR-38/19	Procedure for estimating two-hour catches on vessels conducting continuous krill trawling and proposal for adding the description of the procedure as an annex to CM 21-03 O.A. Bergstad
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SC-CAMLR-38/21	Proposal to improve the Draft Research and Monitoring Plan for the Ross Sea region Marine Protected Area Delegation of the People’s Republic of China
SC-CAMLR-38/22	A proposal for Krill Fishery Observer Workshop Delegation of the People’s Republic of China

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SC-CAMLR-38/BG/01 Rev. 1	Catches of target species in the Convention Area Secretariat
SC-CAMLR-38/BG/02	Vacant
SC-CAMLR-38/BG/03	Domain 1 MPA Proposal CM 91-XXrev1: Rationale of the changes for the Proposal for the Establishment of a Marine Protected Area in the Western Antarctic Peninsula- South Scotia Arc Delegations of Argentina and Chile
SC-CAMLR-38/BG/04	Development of the CCAMLR Marine Protected Area (MPA) Information Repository (CMIR) Secretariat
SC-CAMLR-38/BG/05	Comments and Proposals regarding the Ross Sea region MPA Research and Monitoring Plan Delegation of the Russian Federation
SC-CAMLR-38/BG/06	Report of the Second Annual Meeting of SCAR Krill Action Group B. Meyer, S. Kawaguchi and K. Reid
SC-CAMLR-38/BG/07	Committee for Environmental Protection: 2019 Annual Report to the Scientific Committee of CCAMLR CEP Observer to SC-CAMLR, Dr P. Penhale (USA)
SC-CAMLR-38/BG/08	Summary and feedback of the marine scientific research expeditions carried out with RV *Polarstern* in the 2018/19 season Delegation of Germany
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SC-CAMLR-38/BG/10	Emperor penguins – vulnerable to projected rates of warming and sea-ice loss; an international collaboration to inform species-related conservation decision-making and conservation planning Delegations of the United Kingdom, Australia, France, Germany, SCAR and ASOC

SC-CAMLR-38/BG/11	2019 Report to CCAMLR by Oceanites, Inc. – Antarctic Site Inventory / MAPPPD and Related Projects / State of Antarctic Penguins 2019 Report / Penguin Population Changes / Climate Analyses / Recent, Notable Scientific Papers Submitted by Oceanites, Inc.
SC-CAMLR-38/BG/12	Report of the SC-CAMLR Observer (Japan) to the Fourth Meeting of the Scientific Committee of the Southern Indian Ocean Fisheries Agreement (SIOFA) (Yokohama, Japan, 25 to 29 March 2019) SC-CAMLR Observer (Japan)
SC-CAMLR-38/BG/13	Gentoo penguin (*Pygoscelis papua*) population winter/summer behaviour and CEMP time-lapse cameras validation at Galindez Island in the 2018/19 season Delegation of Ukraine
SC-CAMLR-38/BG/14	Progress report on the scientific data compilation and analyses in support of the planning of a potential Marine Protected Area (MPA) east of the zero meridian in the Weddell Sea (Antarctica) G. Griffith, T. Hatterman, A. Høgestøl, Y. Kasajima, A. Lowther, S. Moreau, B. Njaastad, P. Koubbi, C. von Quillfeldt, T. Brey, K. Teschke and O.A. Bergstad
SC-CAMLR-38/BG/15	Observation and comments on the scientific basis and draft RMP of the WSMPA Proposal Delegation of the People's Republic of China
SC-CAMLR-38/BG/16	The Scientific Committee on Antarctic Research (SCAR) Annual Report 2018/2019 Submitted by SCAR
SC-CAMLR-38/BG/17	Antarctic Climate Change and the Environment – 2019 Update Submitted by SCAR
SC-CAMLR-38/BG/18	Report from the Workshop on Krill-fishery Management for Subareas 48.1 and 48.2 P.N. Trathan, G. Watters, N. Bransome, S. Davie, P.E. Skogrand, R. Werner, A. Kavanagh, C. Johnson and J. Arata (On behalf of the Workshop Organising Committee)

SC-CAMLR-38/BG/19	Proposal for a multi-national research effort to quantify krill flux into, out of, and within the Bransfield Strait using a Super SWeet ARray of Moorings (SuperSWARM) G. Watters, C. Reiss, G. Cutter, J. Hinke and D. Krause
SC-CAMLR-38/BG/20	Observation on interactions between marine mammals and krill mid-water trawl Y. Ying, G. Fan, X. Zhao, J. Zhang, X. Wang and J. Zhu
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SC-CAMLR-38/BG/22	Moving towards a new era in ecosystem-based krill fishery management Submitted by ASOC
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SC-CAMLR-38/BG/29	Expert Workshop on Pelagic Spatial Planning for the eastern subantarctic region (Domains 4, 5 and 6) A.B. Makhado, A. Lowther, P. Koubbi, I. Ansorge, C. Brooks, C. Cotté, R. Crawford, S. Dlulisa, F. d'Ovidio, S. Fawcet, D. Freeman, S. Grant, J. Huggett, M. Hindell, P.A. Hulley, S. Kirkman, T. Lamont, M. Lombard, M.J. Masothla, M.-A. Lea, W.C. Oosthuizen, F. Orgeret, R. Reisinger, T. Samaai, S. Sergi, K. Swadling, S. Somhlaba, A. Van de Putte, C. Von de Meden and D. Yemane
SC-CAMLR-38/BG/30	Report to the Scientific Committee for the Conservation of Antarctic Marine Living Resources on the outcomes of the EU-H2020 Project 'Mesopelagic Southern Ocean Prey and Predators (MESOPP)' and its utility to SC-CAMLR A.J. Constable, P. Lehodey and P. Koubbi (2019). Report from the EU-H2020 MESOPP project, MESOPP-19-0007: 19 pp.

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Other Documents

CCAMLR-38/02	Developing guidelines for conversion factors in new and exploratory toothfish fisheries Delegation of New Zealand
CCAMLR-38/11	Second Performance Review: progress reporting Secretariat
CCAMLR-38/19	Decision to promote the creation of a Southern Ocean Cooperation Platform Delegation of the European Union
CCAMLR-38/20	Proposal to designate a newly-exposed marine area adjacent to Pine Island Glacier (Subarea 88.3) as a Special Area for Scientific Study Delegation of the European Union and its member States
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CCAMLR-38/24	Draft Research and Monitoring Plan (RMP) for the South Orkney Islands Southern Shelf Marine Protected Area Delegation of the European Union and its member States

CCAMLR-38/25 Rev. 1	Revised proposal for a conservation measure establishing a Marine Protected Area in Domain 1 (Western Antarctic Peninsula and South Scotia Arc) Delegations of Argentina and Chile
CCAMLR-38/31 Rev. 2	Revision of the precautionary approach to ensuring the rational use of a living resource (*Dissostichus eleginoides*) in Subarea 48.3 Delegation of the Russian Federation
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CCAMLR-38/BG/12	Fishery monitoring and closure procedures Secretariat
CCAMLR-38/BG/17 Rev. 1	Technical procedure for retrieval and handling of unidentified and unidentified fishing gear in the Convention Area Secretariat
CCAMLR-38/BG/20	South Orkney Islands Southern Shelf Marine Protected Area – Second Report Delegation of the European Union and its member States
CCAMLR-38/BG/37	International Association of Antarctica Tour Operators (IAATO) activities 2018–2019: a summary for CCAMLR Submitted by IAATO
CCAMLR-38/BG/43	ASOC report to CCAMLR Submitted by ASOC
CCAMLR-38/BG/44	CCAMLR MPAs and the global climate and biodiversity crisis Submitted by ASOC
CCAMLR-38/BG/45	Next steps in cooperation between CCAMLR and the Southern Indian Ocean Fisheries Agreement (SIOFA) Submitted by ASOC
CCAMLR-38/BG/53	China's plan for marine investigation and assessment in the East Antarctic sector Delegation of the People's Republic of China
CCAMLR-38/BG/56	The IPCC Special Report on the Ocean and Cryosphere in a Changing Climate: CCAMLR's duty to respond Submitted by ASOC

Annex 3

Agenda for the Thirty-eighth Meeting of the Scientific Committee

Agenda for the Thirty-eighth Meeting of the Scientific Committee for the Conservation of Antarctic Marine Living Resources

1. Opening of the meeting

    1.1 Adoption of the agenda
    1.2 Chair's report

2. Advances in statistics, assessments, modelling, acoustics and survey methods

    2.1 Statistics, assessments and modelling
        2.1.1 Advice to the Commission

    2.2 Acoustic survey and analysis methods
        2.2.1 Advice to the Commission

3. Harvested species

    3.1 Krill resources
        3.1.1 Status and trends
        3.1.2 Ecosystem effects of krill fishing
        3.1.3 Advice to the Commission

    3.2 Fish resources
        3.2.1 Status and trends
        3.2.2 Assessment of fish resources
            3.2.2.1 Advice to the Commission

        3.2.3 New and exploratory finfish fisheries
            3.2.3.1 Progress towards assessments
            3.2.3.2 Advice to the Commission

4. Scientific research exemption

    4.1 Advice to the Commission

5. Non-target catch and ecosystem impacts of fishing operations

    5.1 Fish and invertebrate by-catch
    5.2 Incidental mortality of seabirds and marine mammals associated with fisheries
    5.3 Bottom fishing and vulnerable marine ecosystems
    5.4 Marine debris
    5.5 Advice to the Commission

6. Spatial management of impacts on the Antarctic ecosystem

    6.1 Marine protected areas (MPAs)
        6.1.1 Review of scientific analysis relevant to existing MPAs including the scientific requirements for research and monitoring plans for MPAs

6.1.2 Review of the scientific elements of proposals for new MPAs

6.2 Advice to the Commission

7. IUU fishing in the Convention Area

8. CCAMLR Scheme of International Scientific Observation

8.1 Advice to the Commission

9. Climate change

9.1 Advice to the Commission

10. Cooperation with other organisations

10.1 Cooperation within the Antarctic Treaty System
10.1.1 Committee for Environmental Protection
10.1.2 Scientific Committee for Antarctic Research

10.2 Reports of observers from other international organisations
10.3 Reports of representatives at meetings of other international organisations
10.4 Future cooperation

11. Budget for 2019/20

12. Advice to SCIC and SCAF

13. Scientific Committee activities

13.1 Priorities for work of the Scientific Committee and its working groups
13.2 Second Performance Review
13.3 CCAMLR Scientific Scholarships Scheme
13.4 Invitation of experts and observers to meetings of working groups
13.5 Next meeting

14. Secretariat supported activities

15. Election of Chair and Vice-Chair

16. Other business

17. Adoption of report of the Thirty-eighth Meeting

18. Close of meeting.

Annex 4

Report of the Meeting of the Working Group on Statistics, Assessments and Modelling
(Concarneau, France, 17 to 21 June 2019)

Contents

Report of the Working Group
on Statistics, Assessments and Modelling
(Concarneau, France, 17 to 21 June 2019)

Introduction

1.1 The 2019 meeting of WG-SAM was held at the Concarneau Marine Station in Concarneau, Finistère, France, from 17 to 21 June 2019. The meeting Co-conveners, Dr C. Péron (France) and Dr S. Parker (New Zealand), welcomed participants (Appendix A). The meeting was hosted by the Muséum national d'Histoire naturelle and in welcoming participants to the meeting, Dr M. Eléaume (Curator of Echinoderms, Muséum national d'Histoire naturelle and Scientific Committee Representative for France) provided an overview of the meeting facilities and encouraged all participants to enjoy all that Concarneau has to offer.

Adoption of the agenda and organisation of the meeting

2.1 Dr Parker reviewed the provisional agenda and the papers that had been submitted for consideration of WG-SAM and how these addressed the priorities identified by the Scientific Committee for the work of WG-SAM. In order to streamline the work of the meeting, the provisional agenda was revised and adopted (Appendix B).

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

2.3 In this report, paragraphs that provide advice to the Scientific Committee and its other working groups have been indicated in grey. A summary of these paragraphs is provided in Item 9.

2.4 The report was prepared by M. Baird (New Zealand), M. Belchier (UK), C. Chazeau (France), C. Darby (UK), A. Dunn (New Zealand), T. Earl (UK), N. Gasco (France), C. Jones (USA), D. Maschette (Australia), K. Reid (Secretariat), M. Söffker (EU), S. Thanassekos (Secretariat), D. Welsford and P. Ziegler (Australia).

Assessments to estimate sustainable yield

3.1 WG-SAM-2019/04 presented work to estimate natural mortality (M) within the CASAL assessment for Antarctic toothfish (*Dissostichus mawsoni*) in the Ross Sea region in response to the recommendations of the CCAMLR Independent Stock Assessment Review for Toothfish (SC-CAMLR-XXXVII, Annex 5). This was accomplished by setting selectivity in the northern fishery to a logistic instead of a double normal (i.e. fully selected older fish) and including M as an estimable parameter. The resulting estimate of M was similar to the current externally estimated value of M used in the model and B_0 was higher.

3.2 The Working Group noted that although this assessment was data rich, estimating M within assessments may overestimate biomass when there is model mis-specification, and hence may not be precautionary. The Working Group recalled that likelihood profiles indicated that different cohorts of tagging data provide conflicting estimates of M, and that further work would be required to identify the most influential data on estimates of M.

3.3 The Working Group noted that the current CASAL model uses a constant M over time and age, and further work would be required to test whether it is feasible to estimate temporal trends in M, and to evaluate the impact of changes in M on the management of the stock through simulations and management strategy evaluations.

3.4 WG-SAM-2019/27 presented preparatory work towards the update of the assessment of Patagonian toothfish (*D. eleginoides*) in Division 58.5.2. The paper presented revised estimates of the maturity-at-age relationship and estimates of removals due to lost longlines using either the geometric mean of catch rates from the fishing season during which the gear was lost, or the catch-per-unit-effort (CPUE) from the recovered part of the longline.

3.5 The Working Group recommended that the mean CPUE from the season be used to estimate mortality from lost gear to provide an unbiased estimate of the expected mortality and that the sensitivity of including this mortality in the stock assessment for Division 58.5.2 be evaluated.

3.6 An updated maturity ogive for female fish was calculated in response to comments from the CCAMLR Independent Stock Assessment Review for Toothfish (SC-CAMLR-XXXVII, Annex 5) combining a logistic fitted curve with assumed zero maturity at ages 1–5. The Working Group agreed that this maturity ogive could be used in the assessment to provide management advice in 2019 and welcomed the paper's proposals to provide a bridging analysis or sensitivity analysis to understand the causes of any changes to the status of the stock.

3.7 Dr Söffker informed the Working Group that biological data from toothfish fishing activities collected in the Southern Indian Ocean Fisheries Agreement (SIOFA) area adjacent to the Convention Area was initially planned to be submitted for information of WG-SAM, but in consultation with the Co-conveners of WG-SAM, this would be more relevant to the work of WG-FSA, and would be presented there.

3.8 An updated CASAL assessment model for *D. eleginoides* in Division 58.4.4b was presented in WG-SAM-2019/30. The Working Group welcomed the substantial progress that has been made in developing the model. The Working Group recommended that age–length keys (ALKs) be calculated separately for each year, and the impact of using smaller length classes be investigated. The Working Group noted that the required number of otoliths can be calculated based on a target coefficient of variation (CV). The Working Group recommended that CVs are indicated as part of the growth model and length–weight model fits. The Working Group drew attention to previous work on standard diagnostics (WG-SAM-2015 report, paragraphs 2.33 to 2.43 and Appendix D) and recommended that these should be presented for this assessment.

3.9 The Working Group noted that CASAL can be used to estimate a constant harvest rate (F_{CAY}) that would lead the stock to 50% B_0 based on the selectivity and biological estimates, regardless of the initial status of the stock. The assessments available to the Working Group gave a preliminary indication that harvest rates of 4–6% would be consistent with achieving this target. The Working Group noted that this was consistent with the 4% value estimated by previous work (Welsford, 2011) to calculate a precautionary harvest rate for exploratory fisheries where there is no estimate of B_0. The timescale for achieving the target of 50% B_0 may be long if the stock is depleted. Details of the calculation, and how to perform it, are given in the CASAL manual (sections 3.1 and 7.5.1).

3.10 The Working Group noted that this method could be applied to provide catch advice for stocks where there are uncertainties in the historic catch data due to unquantified illegal, unreported and unregulated (IUU) fishing, or in other circumstances where the virgin biomass is unknown.

3.11 The Working Group recommended that Members developing stock assessments calculate the harvest rate associated with achieving 50% B_0 to help evaluate the yield calculations using the CCAMLR decision rules, and further recommended that Members with historic assessments available present the harvest rates that these assessments would indicate so that the variability over assessments can be better understood.

3.12 WG-SAM-2019/32 addressed the recommendation in WG-FSA-2018 report, paragraphs 2.28 to 2.31, by analysing the time series of changes in the biological productivity parameters in Subarea 48.3, particularly whether the proportion of females in the catch, maturity at length and age, length–weight relationships and growth rates have changed through time.

3.13 The Working Group noted variation through time in the Subarea 48.3 sex ratio, maturity, growth and length–weight parameter estimates, but no systematic trends. When the effects of confounding factors, such as depth, were included in the analysis, there was no indication of systematic change that would indicate potential impacts from external influences such as the fishery or climate change. The current stock assessment is robust to the changes in growth parameters.

3.14 The Working Group noted that the revised Fisheries Reports could provide a valuable source of information as to where changes in management practices had occurred that would impact the data collected.

3.15 Dr S. Kasatkina (Russia) noted that the history of the fishery in Subarea 48.3 indicates that the percentage of fish caught in older age groups in recent times (2010–2017) has decreased and young fish remained predominant in toothfish catches. She noted that WG-SAM-2019/32 does not provide clarity as to whether this was an effect of changes in the fishery selectivity or in the distribution of the stock or whether this was a change in the population structure under the impact of the fishery. She noted that it will be important to understand how fishing will influence the stock in the future.

3.16 The Working Group recalled that the variation in length distributions had been reviewed previously by WG-FSA-2018 (WG-FSA-2018 report, paragraphs 3.18 to 3.20) as well as WG-SAM-2019/32. The length (or age) distribution of the catch is influenced by a combination of factors resulting from the overlap of the fishery and the stock in time, by area and depth, as well as the selectivity of the fishing gear.

3.17 The Working Group noted that longline fisheries for toothfish provide an example of why the length structure of the fishery catch may not represent the length structure of the underlying population. A range of fishery-dependent and fishery-independent research has determined that smaller toothfish of both species typically occupy shallow depths on the Antarctic and sub-Antarctic shelves. Fishing in deep water results in catches of large fish but does not imply that smaller fish are absent from the population.

3.18 The Working Group recalled that the underlying population structure can currently be best estimated within a stock assessment model, such as CASAL, which integrates across the catch distribution and the trends in the tagging data. The CCAMLR Independent Stock Assessment Review for Toothfish (SC-CAMLR-XXXVII, Annex 5) has reviewed the assessment and endorsed its use for providing management advice. The independent review panel noted that the reviewed assessments provide precautionary management advice and are world-leading.

3.19 The Working Group also recalled that changes in the catch structure resulting from fishery selection, recruitment events and movement of the stock through time are compensated for by the use of the CCAMLR decision rules, whatever the resulting catch structure.

3.20 The Working Group noted that as there had been no proposal for a change of version, that CASAL version 2.30-2012-03-21 rev. 4648 remains the current approved CCAMLR version for use in assessments.

Cross-cutting issues in longline fisheries affecting data quality

Tagging

4.1 WG-SAM-2019/07 presented a new tag-linking approach that has been developed by the Secretariat to provide greater flexibility in linking recaptures to releases, including where a recapture is linked to multiple releases or multiple recaptures are linked to a single release with equal probability. The tag-linking process produces a table containing all links that were made, including ambiguous links, their scores, the number of tags linked and the occurrence of mismatches. The table also includes the linked ‘Akeys’, i.e. the unique row identifiers in the recaptures and releases datasets. This new approach uses more of the available data, increases the level of transparency and provides an index of the level of confidence in all linked mark-recapture data.

4.2 The Working Group welcomed this approach and its greater transparency about the tag-linking process. It noted that this algorithm is the first step in linking tag releases and recaptures, and that, where this was not able to link a recapture to a single release event, other information, such as the release and recapture locations, could subsequently be used to select likely links.

4.3 The Working Group recommended that the new approach outlined in WG-SAM-2019/07 be routinely implemented by the Secretariat and requested that the Secretariat provide the links from the currently implemented approach and the new approach to help data users to compare the differences between approaches. The Working Group agreed that the greater transparency and inclusion of data-quality metrics would provide the basis to improve the new algorithm over time in a collaborative process between the Secretariat and data users.

4.4 The Working Group requested that the Secretariat:

(i) report each year to WG-FSA a summary of the linking process. This report should include, inter alia, how many tags have been successfully or unsuccessfully linked and what reasons led to unsuccessful links, and how many tags have been released with missing data or inappropriate values

(ii) provide the data link output from the previous year in extracts to data users to support data comparisons between years

(iii) provide the details of all the fish included in an ambiguous link where one of the links includes the area for which the data has been requested

(iv) provide metadata in association with tagging data on known issues to allow users to undertake appropriate analyses

(v) investigate whether releases from the early years of the fishery in Subarea 88.1 and small-scale research units (SSRUs) 882A–B, previously submitted by New Zealand but not entered into the CCAMLR database, can now be included in the tag-linking process

(vi) identify situations where fish may have been released and recaptured multiple times and are therefore likely to have ambiguous links.

Catch estimation

4.5 WG-SAM-2019/14 provided a description of the potential effects of operating conditions on the estimation of catch weights that sought to address concern from SC-CAMLR-XXXVII on discrepancies in reported catches (C2) and landings (*Dissostichus* Catch Document (DCD)) (SC-CAMLR-XXXVII, paragraphs 12.3 to 12.5). The paper highlighted that the instructions provided on some vessels may have resulted in the underestimation of catches as reported on the C2 forms.

4.6 The Working Group thanked Ukraine for the transparency and requested that Ukraine work with the Secretariat to provide further details of the potential underestimation of catches (including by vessel, year and area) in order that the implications of this on the provision of management advice can be reviewed by WG-FSA. The Working Group also agreed that the potential underestimation of catches be considered by the Standing Committee on Implementation and Compliance (SCIC).

4.7 The Working Group recommended that in the interim of a decision being made on how the underestimation of catches is addressed, including how this data is flagged in the CCAMLR database, data extracts from the CCAMLR Secretariat should include a reference to WG-SAM-2019/14 linked to the data in question.

Fishery Reports

4.8 WG-SAM-2019/35 presented a new Fishery Report format that has been developed by the CCAMLR Secretariat, using R Markdown. Many of the data summaries can be automatically generated and formatted into a publication-ready format for Fishery Reports.

4.9 The Working Group welcomed this new format, its greater flexibility and its potential as a means to increase consistency across Fishery Reports. It noted that some modifications were necessary, such as the inclusion of a table of contents, stock status summary and consideration of environmental effects. The Working Group suggested that the Fishery Reports have the content as given in Appendix D and requested further review by WG-FSA.

4.10 The Working Group agreed that in the future, Fishery Reports could be part of a set of documents designed to inform a broad range of audience, from the general public to stock assessment scientists. It noted that a hierarchical approach, whereby a simple and concise 'Fishery Summary' would link to three detailed documents (namely a Fishery Report, a Species Description and a Stock Assessment Annex) to communicate fishing and research activities in the Convention Area (Appendix D).

4.11 The Working Group encouraged Members providing integrated toothfish assessments to WG-FSA this year to develop the Stock Assessment Annexes for those stocks (WG-FSA-2018 report, paragraphs 2.32 and 2.33).

4.12 The Working Group agreed that the Fishery Summary should include a figure of the region for which the Fishery Report applies, the species name, a visual representation of the species, a graphic summary of the catch time series, and a summary table detailing: the status of the fishery, the wider environmental consideration (e.g. seabirds, vulnerable marine ecosystem (VME) triggers), the type of fishery (e.g. exploratory, Conservation Measure (CM) 24-01), the vessel types and gears involved. The Fishery Summary would also include links and references to the relevant Fishery Report, the Species Description and the Stock Assessment Annex.

4.13 The Working Group requested that the Secretariat implement this hierarchical structure for Fishery Reports and present this at WG-FSA-2019.

Data Services Advisory Group (DSAG)

5.1 The Data Services Advisory Group (DSAG) Co-convener, Mr Dunn, provided an update on recent developments in the DSAG, detailing how the group has been working with the Secretariat on the development of plans to implement and improve data access and documentation procedures. Mr Dunn informed the Working Group about a virtual meeting of the DSAG, proposed for August 2019, where interested parties could discuss these developments. He encouraged DSAG members to participate. The CCAMLR Science Manager, Dr Reid, further summarised the developments in the Secretariat, including investment in resources and infrastructure.

5.2 The Working Group welcomed the progress and collaboration between DSAG and the Secretariat, thanking both for their engagement. The Working Group supported the proposed virtual DSAG meeting in August 2019, and further encouraged participants to visit the DSAG e-group since the Secretariat has recently introduced a standardised data request submission form.

Review of research plan proposals and results

Research standardisation

6.1 The Working Group recalled the discussions at WG-FSA-2018 regarding research standardisation and ways to control or quantify the impact of gear on conclusions drawn from research data, and best practice for developing and presenting analyses (WG-FSA-2018 report, paragraphs 4.27, 4.29 and 4.30).

6.2 WG-SAM-2019/34 summarised two alternative approaches to standardisation of data from research conducted by longline fishing vessels, derived from the discussions at WG-FSA (WG-FSA-2017 report, paragraph 4.20; WG-FSA-2018 report, paragraphs 4.27 to 4.30) and the Scientific Committee (SC-CAMLR-XXXVII, paragraphs 3.138 to 3.144), namely:

(i) using standardised longline gear for multi-Member research programs on *D. mawsoni* in East Antarctica

(ii) using different longline types and post-hoc analyses to estimate the impact of gear on the results of research.

6.3 Dr Kasatkina also presented an overview of multinational trawl survey designs used in the International Council for the Exploration of the Sea (ICES) to illustrate the need for consideration of gear effects in designing research surveys. She highlighted that the trawl fishing process and fishing gears are so complex that catches depend on many factors (in particular, behaviour and distribution of fish, and their influence on catchability properties of fishing gear, team experience, etc.), which cannot be addressed using data standardisation. She further noted that, in her opinion, the best way to address this situation is to use standard fishing gear for trawl surveys, especially those involving several vessels. She noted that the use of standard trawl gears accompanied by standard procedures and survey design are the basis for international surveys in the ICES areas. She stressed that the ICES manuals for multivessel surveys do not include requirements for intercalibration between participating vessels (ICES, 2017a, 2017b).

6.4 Dr Kasatkina noted that, in her opinion, methodical aspects of the implementation of the research program in Division 58.4.1, such as follows: lack of standardised design of longline surveys (concentration of longline settings in local areas of research blocks, variation of longline gear types and fishing efforts in research blocks by years), impact of fishing longline gear on length and age composition, proportion of mature fish and results of tag recapture (WG-FSA-16/13 Rev. 1; WG-FSA-17/15; WG-FSA-17/16; SC-CAMLR-XXXVII/BG/23), do not provide adequate data for achieving objectives and goals of the research activity on *D. mawsoni* in East Antarctica (Divisions 58.4.1 and 58.4.2) between the 2011/12 and 2017/18 fishing seasons. She proposed the use of standardised fisheries-dependent survey design and standardised longline gear for multi-Member research activity in this region. She also noted that there still is insufficient understanding of longline gear as a tool for research activity including the ‘swept area’ or sampling volume of longlines, catchability and selectivity properties, and hence catch rates from longlines cannot be used as an absolute measure of abundance.

6.5 The Working Group noted that in ICES trawl surveys, which are used as the basis of CPUE time series, while there is a single type of gear specified, the actual designs of the deployed nets vary across the survey area to account for differences in sea-floor characteristics, and to maintain important time series that pre-date the multinational survey. It further noted that despite using standardised gear, vessel effects remained an important source of variation in these surveys, and hence the ICES survey designs include substantial overlap in survey hauls between vessels and nations to allow statistical standardisation of the results prior to conclusions being drawn on stock abundance (e.g. Walker et al., 2017).

6.6 WG-SAM-2019/25 described an exploration of the main sources of variation in CPUE analyses using data from the exploratory longline fishery for *D. mawsoni* in the Ross Sea. The Working Group noted that according to generalised linear model (GLM) analyses, the total number of hooks is the preferred effort measure when comparing CPUE from different types of longline (autoline, trotline, Spanish line). However, the Working Group noted that the effect of effort measure was sufficiently small that it would not impact on trend analyses for the purposes of setting catch limits in data-limited exploratory fisheries.

6.7 The Working Group also noted that vessel identity was the largest driver of variations in CPUE. Excluding trips by vessels with only one year of fishing reduced the size of the vessel effect, however, it remained the most important explanatory variable in all models, with effect size three times higher than the gear effect.

6.8 Dr Kasatkina noted with concern the large 'vessel effect' which, in her opinion, makes the research data unpredictable. She noted the need to minimise the effect of the vessel using standardised gear and standardisation of all aspects of vessel activity (catch rates, calculation of conversion factors, etc.). She noted that while the method to standardise for vessel effects on CPUE was well established, in her view, analysis of the impacts on other variables still needed further development, otherwise standardised CPUE will be dominated by vessel effects. Dr Kasatkina further noted that CCAMLR should continue to work to understand and standardise, where possible, the impacts of vessel effects on data.

6.9 To assist in future quality checking of data, the Working Group recommended the Secretariat develop an appropriately documented new reporting field in the C2 form for the number of droplines per line when using trotline.

6.10 The Working Group noted that the Coalition of Legal Toothfish Operators (COLTO) would be hosting an industry–science data management workshop to achieve best practices within CCAMLR (SC-CAMLR-XXXVII, paragraph 3.45; SC CIRC 19/29) and that one of the aims of this workshop was to provide a multi-stakeholder review of the current data reporting specifications on the C2 form and that this would include consideration of a potential revision of the C2 form.

6.11 The Working Group agreed that there were many potential reasons why vessel effects would be important in explaining the variation observed in CPUE, including fishing strategy, vessel design, crew and skipper experience and behaviour, data collection equipment and observation error. It noted that all these factors would be impossible to control a priori in any multivessel research activity. It therefore recommended that toothfish research fishing is conducted with a high level of spatial and temporal overlap between vessels and gear types to allow for a meaningful standardisation of variables such as catch rates, mean length or sex ratio.

6.12 The Working Group noted that the design of research activities, and the likely impacts of gear and vessel effects, depend on the objectives of this research. The Working Group recalled the WG-FSA-2018 report, paragraph 4.29, which described the process for approaching standardisation analyses. To assist with the design and evaluation of research plans, the Working Group developed a table to indicate which factors were likely to be important in the design of data collection and analysis of key datasets (Table 1).

6.13 The Working Group recalled that CPUE is influenced by many factors, highlighting the rationale for why unstandardised CPUE data are not used in CCAMLR stock assessments when other less confounded indices are available. The table highlighted that a number of factors need to be considered in standardisation for questions related to CPUE or age structure, but that few variables need to be standardised for questions related to tag data or distribution. For most types of fisheries-dependent studies, standardising for effects related to space, time and vessel were most important. It further highlighted that power analysis was a key step in determining the likelihood success of all research activities.

6.14 WG-SAM-2019/37 described an analysis of CPUE from the exploratory longline fishery for *D. mawsoni* in Subarea 48.6. The Working Group noted that this analysis indicated that overall CPUE has been increasing in this subarea. However, it also noted that CPUE analyses and tag-recapture analyses at the individual research block scale were still required to ensure that fishing was not resulting in localised depletion, and to enable the setting of research catch limits.

6.15 WG-SAM-2019/06 described guidelines for assessing research from fishing vessels that is directed at the Research and Monitoring Plan (RMP) for the Ross Sea region marine protected area (MPA).

6.16 The Working Group agreed that any research fishing proposed in MPA zones should ensure it maximises scientific outputs and that robust scientific conclusions can be drawn from those outputs. The Working Group recalled the conclusions of the WG-SAM-2018 report, paragraph 6.45 and the WS-SM-2018 report, paragraph 6.4 and recommended to the Scientific Committee that research proposals should:

(i) identify which priority research elements are addressed

(ii) explicitly integrate core concepts of good scientific research design (replication, randomisation and reference areas) to ensure robust experimental results

(iii) explain why the proposed research or data collection cannot be conducted during the exploratory fishery

(iv) provide a detailed rationale for the choice of comparable reference areas

(v) demonstrate how coordinating vessels will employ robust standardised procedures, including how the vessels involved will provide high-quality and comparable data, especially with respect to toothfish tag-survival and tag-detection rates

(vi) demonstrate Members' capacity to conduct high-quality and timely shore-based analyses necessary to utilise the data to inform the RMP evaluation process

(vii) describe the mechanism by which research fishing is coordinated with other research fishing and with any Olympic fishery, and how the research will avoid being compromised by spatial and temporal interactions

(viii) provide an environmental impact assessment for the research, and an assessment of how the research may impact the objectives of the MPA.

6.17 The Working Group further recommended to the Scientific Committee that research proposals should include design components, including:

(i) a clear rationale and approach for the definition of experimental strata

(ii) well-designed statistical approaches to standardise the results to control for variation due to operational effects (e.g. catch-rate standardisation)

(iii) removing the effects of vessel choice in fishing location through randomisation of survey stations locations

(iv) the use of power analyses and simulations to ensure robust statistical comparisons

(v) ensuring that the proposed data collection requirements can be implemented by including the appropriate scientific expertise, numbers of people sampling, and/or use of scientific electronic monitoring.

6.18 The Working Group noted that Mr Dunn had provided an R script that could assist with evaluating the power of a survey design (included as an appendix in WG-SAM-2019/06). The Working Group recommended that proponents of research in MPAs (and for research plans on general) use statistical power analyses to assess the likelihood of their designs achieving their objectives and encouraged the use of the provided code.

6.19 The Working Group noted that research in closed areas is notified under CM 24-01, which includes requirements for research plans in Annex 24-01/B. It noted that this annex had not been reviewed for several years, and requested the Scientific Committee consider if the annex should be updated to include the requirements for research within MPAs. It also noted that research targeting toothfish should not undermine the other objectives that MPAs are designed to achieve for CCAMLR.

6.20 WG-SAM-2019/09 described preliminary results from statistical modelling of grenadier by-catch by longlines in research block 486_2. The Working Group noted that this analysis indicated that despite using a large number of zero-inflated distribution models, none of the models trialled was able to predict zero catches satisfactorily. The Working Group noted that there was spatial structure apparent in the distribution of zero catches of grenadiers and recommended further development of these models to include spatial effects.

Proposals and research results for toothfish from Area 48

Subarea 48.6

6.21 The Working Group considered papers on the results of research from Subarea 48.6 by Japan, South Africa and Spain. WG-SAM-2019/15 provided an analysis of the sea-ice concentration in research blocks 2, 3, 4 and 5 of Subarea 48.6. The paper noted that lower sea-surface temperature (SST) anomalies corresponded with higher sea-ice concentration in 2019 both in research blocks 486_4 and 486_5. The paper noted that it may be possible to predict future research vessel accessibility into research blocks 486_4 and 486_5 using SST from the HYCOM model.

6.22 WG-SAM-2019/16 described an oceanographic study of Subarea 48.6 using SST, sea-ice concentration, temperature-at-depth profiles, current and wind vectors. The paper noted that lower SST corresponded to the higher sea-ice concentration and was related to the patterns in wind vectors.

6.23 The Working Group noted that both papers observed considerable variability in anomalies especially in more recent years, and that this could be tied to global climatic change and prevalent climate modes in addition to local conditions. The Working Group noted that Antarctic region trends in climate variables are described in WG-EMM-2019/39, and suggested exploring whether prevalent climate mode was a factor in the accessibility of the southern research blocks.

6.24 WG-SAM-2019/36 presented updated biological parameters of *D. mawsoni* in Subarea 48.6 from research surveys, including an updated length–weight relationship, ALK, von Bertalanffy growth curves and maturity ogives. The paper noted that due to insufficient ageing of otoliths, annual ALKs were not yet available.

6.25 The Working Group noted that the observations of age at length for some of the data was unusual, and that the age estimates may need to be verified and checked. Dr T. Okuda (Japan) noted that not all the readings had been made by two different readers. He noted that they would investigate these data to confirm or update these age readings.

6.26 The Working Group noted that diagnostic plots of the fits for length weight, growth and maturity ogives may help identify where there were unusual patterns of residuals. The Working Group recommended that residuals from fits be produced, and that plotting residuals by age, year of sampling or reader may provide an insight into whether there were unusual patterns that would need additional investigation.

6.27 The Working Group reviewed the research proposal for Subarea 48.6 by Japan, South Africa and Spain given in WG-SAM-2019/13 Rev. 1. The research program has seven main objectives, including an assessment of abundance, growth, population structure and ecological traits of *D. mawsoni*; by-catch species distribution; knowledge about Antarctic marine ecosystems; and effects of depredation.

6.28 The Working Group noted that this research program was initiated in 2018/19, and comprised three years of on-water research for the seasons 2019, 2020 and 2021. The research proposal noted that some off-water analyses would be completed in 2022 to meet the research program objectives.

6.29 The Working Group reviewed the research proposal as an ongoing research proposal and summarised its advice for WG-FSA-2019 in Table 2.

6.30 The Working Group reviewed progress against the 19 specific and six additional research milestones as described in WG-SAM-2019/13 Rev. 1, Appendix 1, Table 1. The table provided descriptions of the research program milestones and the achievements and reports for those milestones.

6.31 The Working Group noted the considerable progress against the milestones that has been provided by Japan, South Africa and Spain. The Working Group agreed that, in reviewing the results of research against milestones 1, 2, 3, 6, 7, 9, 10, 11, 12 and 18, these milestones had been achieved.

6.32 The Working Group noted partial progress against milestones 5 and 19 had been presented and agreed that the work currently being undertaken was likely to lead to the achievement of these milestones and encouraged the proponents of the research proposal to continue their work to complete these milestones.

6.33 The Working Group noted that additional work would be required to meet milestones 4, 8, 13, 14, 15, 16 and 17. Specifically, additional otoliths would need to be read to provide data for annual ALKs (milestones 4 and 8); the research proposal would need to specify how information from this proposal or additional research would allow testing of the stock hypotheses (13); vessel calibration studies should be developed, noting that the number of tag recaptures obtained from the current research would not allow this to be evaluated (14); that methods of IUU estimation require additional research (15); reports on the tagging performance (16); and development of preliminary stock status, given the tag performance.

Subarea 48.1

6.34 WG-SAM-2019/33 presented the results of the longline survey conducted by Ukraine in Subarea 48.1 as set out in WG-FSA-18/20 Rev. 1. The survey had been restricted by ice conditions and only deployed and successfully retrieved seven sets (of the planned 36) in research block 481_1, due to an inability to access research block 481_2; two additional lines, comprising 25% of the hooks deployed, had also been lost under ice and not retrieved.

6.35 The authors presented the preliminary survey results on length distributions, maturity and by-catch, which will be updated and supplemented with further analysis at WG-FSA-2019. Otoliths from the survey had yet to be read and microchemistry and genetic samples have been sent to collaborating organisations in order to establish potential biological links of the toothfish with other regions in Area 48 as part of the research requested by the Workshop for the Development of a *Dissostichus mawsoni* Population Hypothesis for Area 48 (WS-DmPH).

6.36 The importance of collecting information on the toothfish stock characteristics in this area was highlighted by the Working Group and it noted that the survey had provided a valuable dataset, despite the difficulties it had in collecting it. The Working Group noted the high percentage of full stomachs in the sampled catch, with a substantial amount of digested material and suggested collecting samples for fatty acid analysis. The authors noted that in the next research proposal stomachs were to be collected and returned for more detailed analysis.

6.37 A large range of sizes was observed with a bimodal distribution. The Working Group suggested separating the length distribution by depth to determine the local stock structure.

6.38 The Working Group noted that the tag-overlap statistic for the survey was lower than the 60% threshold specified by CM 41-01, while the number of fish tagged was greater than the 30 minimum for the threshold to apply and recommend it be reviewed by SCIC. The low overlap percentage resulted from a low number of large fish in the tagged fish length distribution compared to the catch.

6.39 The Working Group noted that the research report indicated that the observers were responsible for meeting the survey objectives. It reiterated observers are responsible for CCAMLR Scheme of International Scientific Observation (SISO) sampling and that it is the Members which have responsibility for completing the survey objectives.

6.40 The presence of ice in large concentrations had previously been noted by the Working Group as a risk to completion of its objectives (WG-FSA-2018 report, paragraphs 4.48 to 4.52), and it was noted that the subsequent confirmation of this advice was beneficial. Procedures to review the potential for completing research in the ice-restricted areas should be routine within survey submissions.

6.41 The Working Group noted that the risk remains to the completion of objectives if the survey continues. It recommended that the authors review their program aims to ensure focus on objectives that can be completed in a restricted time and area. The authors noted that a review of the ice conditions in the region indicated that conducting the survey in February should allow for better access to the area and that this would be set out in a revised proposal to WG-FSA-2019.

6.42 The Working Group noted that SC-CAMLR-XXXVII (SC-CAMLR-XXXVII, paragraph 3.122) had advised that this research program be conducted for one year as a trial and that further research would require a new submission, as presented in WG-SAM-2019/28.

6.43 WG-SAM-2019/28 presented a proposal to continue the research in Subarea 48.1. The objectives were the same as the previous proposal, collection of data on stock structure, genetic samples and conducting plankton sampling. The vessel intended to start earlier to take advantage of less ice in the area and to conduct research in research blocks 481_1 and 481_2 only. The authors indicated that the plan was intended to collect data for one further year only, however, the research analysis and reporting would continue after the on-water activities were completed.

6.44 The Working Group reviewed the research proposal as an ongoing research proposal and summarised its advice for WG-FSA-2019 in Table 2.

Subarea 48.2

6.45 WG-SAM-2019/29 presented the results of the fifth year the longline survey was conducted by the Ukrainian vessel *Simeiz* in Subarea 48.2 in March–April 2019, as set out in WG-FSA-18/49. Significant reductions were noted in the CPUE of *D. mawsoni* in the survey area compared with 2018. Data on the CPUE of the target and main by-catch species, biological characteristics of toothfish and by-catch and seabird and marine mammal observations were presented. The authors noted there was no plan to continue fishing activities in 2019/20, but to instead focus on delivery of research objectives off the water.

6.46 The Working Group noted that the analysis of the work was ongoing and that following this preliminary report a more detailed research report on the survey in this area would be presented to WG-FSA-2019. It requested that the update include a time series summary of the CPUE within each research block in order to determine the local dynamics.

6.47 The Working Group recalled the discussion on the differences between C2 catch records and Catch Documentation Scheme for *Dissostichus* spp. (CDS) landings (paragraphs 4.5 to 4.7 and SC-CAMLR-XXXVII, paragraphs 12.3 and 12.4) that indicated that there may have been underestimation of the catch by the vessel taking part in this survey. Consequently, these differences should be considered in the analysis of trends in the CPUE from this research. The authors of WG-SAM-2019/29 reported that in 2019 there was no discrepancy between the reported catch and the verified landings in the CDS.

6.48 The Working Group noted that differences between C2 catch records and CDS landings provide a very useful means of highlighting where there may have been issues with catch data reporting that have the potential to impact the advice provided on catch limits. It welcomed the recommendation of the Scientific Committee that this information be routinely reported (SC-CAMLR-XXXVII, paragraph 3.39).

6.49 The Working Group noted the increase in the catch of grenadier through the survey time series and asked the survey authors to investigate what factors this resulted from including the survey design. The Working Group further requested a figure showing all fishing locations for the five years of the survey by year for WG-FSA, so that it would be better able to evaluate causes for the change in toothfish and grenadier CPUE.

6.50 The Working Group noted that the changes in toothfish CPUE were not a result of the gear type design as it had been consistent during the five years, therefore the variation resulted from changes in the underlying stock. The short survey by Chile in 2017 had not been included in the analysis. The survey had been of such limited effort that there could be no valid comparison between gears.

Subareas 48.2 and 48.4

6.51 Dr Darby noted that that the on-water activities of the UK research survey in the Subareas 48.2 and 48.4 survey, as described in WG-FSA-18/52, were completed in 2019 and that the survey analysis was now being conducted. A first report of the analysis would be presented to WG-FSA-2019. Further analyses of the results of the time series would be presented to WG-FSA as outlined in the timeline presented in WG-FSA-18/52.

Proposals and research results for toothfish from Subarea 58.4

Divisions 58.4.1 and 58.4.2

6.52 The Working Group considered WG-SAM-2019/20, which described the preliminary results of a modelling study of egg and larval transport of *D. mawsoni* in the East Antarctic region. The Working Group thanked the authors for this large body of work and noted that it could be a useful tool to assess different stock hypotheses including those developed at WS-DmPH as well as having potential for assessing larval transport patterns under different climate modes. The Working Group also noted that the model could be used to investigate the regional transport of krill or be coupled with microchemistry studies for toothfish connectivity.

6.53 The Working Group noted that a consistent trend in the model for particles to move onshore from the slope towards the shelf may suggest that there is a consistent requirement for adult fish to migrate and spawn offshore to enable eggs and larvae to return to shelf areas. The Working Group noted that bathymetry data are a key input to the model but the quality of these data varies from region to region.

6.54 WG-SAM-2019/26 provided an update of the second season of multi-Member toothfish research in Divisions 58.4.1 and 58.4.2. The Working Group recalled that only Division 58.4.2 was open for fishing in 2018/19. A vessel from Australia and one from France undertook research fishing in Division 58.4.2 during the 2018/19 season.

6.55 The Working Group agreed that the loss of a season's data from Division 58.4.1 has resulted in a break in the time series of the data collected in the division. This could cause a delay to the further development of a stock assessment and the ability of Scientific Committee to provide advice to the Commission for this division.

6.56 WG-SAM-2019/05 provided details for the continuation of a multi-Member research program on *D. mawsoni* in the exploratory fishery in East Antarctica (Divisions 58.4.1 and 58.4.2) from 2018/19 to 2021/22. Changes had been made to the research plan, including operational details and the addition of the larval and egg transport study (paragraphs 6.52 and 6.53) in the milestones. Research blocks will again be allocated between Members to ensure overlap between fishing gear types and vessels to enable further assessment of gear and vessel effects.

6.57 The Working Group recalled that the proposal had been thoroughly reviewed over the last three years by WG-SAM and WG-FSA and had achieved all research milestones as noted by the Scientific Committee in 2018 (SC-CAMLR-XXXVII, paragraph 3.138).

6.58 The Working Group considered WG-SAM-2019/19, a proposal by Russia for a three-year program of toothfish research within Divisions 58.4.1 and 58.4.2 within the same research blocks as the multi-Member research proposal. The stated objectives of the research are the same as for the multi-Member proposal but participation is restricted to vessels using autolines only, and includes three vessels from Russia. Russia invited other Members to participate in this research using vessels with the same autoline gear specifications. The objective is to collect data using a single standardised fishing gear using a random stratified design to allocate effort in research blocks and depth strata. The proposed catch limits for each research block are those agreed by the Scientific Committee in 2018, noting that research was not conducted in Division 58.4.1 in 2018/19. The catch limits proposed in the proposal are the same as those agreed for research in this division in 2018. The Working Group noted that these are based on data obtained from the research conducted to date within the research blocks under the multi-Member research effort.

6.59 The Working Group recalled its previous advice and that of WG-FSA, the Scientific Committee and the CCAMLR Performance Review that proponents of new research should seek to collaborate with Members who are currently participating in established research programs within the same area. It was noted that other Members were invited to participate in the Russian research but that it was restricted to vessels using autoline gear and that no approach had been made to Members prior to the submission of the proposal to WG-SAM.

6.60 The Working Group noted that Russia had notified three autoline vessels to participate in the research in Division 58.4.1 but that there were differences among the types of autoline gears used by each vessel. Two vessels (*Palmer* and *Volk Arktiki*) had notified to use a Mustad integrated weighted autoline system whilst the third (*Sparta*) used a Mustad system without an integrated weighted line. The Working Group also noted that tagging survival and detection statistics among vessels in the Ross Sea varied widely among autoline vessels, suggesting that using autoline vessels alone does not guarantee consistent performance.

6.61 The Working Group sought clarity from the proponents as to why there is a need to adopt a different approach to research within Division 58.4.1 and what the scientific basis for treating this region differently to others within the Convention Area is. The Working Group noted that multi-Member research is undertaken across the Convention Area by vessels using different fishing gears that has been used to set catch limits and develop integrated stock assessments.

6.62 Dr Kasatkina indicated that the issue of gear standardisation was a problem for data-limited fisheries across the Convention Area and that this issue should be addressed by conducting research using standardised gear that is appropriate for the research and region. This would provide improved data for estimating abundance, population structure, productivity indices and distribution of toothfish and by-catch.

6.63 The Working Group noted that CCAMLR has never specified the need for a prescribed ‘standard gear’ for research. It was noted that where long-term multinational ‘standardised’ trawl surveys are conducted elsewhere in the world, gear differs between participants reflecting local conditions.

6.64 The Working Group noted that the proposal from Russia provides details of how data will be collected from research fishing activities but there is considerable uncertainty and a lack of clarity as to which analyses will subsequently be undertaken and by whom. The Working Group also noted that there is no indication as to whether or not data collected in recent seasons as part of the multi-Member research in these divisions will be integrated into any subsequent analyses.

6.65 The Working Group requested that the proponents provide additional information on the fishable seabed area within each research block, and the number of stations that will be sampled by the survey and how the proposed catch limits are related to the survey design. The Working Group also noted that the survey design does not address temporal and spatial effects and that there is a lack of information as to how the research will be implemented, particularly if other Members’ vessels join the research program.

6.66 The Working Group noted that in order to increase its research fishing activities within the Convention Area, France has invested heavily to increase its research capacity (taking on an additional 3.5 staff) in order to achieve its research objectives. The Working Group noted that the Russian program is very ambitious, but it is not clear whether the capacity exists to undertake subsequent analyses (WG-FSA-2018 report, paragraph 4.167).

6.67 The Working Group recalled that a preliminary integrated stock assessment had been developed for Division 58.4.1 that had been reviewed by the WG-FSA-2018 (WG-FSA-2018 report, paragraph 4.108). It further noted that such an assessment relies on tag-recapture data and not standardised CPUE data and therefore the tagging performance of vessels undertaking research is an important consideration when assessing the likely success of a research program (WG-FSA-2017 report, paragraphs 3.69 to 3.71).

6.68 The Working Group highlighted additional issues with the research proposal for which greater clarity was required, including the provision of details of how existing data will be used within the planned research program. The Working Group requested more information on the sampling regime for by-catch and otolith collection which is restricted in the proposal to fish less than 150 cm in length, noting a large proportion of historical catch has been larger than this. The Working Group also requested that additional information is provided to address concerns that it will be difficult to conduct research in prescribed fine-scale rectangles when ice conditions are unpredictable and likely to impact on access.

6.69 The Working Group evaluated the research proposal against the standard criteria and format for research proposals as shown in Table 3.

6.70 The Working Group noted that a disruption to a survey time series would have a detrimental effect on the ability to provide advice to the Scientific Committee and the Commission. In order to avoid this disruption, any new proposals should be integrated within existing research in the area.

6.71 The Working Group recommended that the proponents evaluate the likelihood of success of the research both as described in the proposal where it is restricted to the participation of vessels from Russia, but also with the addition of other Members' vessels. In particular, further clarity is required on the distribution of effort within the fine-scale rectangles.

6.72 During the course of the meeting, Dr Kasatkina agreed to work intersessionally to develop a joint research proposal with the existing research proponents of Divisions 58.4.1 and 58.4.2 for consideration by WG-FSA-2019. This proposal would aim to address many of the issues highlighted in paragraphs 6.64 to 6.69. The Working Group welcomed this development and looked forward to seeing the outcomes of these intersessional discussions.

Division 58.4.4b

6.73 Following the discussions of WG-FSA-18 (WG-FSA-2018 report, paragraphs 4.132 and 4.134), WG-SAM-2019/01 presented an overview of the rate of killer whale (*Orcinus orca*) interactions, the estimated amount of depredated fish and new data on numbers and movements of killer whales using photo-identification for Division 58.4.4b. The paper also highlighted movements of individually identified killer whales observed between Division 58.4.4 and Subarea 58.6.

6.74 The Working Group noted that the depredation rates over time in research blocks 5844b_1 and 5844b_2 were 1.7% and 0% respectively. Further, the Working Group agreed that using the assumption that any killer whale observed near the vessel was interacting with the gear was a conservative one. The Working Group also agreed with the recommendation of the paper that photos should be taken when any killer whales are observed near the vessel to assist in the understanding of killer whale ecology and depredation behaviour in Area 58. It also agreed the best-practice action is to buoy off the line and return to haul once killer whales have left the area, in order to prevent learning and naive groups starting to interact.

6.75 WG-SAM-2019/08 presented an updated research plan for research blocks 5844b_1 and 5844b_2, proposing to continue the current research operation with updated research design to account for comments made by WG-SAM-18 and results presented at WG-FSA-18 and SC-CAMLR-XXXVII, Annex 12. The paper also highlighted the addition of one new vessel, the *Cap Kersaint*, to increase on-water capacity and that fishing for this season was still underway.

6.76 The Working Group noted that all milestones due for WG-SAM-2019 had been achieved. Upon reviewing the future milestones, the Working Group recommended that the milestone schedule be amended to deliver updated growth, maturity and ALKs to future WG-FSA meetings only and not require these to be reviewed by WG-SAM unless methodological issues need review. Additionally, it recommended separating the CASAL milestone into two; the first outlining CASAL developments which will be presented to future

WG-SAM meetings, and the second outlining CASAL evaluation which will be presented to WG-FSA meetings. The Working Group also suggested incorporating the calculation of harvest rate under varying scenarios of IUU and depredation.

6.77 The Working Group also noted that the two research blocks in Division 58.4.4b represent a small proportion of the Division 58.4.4 population, and consideration should be given to how the populations in these research blocks relate to the population in Division 58.4.4 more broadly and how to develop a stock hypothesis.

6.78 The Working Group noted that while the notified vessels have experience in tagging in other CCAMLR fisheries, tag survivability and detection rate estimates are not yet available for the vessels fishing in this area and it recommended that these be calculated for the vessels from France which have fished in Crozet and Kerguelen.

6.79 The Working Group reviewed the research proposal as an ongoing research proposal and summarised its advice for WG-FSA-2019 in Table 3.

Review of research proposals and results for toothfish from Area 88

Subarea 88.1

6.80 WG-SAM-2019/03 described the results from the 2019 Ross Sea shelf survey and the notification for the survey in 2020. The objectives of the survey included monitoring the abundance and age structure of sub-adult toothfish in the south of SSRUs 881J and 881L in the southern Ross Sea using standardised gear in a standardised approach, and monitoring trends in large sub-adult and adult toothfish in two areas situated in SSRU 881M which are of importance to mammalian toothfish predators.

6.81 The Working Group noted the importance of this time series of surveys for the Ross Sea region stock assessment in delivering a long-term time series of recruitment.

6.82 The Working Group reviewed the research proposal as an ongoing research proposal and summarised its advice for WG-FSA-2019 in Table 4.

6.83 The Working Group recalled the advice by the Commission in 2018 (CCAMLR-XXXVII, paragraph 5.30) that all continuing research in closed areas shall only be reviewed annually at WG-FSA and continuing research in exploratory fisheries be reviewed every second year at WG-FSA. The Working Group therefore recommended that the survey results paper be referred to WG-FSA-2019.

6.84 WG-SAM-2019/17 presented a proposal for a research program from 2019/20 to 2027/28 to investigate the life cycle, distribution and movement, biological parameters and stock structure of *Dissostichus* spp. in the eastern part of the Ross Sea over the shelf and continental slope in the Special Research Zone (SRZ).

6.85 The Working Group noted that the objectives and methods in this proposal were the same as in WG-FSA-18/33 Rev. 1 and recalled its discussion and advice from the WG-FSA-2018 report, paragraphs 4.155 to 4.168. It expressed concerns that this advice had not been addressed in this proposal and noted that:

(i) The survey design, in which vessels fish in separate areas, would not allow for vessel effects to be removed from the estimation of the monitored population characteristics. The Working Group recommended that overlapping sampling effort by each vessel would allow vessel effects to be disentangled, such as effective tagging survival and tag detection rates.

(ii) The systematic design of the survey in the first year would provide information on the distribution of the stock within the SRZ for the subsequent stratification of the research stations which is planned as part of this research proposal. However, the Working Group considered that there was sufficient information from the commercial fishery already available to allow for the survey to be stratified from the first year onwards. It also noted that using fixed stations can be impacted by high sea-ice concentrations and recommended that a more flexible random stratified design be considered.

(iii) A vessel with negligible recaptures of tags, and a vessel with unknown tagging performance were proposed for delivering the research objectives of this proposal based on information available in WG-FSA-17/36. The analysis of tagging performance will be updated for WG-FSA-2019.

(iv) Given the expected catch rates and the number of haul stations, it is unlikely that the survey could be completed within the proposed catch limits. Errors in the calculation of catch limits for this proposal need to be corrected.

(v) There are proposed sampling locations that are outside the SRZ and using geographic reference data for the SRZ from the CCAMLR geographic information system (GIS) would assist in presenting this information in a consistent projection.

(vi) The proponents should undertake a power analysis to determine the required number of survey stations given the research objectives (see e.g. WG-SAM-18/06).

6.86 The Working Group noted that the proposed survey design and methods in WG-SAM-2019/17 are unlikely to achieve the objectives of this research plan. However, it noted the high importance of the area and science within the SRZ (paragraphs 6.16 and 6.17), and that the Scientific Committee had identified that there was a high priority for research within this area. It encouraged the proponents to submit a revised version addressing the issues outlined in the paragraph above.

6.87 The Working Group evaluated the research proposal in WG-SAM-2019/17 against the criteria set out in the WG-FSA-2017 report, paragraph 4.7 (Table 4).

Subareas 88.2 and 88.3

6.88 WG-SAM-2019/11 provided a progress report on the joint research survey for *D. mawsoni* in Subarea 88.3 by the Republic of Korea (Korea) and New Zealand in 2018/19. The survey was undertaken by one Korean vessel in seven research blocks in SSRUs 883A–D. As a result of extreme ice conditions covering the southern part of Subarea 88.3, New Zealand was not able to access the area to conduct its part of the survey. The total survey catch was

63 840 kg, and catch rates showed regional differences among the research blocks, with similar CPUEs in research blocks 883_1, 883_3 and 883_4, and lower CPUEs in research blocks 883_5, 883_8 and 883_9.

6.89 The Working Group noted that there were four tags recaptured, which represents the first tag recaptures in Subarea 88.3 for *D. mawsoni*.

6.90 Dr Kasatkina noted that the two vessels that notified to undertake the research had different longline configurations, and that this may impact CPUE patterns between different research blocks. Dr S.-G. Choi (Korea) informed the Working Group that efforts to standardise between fishing gears would take place in research block 883_3 in the coming fishing season though spatial overlap of vessels with different gear-types, random station allocation and with scientific electronic monitoring systems on each vessel.

6.91 The Working Group also noted differences in the size composition of *D. mawsoni* in different research blocks throughout the region, and that northern and southern regions of the survey area have different size structures.

6.92 WG-SAM-2019/02 provided details for an integrated survey for *D. mawsoni* in Subarea 88.3 for the 2019/20 fishing season by Korea, New Zealand and Ukraine. The Working Group noted that this research was entering the third and final year of a joint research proposal by Korea and New Zealand, endorsed in 2017/18, and this proposal was designed to build on Korea’s previous research by continuing to focus on research blocks where tagged fish have previously been released on the slope, while also prospecting two northern seamount complexes and two areas on the continental shelf, where no research has occurred.

6.93 The Working Group noted that WG-SAM-2019/02 was developed following a proposal from the Ukraine to join the research plan in 2018. The Scientific Committee requested an integrated proposal be developed for all three Members (SC-CAMLR-XXXVII, paragraph 3.191). The Working Group noted that the objectives of the integrated proposal were unchanged from the original proposal, and included secondary objectives to improve understanding of stock structure in Subarea 88.3, carry out calibration trials among the vessels, collect data on the spatial and depth distributions of by-catch species and to trial scientific electronic monitoring technologies.

6.94 The Working Group noted the intention to undertake gear calibration experiments with spatial overlap of vessels to take place in research block 883_3 and scientific electronic monitoring on all vessels engaged in the research. It was further noted that an additional milestone was added to account for off-water research activity. The Working Group agreed that a full review of this survey be undertaken after the 2019/20 season, and that a new proposal will be required for the 2020/21 fishing season.

6.95 The Working Group noted recent environmental changes that have taken place adjacent to research block 883_2, where there have been recent significant calving events of the Pine Island glacier that may result in future logistic problems in relation to access to this research block.

6.96 The Working Group recommended that details and catch limits be specified in research blocks following the specific nomenclature set out in SC-CAMLR-XXXVII, Table 1.

6.97 The Working Group reviewed the research proposal and summarised its advice for WG-FSA-2019 in Table 4.

Review of research proposals and results for other species

Icefish trawl survey proposal

6.98 WG-SAM-2019/29 presented a draft proposal to WG-SAM for feedback, to conduct a local survey of mackerel icefish (*Champsocephalus gunnari*) by midwater trawl in Subarea 48.2. The proposal indicated a research area on the shelf and slope west of the South Orkney Islands in February–April 2020. The survey would be conducted as a limited effort series (37 trawl stations) with a precautionary catch limit of 70 tonnes.

6.99 The Working Group noted that discussions on the design of surveys for icefish in Subarea 48.2 had occurred at length at WG-SAM and WG-FSA during the previous few years in relation to the Chilean survey in the region. Icefish are both demersal and pelagic and catches in the water column can be highly variable. A purely pelagic trawl survey would not provide information on the total stock in the area and consequently the utility of such a survey in the determination of stock abundance was not considered appropriate. The design and the methodology to be applied during the survey was not clear, in particular whether the survey was a multibeam acoustic survey in which species aggregations were targeted for identification or whether the survey was purely a grid of survey stations at which a trawl would be deployed.

6.100 The authors thanked the Working Group for its comments and noted that they would review the feedback and revisit the proposal at a future meeting.

Crab research results and proposals

6.101 WG-SAM-2019/31 reported on the outcomes of the first year of research fishing for Lithodidae (Anomura, Decapoda) in the Amundsen and Bellingshausen Seas in 2019. The activities took place in March 2019 and two species were caught: *Paralomis birsteini* and *Neolithodes yaldwini*. Results included length–weight relationships, length distributions, sex ratios and reproductive state, and samples were collected for histological, genetic, isotope and parasite studies. By-catch of *D. mawsoni*, Whitson’s grenadier (*Macrourus whitsoni*) and *Chionobathyscus dewitti* was reported, for which length and weight were taken. Otoliths were sampled from 12 of the 17 by-caught toothfish, and two toothfish were tagged and released. The authors informed the Working Group that due to the short time between the end of the Commission meeting in 2018 and the start of the 2018/19 season, video cameras were not available to the vessels in time, but that these would be deployed in the following year together with salinity-temperature-depth probes. The authors invited suggestions for which video camera equipment would be most suitable to withstand the pressure at depths fished.

6.102 The Working Group noted that the locations for some of the pots set deviated from those in the initial proposal, due to operational constraints with environmental conditions and sea-ice. It further noted that some of the toothfish caught in Subarea 88.3 were small (<70 cm), which for a region where information is limited and efforts are under way to improve knowledge of local toothfish stocks (paragraphs 6.88 to 6.97) is important information, and welcomed the collection of otoliths. The authors informed the Working Group that more detailed by-catch analyses would be presented at WG-FSA-2019.

6.103 The Working Group recalled previous research (WG-FSA-96/35; Watters and Hobday, 1998) that showed allometric relationships between carapace length and chela size can be used to determine size at sexual maturity, and such additional information on allometric measurements would bring additional benefit to this research investigating the life history of these species. The Working Group recalled that WG-FSA had noted (WG-FSA-2018 report, paragraph 4.210) the opportunity of this program to test two concurrent scientific hypotheses, whether Lithodidae were endemic or invasive species to this region, and noted that collecting environmental data would be fundamental to resolving this question.

6.104 The Working Group wished to highlight this research to WG-EMM-2019 and WG-FSA-2019, as approximately 45 pots were lost during operations as well as a further 30 damaged, and there was some concern about the potential to impact seabed communities in this area.

6.105 The Working Group requested that the proposed catch limits be reviewed by WG-FSA to reflect the actual catch rates from 2019 together with the proposed effort.

6.106 The Working Group requested that the reporting forms specified by the Scientific Committee (SC-CAMLR-XXXVII, paragraph 4.3) be considered by WG-FSA-2019 to ensure they are consistent with the recent reviews of the trawl and longline data reporting forms.

6.107 WG-SAM-2019/18 provided a proposal to continue the investigation on species composition, biology, life cycle, distribution, and structure of Lithodidae stocks (Anomura, Decapoda) in Subareas 88.2 and 88.3, to further assess their resource potential. The proposal provided two options, one to continue under CM 24-01, and the other to move to a new fishery under CM 21-01 (paragraphs 8.7 and 8.8).

6.108 The Working Group reviewed the research proposal for Lithodidae by Russia given in WG-SAM-2019/18. The research program has four main objectives, including to improve understanding of species distribution and life history, assess the resource potential and commercial significance, contribute to ecosystem approach to managing fisheries in Subareas 88.2 and 88.3, and contribute to spatial management of fisheries in Area 88.

6.109 The Working Group suggested investigating the possibility of using methods such as the CPUE × seabed area along with available habitat to try and develop an understanding of distribution and relative abundance to provide advice on appropriate precautionary catch limits of this research proposal.

6.110 The Working Group requested that, should the research go ahead, data also be collected on viability of the large percentage of crabs being returned to sea, in line with studies carried out previously and presented in WG-FSA-00/24.

6.111 The Working Group reviewed the research proposal and summarised its advice for WG-FSA-2019 in Table 4.

Future work

WG-SAM workplan

7.1 The Working Group identified strategic work areas for consideration by the Scientific Committee. The Working Group noted that the Strategic Plan was last updated in 2016, and the current five-year work plan should be updated.

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

(i) develop ecosystem models for toothfish

(ii) promote interaction between WG-SAM and WG-EMM on methods and survey design

(iii) review new stock assessments developing from research plans

(iv) implementation of recommendations of the CCAMLR Independent Stock Assessment Review for Toothfish

(v) development of integrated assessments at population scale

(vi) management strategy evaluations

(vii) Scientific Committee on Antarctic Research (SCAR) joint symposium on 'role of fish in Antarctic ecosystems'

(viii) uncertainty in linear trend analysis catch limits

(ix) implementing CCAMLR decision rules with F-based assessments

(x) methodologies for spatially explicit risk assessments with regard to krill but also by-catch or protected species

(xi) develop toothfish tagging best practices

(xii) development of current method and alternatives for calibration between vessels for tagging survival and tag detection

(xiii) operating models for CCAMLR fisheries (e.g. krill and toothfish)

(xiv) development of a strategic plan within WG-SAM

(xv) further streamlining of review processes to focus on quantitative methods

(xvi) CASAL 2 development

(xvii) methods for multivessel research designs.

7.3 The Working Group requested that the Scientific Committee consider developing an overarching strategic direction for the work plan to more clearly define the role of the Working Group, noting that cross-links with SG-ASAM and WG-EMM could create opportunities for sharing of scientific expertise on high-priority quantitative work areas.

Research plan timeline

7.4 The Working Group noted that CM 24-01 notification requirements may be confusing and may conflict with the updated review procedure agreed by the Commission (CCAMLR-XXXVII, paragraph 5.30). The Working Group noted that most research plans were being annually reviewed by the Working Group.

7.5 The Working Group noted that a timeline is required for research plans in order to effectively monitor, strategically align and clarify the review process for each research plan.

7.6 The Working Group noted that the three-year restriction of research plans adopted by the Commission in 2018/19 relates to the elements of the research that require an exemption from conservation measures, and that analysis of data and samples collected is able to be completed outside of this time period.

7.7 The Working Group requested that a description of the current review timeline be developed intersessionally by the Scientific Committee Bureau, to clarify the process for proponents and provide an opportunity for the Scientific Committee to review and further streamline the notification and review of research plans.

Other business

Fishing location reporting

8.1 WG-SAM-2019/22 examined the potential for difference between the location of gear on the sea floor and the vessel location as reported on C2 forms for longline sets in exploratory fisheries. All gear types were estimated to achieve similar sink rates and the potential differences in the coordinates between setting and hauling increased with depth and in areas of high current velocities.

8.2 The Working Group noted that while the authors of WG-SAM-2019/22 suggested revising the radius of risk areas around potential VMEs from 1 n mile to 1.5 n miles, further work would be required to examine the effect of other factors, including incorporating the improvements in the vessel positioning systems through time, and the observed sink rates of lines based on the weights of line anchors and on gear positioning on the sea floor relative to the vessel location.

Skate ageing

8.3 The Working Group considered WG-SAM-2019/10 which described a protocol to mark Antarctic starry skate (*Amblyraja georgiana*) chemically in order to validate the thorn ageing method. This protocol represents a simple addition that will complement the aims of the skate tagging program in the Ross Sea in 2020 and 2021 (WG-FSA-2018 report, paragraphs 6.34 to 6.36).

8.4 The Working Group welcomed the offer from Dr Parker to provide the necessary hardware and training to scientists on vessels transiting through New Zealand en route to the

Ross Sea to encourage participation in this program. WG-SAM-2019/10 provided examples of the vendors for injection materials and instructions for how to tag and chemically mark the skates.

Satellite tagging of toothfish outside the Convention Area

8.5 WG-SAM-2019/12 presented the details of a plan for a study on *D. eleginoides* in the southwest Atlantic (FAO Area 41) using satellite tags. The main objectives of the study are to investigate movements of the species and the connectivity between FAO Area 41 and the Convention Area by deploying a total of 50 pop-up satellite archival tags on adult *D. eleginoides* over two years from Korean longline vessels.

8.6 The Working Group welcomed this initiative and its initial results that showed toothfish undertaking regular, extensive vertical movements and noted its potential to improve our understanding of *D. eleginoides* in this area.

New fishery notification

8.7 WG-SAM-2019/21 outlined a proposal from Russia for a new fishery for crabs in Subareas 88.2 and 88.3 in accordance with CM 21-01 based on the recommendations of the Scientific Committee (SC-CAMLR-XXXVII, paragraph 4.3).

8.8 The Working Group noted that the process for the notification for a new fishery had both administrative and scientific components and that the discussion on this fishery in paragraphs 6.102 to 6.111 should form an important part of the process.

Advice to the Scientific Committee

9.1 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) consideration of the implications of potential underestimation of catches in exploratory fisheries by WG-FSA and SCIC (paragraph 4.6)

(ii) specification of requirements for research fishing being proposed in MPAs (paragraphs 6.16, 6.17 and 6.19)

(iii) recommendation that the low tag-overlap statistic for the survey in Subarea 48.1 be reviewed by SCIC (paragraph 6.38)

(iv) request for the reporting forms specified by the Scientific Committee for crab research to be made available to WG-FSA-2019 (paragraph 6.106)

(v) request that a description of the current review timeline be developed intersessionally by the Scientific Committee Bureau (paragraph 7.7).

Adoption of report and close of meeting

10.1 In closing the meeting, Dr Parker thanked all participants for their hard work in preparation for, and engagement in, the Working Group meeting.

10.2 Dr Parker thanked the hosts for the excellent facilities and stunning venue for the meeting, as well as the support provided by the team from the Muséum national d'Histoire naturelle that had all contributed to such a successful Working Group meeting.

10.3 Dr Péron also thanked all participants and, in particular, Dr Parker for his mentorship that had allowed for a very positive handover of the role of Convener.

10.4 On behalf of the Scientific Committee and the Working Group, Dr Belchier thanked Drs Parker and Péron for their successful co-convening of the meeting. He thanked Dr Parker for his five years of convening the Working Group in a very agreeable and languid style that had delivered much progress in the development of the research in data-limited fisheries.

References

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Watters, G. and A.J. Hobday. 1998. A new method for estimating the morphometric size at maturity of crabs. *Can. J. Fish. Aquat. Sci.*, 55 (3): 704–714.

Welsford, D.C. 2011. Evaluating the impact of multi-year research catch limits on overfished toothfish populations. *CCAMLR Science,* 18: 47–56.

Table 1: Factors that are considered to be important in the design of data collection and analysis of key datasets. * Vessel is a proxy for other factors such as crew, skipper, and other vessel specific operational effects.

Datasets/parameters to be estimated	Influential factors													
		Fishing										Environmental		
	Tag rate	Bait	Depredation	Gear	Hook number	Hook type	Location	Nationality	Soak time	Time	Vessel*	Depth	Temperature	Salinity
Abundance														
CPUE		X	X	X	X	X	X	X	X	X	X	X	X	X
Tags	X						X			X	X			
Life history														
Mortality			X				X			X				
Recruitment		X	X	X	X	X	X	X	X	X	X	X		
Growth							X			X		X	X	
Maturity							X			X		X	X	
Length/weight							X			X		X	X	
Stock structure														
Distribution		X	X	X	X	X	X	X	X	X	X	X	X	X
Age							X			X		X	X	
Size							X			X		X	X	
Genetics							X			X				
Ecosystem														
By-catch		X	X	X	X	X	X	X	X	X	X	X	X	X
Diet							X		X	X		X		
VME				X	X	X	X	X			X	X	X	X

Table 2: Summary of the assessment of the new and underway Area 48 research proposals against the criteria set out in WG-FSA-2017 report, paragraph 4.7. Summary of the rationale behind the scores are in the notes below, and the table should be taken in the context of the details in paragraphs 6.21 to 6.44. TBD indicates that catch limits will be discussed at WG-FSA.

Subarea:	48.1	48.6
Proposal and country/criteria:	WG-SAM-2019/28 Ukraine (year 1 of 1)	WG-SAM-2019/13 Japan, South Africa and Spain (year 2 of 3)
Conservation measure under which proposal submitted	24-01	21-02
(i) (a) Is the proposed research likely to generate an index of local stock abundance?	N[2]	Y
(b) Is the proposed research likely to generate estimates of biological parameters relating to productivity?	Y	Y
(c) Is the proposed research likely to test a hypothesis of relationship of fish in the research area to the overall stock?	Y	Y
(ii) Is the catch limit for the proposed research plan sufficient to achieve the agreed research objectives and consistent with Article II of the Convention?	TBD	TBD
(iii) Are the likely impacts from the proposed research to dependent and related species consistent with Article II?	N[1]	N[4]
(iv) Does the proposed research contain the details needed for WG-SAM, WG-FSA and the Scientific Committee to evaluate the likelihood of success, and relevant milestones specified with the detail necessary to evaluate the likelihood of success of the proposal?	Y	N[3]
(v) Do the proposed research platforms intended for this work have demonstrated experience and performance in toothfish tagging programs?	Y[5]	Y[5]
(vi) Has the collective research team demonstrated a thorough understanding of environmental conditions and associated logistics and capacity to carry out the proposed research plan (on the water)?[6]	N[2]	Y
(vii) Has the collective research team demonstrated experience and sufficient resources and capacity, or identified a reliable mechanism, for analysis of data to achieve the objectives of the research (data and sample analyses)?[6]	N[8]	N[1]
(viii) Has the research team demonstrated achieving all milestones in previous proposals for this area, or provided a reasonable account of why some milestones were not able to be achieved?	Y[9]	N[7]

Table 2 (continued)

Notes:

1. There is not enough information in the proposal.
2. There are concerns about the repeated accessibility of the fishing grounds due to sea-ice (WG-FSA-2018 report, Figure 5).
3. Not all milestones were sufficiently specified in the proposal (paragraphs 6.30 to 6.33).
4. Requires more data analysis.
5. Based on vessel tagging detection and survival rates in WG-FSA-17/36.
6. Based on milestones not being achieved on the assessment of biological parameters, analyses of by-catch species, seabirds and marine mammals.
7. Based on milestones not being achieved on productivity parameters.
8. There is concern that the vessel did not meet the tag-overlap statistic requirement or the tag-rate requirement.
9. Refer to comments in text under paragraphs 6.73 to 6.79.

Table 3: Summary of the assessment of the new and underway Area 58 research proposals against the criteria set out in WG-FSA-2017 report, paragraph 4.7. Summary of the rationale behind the scores are in the notes below, and the table should be taken in the context of the details in paragraphs 6.52 to 6.78. TBD indicates that catch limits will be discussed at WG-FSA.

Division:	58.4.4b	58.4.1 and 58.4.2	58.4.1 and 58.4.2
Proposal and country/criteria:	WG-SAM-2019/08 France and Japan (year 3 of 5)	WG-SAM-2019/05 Australia, France, Japan, Republic of Korea, Spain (year 2 of 4)	WG-SAM-2019/19 Russia (year 1 of 3)
Conservation measure under which proposal submitted	24-01	21-02	21-02
(i) (a) Is the proposed research likely to generate an index of local stock abundance?	Y	Y	N[1]
(b) Is the proposed research likely to generate estimates of biological parameters relating to productivity?	Y	Y	N[1]
(c) Is the proposed research likely to test a hypothesis of relationship of fish in the research area to the overall stock?	N[8]	Y	N[1]
(ii) Is the catch limit for the proposed research plan sufficient to achieve the agreed research objectives and consistent with Article II of the Convention?	TBD	TBD	TBD
(iii) Are the likely impacts from the proposed research to dependent and related species consistent with Article II?	Y	Y	N[1]
(iv) Does the proposed research contain the details needed for WG-SAM, WG-FSA and the Scientific Committee to evaluate the likelihood of success, and relevant milestones specified with the detail necessary to evaluate the likelihood of success of the proposal?	Y	Y	N[1,4]
(v) Do the proposed research platforms intended for this work have demonstrated experience and performance in toothfish tagging programs?	N[2]	N[3]	N[5]
(vi) Has the collective research team demonstrated a thorough understanding of environmental conditions and associated logistics and capacity to carry out the proposed research plan (on the water)?[7]	Y	Y	N[6]
(vii) Has the collective research team demonstrated experience and sufficient resources and capacity, or identified a reliable mechanism, for analysis of data to achieve the objectives of the research (data and sample analyses)?[7]	Y	Y	N[1]
(viii) Has the research team demonstrated achieving all milestones in previous proposals for this area, or provided a reasonable account of why some milestones were not able to be achieved?	Y	Y	N[7]

(continued)

Table 3 (continued)

Notes:

1. There is not enough information in the proposal.
2. The proposed vessels have multiple years of experience but have unknown calculated effective survival rates.
3. The vessels proposed by Australia and Spain have demonstrated experience and performance in toothfish tagging programs based on the vessel tagging detection and survival rates in WG-FSA-17/36. The vessel proposed by the Republic of Korea has limited tagging experience and unknown calculated effective survival rates. The vessels proposed by France and Japan have tagging experience but unknown effective survival rates.
4. Increased biological sampling rates would be required to achieve objectives.
5. Of the three vessels proposed for this research, two have calculated tag detection and survival statistics, one of which has a negligible tag-survival rate (WG-FSA-17/36). The *Arctic Wolf* has no calculated tag-performance statistics available.
6. The proposed vessels would be new to fishing in that area.
7. Priority should be given to the completion of research programs already in place over new research proposals.
8. Refer to report text.

Table 4: Summary of the assessment of the new and underway Area 88 research proposals against the criteria set out in WG-FSA-2017 report, paragraph 4.7. Summary of the rationale behind the scores are in the notes below, and the table should be taken in the context of the details in paragraphs 6.80 to 6.86. n/a indicates not applicable.

Subarea:			88.1		88.2/3	88.3
Proposal and country/criteria:			WG-SAM-2019/17 Russia (year 1 of 9)	WG-SAM-2019/03 New Zealand (year 3 of 5)	WG-SAM-2019/18 Russia (year 1 of 3)	WG-SAM-2019/02 Republic of Korea, New Zealand and Ukraine (year 3 of 3)
Conservation measure under which proposal submitted			24-01	24-01	24-01	24-01
(i)	(a)	Is the proposed research likely to generate an index of local stock abundance?	Y	Y	N[5]	Y
	(b)	Is the proposed research likely to generate estimates of biological parameters relating to productivity?	Y	Y	Y	Y[2]
	(c)	Is the proposed research likely to test a hypothesis of relationship of fish in the research area to the overall stock?	Y	Y	N[6]	Y
(ii)		Is the catch limit for the proposed research plan sufficient to achieve the agreed research objectives and consistent with Article II of the Convention?	TBD	TBD	TBD	TBD
(iii)		Are the likely impacts from the proposed research to dependent and related species consistent with Article II?	Y	Y	N[7]	Y
(iv)		Does the proposed research contain the details needed for WG-SAM, WG-FSA and the Scientific Committee to evaluate the likelihood of success, and relevant milestones specified with the detail necessary to evaluate the likelihood of success of the proposal?	N[8]	Y	Y[9]	Y
(v)		Do the proposed research platforms intended for this work have demonstrated experience and performance in toothfish tagging programs?	N[10]	Y[1]	N[11]	N[3]
(vi)		Has the collective research team demonstrated a thorough understanding of environmental conditions and associated logistics and capacity to carry out the proposed research plan (on the water)?	Y	Y	Y[7]	Y
(vii)		Has the collective research team demonstrated experience and sufficient resources and capacity, or identified a reliable mechanism, for analysis of data to achieve the objectives of the research (data and sample analyses)?[5]	Y	Y	Y	Y
(viii)		Has the research team demonstrated achieving all milestones in previous proposals for this area, or provided a reasonable account of why some milestones were not able to be achieved?	N[12]	Y	Y	N[4]

(continued)

Table 4 (continued)

Notes:

1. Based on vessel tagging detection and survival rates in WG-FSA-17/36.
2. Aging data still to be provided.
3. Tagging statistics are not available for the vessels proposed by the Republic of Korea or Ukraine, but they are part of the experimental design.
4. Milestones have been delayed due to the New Zealand vessel not fishing in 2017/18 or 2018/19 due to ice conditions.
5. There is no information available on the distribution of the target species within CCAMLR data, and therefore no relation to the overall stock is possible from this limited area survey.
6. Alternative hypotheses exist for estimating crab populations in the Southern Ocean
7. The proponent has not addressed the potential environmental impact of a large amount of lost gear.
8. The Working Group recommended a review after one year of the research program.
9. Additional information is needed on biological parameters and the potential for high discard mortality.
10. Of the four vessels proposed for this research three have calculated tag detection and survival statistics, and one of these vessels has a negligible tag survival rate (WG-FSA-17/36).
11. Of the two vessels proposed for this research only one has calculated tag detection and survival statistics (WG-FSA-17/36).
12. Analyses are pending for this region.

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Working Group on Statistics, Assessments and Modelling
(Concarneau, France, 17 to 21 June 2019)

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Appendix B

Agenda

Working Group on Statistics, Assessments and Modelling
(Concarneau, France, 17 to 21 June 2019)

1. Introduction

2. Opening of the meeting

    2.1 Adoption of the agenda and organisation of the meeting

3. Assessments to estimate sustainable yield

4. Cross-cutting issues in longline fisheries affecting data quality

    4.1 Tagging
    4.2 Generic

5. Data Services Advisory Group (DSAG)

6. Review of research plan proposals and results

    6.1 Proposals and research results from Area 48

        6.1.1 Subarea 48.6
        6.1.2 Subareas 48.1 and 48.2

    6.2 Proposals and research results from Subarea 58.4

        6.2.1 Divisions 58.4.1 and 58.4.2
        6.2.2 Division 58.4.4

    6.3 Review of research proposals and results for Area 88

        6.3.1 Subarea 88.1
        6.3.2 Subareas 88.2 and 88.3

7. Future work

8. Other business

9. Advice to the Scientific Committee

10. Adoption of report and close of meeting.

Appendix C

List of Documents

Working Group on Statistics, Assessments and Modelling
(Concarneau, France, 17 to 21 June 2019)

WG-SAM-2019/01	Update report on marine mammal interactions in Division58.4.4 N. Gasco, P. Tixier, T. Okuda, C. Péron and F. Massiot-Granier
WG-SAM-2019/02	Integrated research proposal for *Dissostichus* spp. in Subarea 88.3 by the Republic of Korea, New Zealand and Ukraine Delegations of the Republic of Korea, New Zealand and Ukraine
WG-SAM-2019/03	2019 Ross Sea shelf survey results and notification for research in 2020 S. Parker and C. Jones
WG-SAM-2019/04	A preliminary model-based approach for estimating natural mortality of Antarctic toothfish (*Dissostichus mawsoni*) in the Ross Sea Region B. Moore, S. Mormede, S. Parker and A. Dunn
WG-SAM-2019/05	Continuation of multi-Member research on the *Dissostichus mawsoni* exploratory fishery in East Antarctica (Divisions 58.4.1 and 58.4.2) from 2018/19 to 2021/22 Delegations of Australia, France, Japan, Republic of Korea and Spain
WG-SAM-2019/06	Fisheries research within the Ross Sea region Marine Protected Area S. Parker and A. Dunn
WG-SAM-2019/07	Tag linking – revised algorithm (2019) Secretariat
WG-SAM-2019/08	Revised proposal for the ongoing research plan on Patagonian toothfish (*Dissostichus eleginoides*) in Division 58.4.4b (2016/17–2020/21) Delegations of Japan and France
WG-SAM-2019/09	Statistical modelling of by-catch patterns: a preliminary case study using research fisheries in Subarea 48.6 K. Sawada and T. Okuda

WG-SAM-2019/10	Chemical marking protocols for Antarctic starry skate age validation M. Francis and S. Parker
WG-SAM-2019/11	Progress report on the joint research for *Dissostichus* spp. in Subarea 88.3 by the Republic of Korea and New Zealand in 2018/19 Delegations of the Republic of Korea and New Zealand
WG-SAM-2019/12	Patagonian toothfish tagging study plan in the southwest Atlantic (FAO Area 41) C.H. Lam, K.J. Park, J. Lee and S.-G. Choi
WG-SAM-2019/13 Rev. 1	Proposed continuation of a multi-Member longline survey on Antarctic toothfish (*Dissostichus mawsoni*) in Statistical Subarea 48.6 in 2019/20 by Japan, South Africa and Spain Delegations of Japan, South Africa and Spain
WG-SAM-2019/14	The factors causing impact on the toothfish catch estimation on board of fishing vessels K. Demianenko, P. Zabroda, I. Slypko, L. Pshenichnov, A. Bazhan, O. Diripasko and D. Marichev
WG-SAM-2019/15	Analysis of the sea-ice concentration (SIC) in Subarea 48.6, research blocks 2, 3, 4 and 5 with sea-surface temperature (SST) and statistical models T. Namba, R. Sarralde, H. Pehlke, K. Teschke, T. Brey, S. Hain, T. Ichii, T. Okuda, S. Somhlaba and J. Pompert
WG-SAM-2019/16	Oceanographic study of the Subarea 48.6 with sea-surface temperature (SST) anomaly and vertical profile of sea temperature (PST) T. Namba, R. Sarralde, T. Ichii, T. Okuda, S. Somhlaba and J. Pompert
WG-SAM-2019/17	Research program to examine the life- cycle and resource potential of *Dissostichus* spp. in the Special Research Zone within the Ross Sea region marine protected area (RSRMPA) in 2019–2027 Delegation of the Russian Federation
WG-SAM-2019/18	Continuation of the research program on study of life cycle, species compositions, biology and resource potential of craboids (Anomura, Decapoda) in the Pacific Ocean Antarctic Area from 2019/20 to 2020/21 by Russian Federation Delegation of the Russian Federation

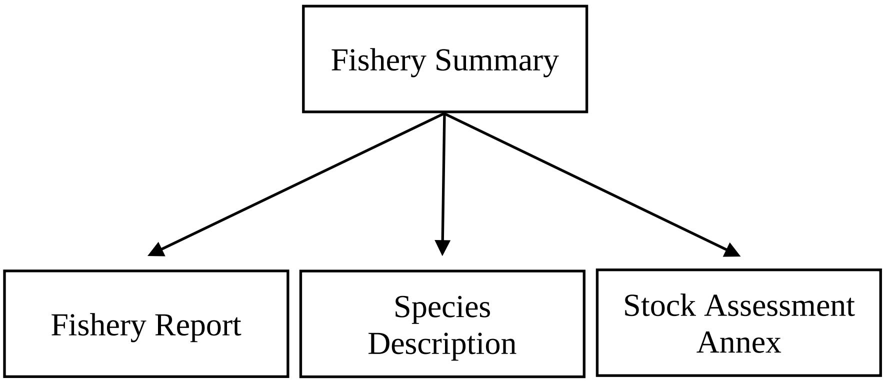
WG-SAM-2019/19	Research program on *Dissostichus* spp. in Divisions 58.4.1 and 58.4.2 from 2019/20 to 2021/22 Delegation of the Russian Federation
WG-SAM-2019/20	Modelling egg and larval transport of Antarctic Toothfish (*Dissostichus mawsoni*) in the East Antarctic region: Plan M. Mori, K. Mizobata, T. Okuda and T. Ichii
WG-SAM-2019/21	Proposal on establishment of a new fishery for craboids (Anomura, Decapoda) in the Subareas 88.2 and 88.3 Delegation of the Russian Federation
WG-SAM-2019/22	On acceptable scattering of longlines geo-referencing in the toothfish fishery in the CAMLR Convention Area O. Krasnoborodko
WG-SAM-2019/23	Information about methods for finding lost longlines P. Zabroda and L. Pshenichnov
WG-SAM-2019/24	A preliminary proposal to conduct a local survey of the *Champsocephalus gunnari* by the midwater trawl in the Statistical Subarea 48.2 Delegation of Ukraine
WG-SAM-2019/25	Exploration of CPUE standardisation variances in the Ross Sea (Subareas 88.1 and 88.2A South of 70°s) Antarctic toothfish (*Dissostichus mawsoni*) exploratory longline fishery D. Maschette, S. Wotherspoon and P. Ziegler
WG-SAM-2019/26	Report on joint exploratory fishing in Divisions 58.4.1 and 58.4.2 between the 2011/12 and 2018/19 fishing seasons Delegation of Australia
WG-SAM-2019/27	Planned updates for the integrated stock assessment for the Heard Island and McDonald Islands Patagonian toothfish (*Dissostichus eleginoides*) fishery in Division 58.5.2 P. Ziegler and J. Dell
WG-SAM-2019/28	Ukraine proposes to continue a scientific survey of *Dissostichus* spp. by bottom longline in the eastern part of Subarea 48.1 in a season 2019/20 Delegation of Ukraine
WG-SAM-2019/29	The preliminary report on the survey in Subarea 48.2 in 2019 Delegation of Ukraine

WG-SAM-2019/30	Revised CASAL model for *D. eleginoides* with updated biological parameters at Division 58.4.4b T. Okuda and F. Massiot-Granier
WG-SAM-2019/31	Report on implementation of research program for study of species composition, biology and resource potential of craboids (Anomura, Decapoda) in the Antarctic Pacific in 2019 Delegation of the Russian Federation
WG-SAM-2019/32	An exploration of the biological data used in the CCAMLR Subarea 48.3 Patagonian toothfish stock assessments E. MacLeod, K. Bradley, T. Earl, M. Söffker and C. Darby
WG-SAM-2019/33	Informational report on research fishing for *Dissostichus* spp. in Subarea 48.1 by Ukraine in 2019 P. Zabroda, L. Pshenichnov and K. Demianenko
WG-SAM-2019/34	Proposals on standardization of toothfish resource research S. Kasatkina
WG-SAM-2019/35	Updates to Fishery Reports – A prototype based on the 'Exploratory fishery for *Dissostichus mawsoni* in Subarea 48.6' Fishery Report Secretariat
WG-SAM-2019/36	Updated biological parameters of *Dissostichus mawsoni* at Subarea 48.6 T. Okuda and R. Sarralde Vizuete
WG-SAM-2019/37	A development of catch per unit effort (CPUE) trends that may be useful in stock assessment for *Dissostichus mawsoni* in Subarea 48.6 S. Somhlaba, K. Leach, M. Bergh, T. Okuda, T, IIchi, R. Sarralde and T. Namba

Appendix D

Fishery Report structure

Hierarchical structure of the future set of documents to communicate CCAMLR fisheries activities.



Fishery Summary

Map of the region
Image of organism with species name
Plot of time-series of catch and catch limits
Summary table:

- Stock status
- Conservation measures in force (with links)
- Wider environmental considerations (e.g. seabirds, vulnerable marine ecosystem (VME))
- Type of fishery (e.g. exploratory, Conservation Measure (CM) 24-01)
- Vessel type and gears involved

Links to relevant Fishery Report, Species Description and Stock Assessment Annex

Fishery Report

Title
Picture of organism
Map

Table of contents

Sections:

1. **Introduction to the fishery**
   History, conservation measures currently in force, active vessels, timeline of spatial management (e.g. changes, additions/removal of research blocks)
2. **Reported catch**
   Season and value of peak catch, catch table, catch limits
   By-catch
   Vulnerable marine ecosystems (VMEs)
   Incidental mortality of seabirds and marine mammals
3. **Illegal, unreported and unregulated (IUU) fishing**
4. **Data collection**
   CCAMLR Scheme of International Scientific Observation (SISO)
   What is collected and under which conservation measure
   Length-frequency distributions
   Tagging
   CCAMLR Ecosystem Monitoring Program (CEMP)
5. **Research**
   Research plans, advice by the Scientific Committee, status of the science (full assessment or other approach), climate change
6. **Stock status**
   Catch vs limit/SSB/year-class strength (YCS)/exploitation time-series plots
   Summary of current status (%B_0, current biomass, expected biomass at the end of the projection period)
   Assessment method (integrated model, trend analysis, etc.)
   Year of last assessment, year of next assessment
7. **Environmental variability**
   Changes in biological parameters and productivity assumptions and potential impact on management advice

Species Summary

Image of organism
Map of reported catch in the Convention Area
Life-history description
Parameter estimates
Relevant conservation measures

Stock Assessment Annex

Structure to be determined by e-group intersessionally (WG-FSA-2018 report, paragraph 2.33).

Report of the Working Group on
Ecosystem Monitoring and Management
(Concarneau, France, 24 June to 5 July 2019)

Contents

Report of the Working Group on Ecosystem Monitoring and Management

(Concarneau, France, 24 June to 5 July 2019)

Introduction

Opening of the meeting

1.1 The 2019 meeting of WG-EMM was held at the Concarneau Marine Station in Concarneau, Finistère, France, from 24 June to 5 July 2019. The meeting was convened by Dr C. Cárdenas (Chile) who welcomed participants (Appendix A). The meeting was hosted by the Muséum national d'Histoire naturelle (MNHN) and Dr M. Eléaume (Curator of Echinoderms, MNHN and Scientific Committee Representative for France) welcomed all participants to the Marine Station and to Concarneau.

Adoption of the agenda and appointment of rapporteurs, proposed schedule for the meeting

1.2 Dr Cárdenas outlined the priority work for the Working Group meeting highlighting that the Scientific Committee (SC-CAMLR-XXXVII, paragraphs 13.1 to 13.3) and the Commission (CCAMLR-XXXVII, paragraphs 5.9 and 5.10) had provided very clear guidance in 2018. He emphasised that the Scientific Committee had identified that a priority item of work to be considered by WG-EMM in 2019 would be the development of advice for management of krill resources to advise the review of Conservation Measure (CM) 51-07. Furthermore, the Commission had requested that the Scientific Committee make the development of a preferred option for the management of krill in Area 48 a priority in 2019 and provide clear advice for consideration by CCAMLR-38.

1.3 The Working Group reviewed the provisional agenda (Appendix B) and the documents that had been submitted for consideration to the meeting (Appendix C). In order to streamline the work of the meeting, the agenda item(s) under which some papers were to be considered were revised, and the agenda was adopted.

1.4 In this report, paragraphs that provide advice to the Scientific Committee and its other working groups have been indicated in grey. A summary of these paragraphs is provided in Item 10.

1.5 The report was prepared by M. Belchier (UK), O.A. Bergstad (Norway), T. Brey (Germany), M. Eléaume (France), S. Fielding (UK), E. Grilly (Secretariat), S. Grant and S. Hill (UK), J. Hinke (USA), S. Kawaguchi (Australia), D. Krause (USA), A. Lowther and G. Macaulay (Norway), K. Reid (Secretariat), G. Robson (UK), M. Santos (Argentina), E. Seyboth (Brazil), D. Welsford (Australia) and X. Zhao (China).

Focus topic on krill fishery management

2.1 The Working Group welcomed the preliminary report of the Workshop on Krill-fishery Management for Subareas 48.1 and 48.2 (WG-EMM-2019/25 Rev. 1). The aim of the

Workshop was to discuss harmonising management strategies (e.g. risk assessment, feedback management (FBM), marine protected areas (MPAs)) for the krill fishery. Multiple Members, industry and non-governmental organisation (NGO) representatives participated. The primary output from the Workshop was a collective vision statement for the future of the krill fishery, which was developed from vision statements for four constituent parts (the marine ecosystem, krill harvesting, scientific knowledge and human interactions). The Workshop further identified several ‘big changes’ and ‘actions’ that would be necessary to achieve the overall vision and constituent vision elements. A full report from the Workshop will be provided to the Scientific Committee this year.

2.2 The Working Group endorsed the vision statements in the Workshop report. The Working Group further recommended that the Scientific Committee consider three of the main recommendations from the Workshop, including:

(i) the development of a krill stock assessment was an urgent priority to achieve the objective of the Convention

(ii) the development of the proposed Domain 1 MPA (D1MPA) and FBM strategies for the krill fishery could be progressed independently

(iii) the need to support and improve working collaborations among Members.

In particular, the Working Group noted the discussions of the Workshop on the need to develop a strategy to better fund and share the burden for research needed to manage the krill fishery.

2.3 The Working Group noted WG-EMM-2019/11, an updated analysis first presented in WG-EMM-16/45. The paper demonstrated that appropriate matching of spatio–temporal scales over which forage species, their predators and fisheries interact, can aid the assessment of fishery impacts on dependent predators. Results indicated that local harvest rates $\geq$0.1 and future climate warming led to a 0.77 probability of future penguin performance being below its long-term average. The paper concluded that catch limits that are considered precautionary for forage species such as krill, mainly because the limits are small proportions of the species’ standing biomass, may not be precautionary for their predators, and that krill fishery impacts on penguin performance are evident.

2.4 The Working Group agreed that further monitoring would help to reduce uncertainties highlighted in the analysis presented in WG-EMM-2019/11. In particular, the Working Group noted that high local harvest rates during the winter season were associated with decreased penguin performance, but the relationship between krill biomass and penguin performance was less clear. Continued collection of data on local krill biomass, particularly during winter, and foraging distributions of underrepresented demographic groups (e.g. juvenile and fledgling penguins), would be useful to extend our understanding of fishing impacts on predators.

2.5 The Working Group discussed how research on the characteristics of swarms that are targeted by foraging predators and on how fishing activity affects krill swarm structure or distribution could provide a useful means to further understand how fishing impacts dependent predators. The co-existence of several krill-dependent predator species, for example, implies niche partitioning that might be related to krill swarm structure and distributions. It was noted that the natural spatial and temporal variability in the distribution of krill swarms on multiple scales would need to be considered to understand how fishing effects on krill swarm structure would affect predators.

2.6 The Working Group recalled the recent trend for increasing krill catch levels in some fishing hotspots. The Working Group noted that the increasing concentration of catch in space and time, particularly when it leads to high local harvest rates, is likely to erode the level of precaution intended by CM 51-07. The Working Group noted that possible impacts of this trend should be evaluated and recommended that Members study the mechanisms that may cause fishing fleet concentration in some fishing hotspots.

2.7 The Working Group recalled the analyses of krill abundance indices in the main fishing hotspot in the Bransfield Strait (WG-EMM-17/40, 17/41, 18/41), which indicated that both krill acoustic density and catch-per-unit-effort (CPUE) either remain stable through the fishing season in some years or increased towards the closure of the krill fishery in other years. It encouraged further analyses of this type to be considered as the krill fishery management strategy is refined.

2.8 The Working Group noted WG-EMM-2019/28 and 2019/29. Taken together, the papers urge the development of a krill stock assessment because fishing patterns, krill numerical density, demographic structure, distribution and availability to predators, and climate variables differ from when current fisheries management was implemented. The papers expressed that the need for precaution is likely to be greater now than when the trigger level was established and suggested that the Working Group should progress stock assessment methods to provide the advice requested in the terms of reference of the Working Group. They emphasised that considerable uncertainty will be associated with any assessment of the status of the krill stock, and therefore that there is a need for continued precaution. The papers argued that CM 51-07 should be retained while such methods are developed.

2.9 The Working Group noted that the scale and frequency of risk assessment and stock assessment are key considerations in advancing a management strategy for the krill fishery. The Working Group agreed that multi-scale approaches that range from large-scale synoptic surveys of Area 48 (Subareas 48.1 to 48.4) to sub-subarea were likely to yield information necessary to advance a management strategy.

2.10 The Working Group cautioned that while real-time measurement of krill biomass might be an ideal solution to help manage the fishery to avoid unanticipated increases in local harvest rates, precautionary approaches that consider historical envelopes of variability of krill biomass may be more readily achieved. Such precautionary approaches may lend enhanced protection to predators and add stability to a management strategy for the krill fishery by reducing the frequency of adjustments to catch allocations. The Working Group noted that historical and ongoing time series of krill biomass, available within most subareas, can provide such estimates to help maintain the desired level of precaution.

2.11 The Working Group considered WG-EMM-2019/18 submitted by Norwegian, Chinese and Chilean colleagues who presented it as a response to the Scientific Committee's encouragement to achieve coordination among the various approaches towards developing a practical FBM approach (SC-CAMLR-XXXVI, paragraph 3.23). Following on from the FBM approach that was presented by Norway, Chile and China to the Scientific Committee in 2017 (SC-CAMLR-XXXVI/BG/20), the paper provided a framework and way forward for incorporating aspects of each currently tabled approach, including risk assessments, experimental fishing, decision rule approaches and the FBM approach proposed in 2017. The aim set out in WG-EMM-2019/18 was a comprehensive solution that could be operationalised within reasonable time in relation to the expectations under CM 51-07.

2.12 The Working Group welcomed the efforts to bring together previously considered elements of krill fishery management approaches (WG-EMM-15/10, 16/45 to 16/48 and 16/69). The Working Group noted that a simple approach to a future krill fisheries management strategy would facilitate near-term implementation. The proposed strategy has essential requirements, among others, for a krill stock assessment, predator data to inform a risk assessment, and information on fishery dynamics. Six action points were identified from this strategy that were required to be addressed in order to provide advice to the Scientific Committee in line with the expectations of CM 51-07 (Table 1). The Working Group agreed that sufficient data from these components are available to make progress on addressing them in the near term.

2.13 The Working Group noted that the development of the management strategy is an ongoing process and that some datasets remain desirable targets for future work. The Working Group highlighted that datasets for the risk assessment could include consideration of movement of krill as well as predators that are not represented in the current CCAMLR Ecosystem Monitoring Program (CEMP), particularly krill-dependent cetaceans, pack-ice seals and demographic groups other than adult penguins.

2.14 The Working Group recalled that CM 51-07, paragraph 4, stated that the conservation measure will expire at the end of the 2020/21 fishing season if agreement has not been reached on an update or replacement to the conservation measure.

2.15 The Working Group discussed the possibility that the preferred management strategy for the krill fishery might be delayed beyond 2021 and identified a need for a default krill fishery management position, defined as one that is no less precautionary than the current combination of CMs 51-01 and 51-07. The Working Group agreed that the observed spatial concentration of the fishery and the absence of the spatial allocation provisions of CM 51-07 would be likely to lead to an undesirable distribution of fishing effort and there was general support for such a default management approach. It was suggested that the current provisions of CM 51-07 should provide a default management strategy until the preferred management strategy (paragraphs 2.60 to 2.64), based on focused effort, is agreed and implemented. The Working Group stressed that, while maintaining the option of such a default management approach is desirable, the commitment to progressing a preferred management strategy remained the priority objective.

2.16 The Working Group also noted that several factors external to CCAMLR have contributed to the spatial distribution of fishing effort. Such factors include environmental (e.g. changing sea-ice conditions, weather conditions), economic (e.g. subsidies, vessel operation costs, licensing fees, processing capacity, cost of searching for suitable fishing grounds) and fleet dynamics (e.g. voluntary coastal closures, vessel cooperation, the experience of the skipper). Combined with such factors, the Working Group noted that CM 51-07, which allocates the trigger level among subareas, may inadvertently promote the concentration of fishing effort, especially in the context of Olympic fishing. Such factors may influence future fishery activity and the Working Group agreed that this lends urgency to the work to develop a management strategy for the krill fishery.

2.17 Aware that timelines are helpful to motivate progress on the development of a management strategy for the krill fishery, and noting that CM 51-07 expires after the 2020/21 fishing season, the Working Group agreed a prioritisation of several tasks to advance a management strategy for the krill fishery (Table 1). This prioritisation fully intends to develop the scientific basis for a revision to CM 51-07 while progressing a harvest strategy for krill fishing, including catch limits and their spatial distribution by 2021 (Figure 1).

2.18 The Working Group agreed a prioritised, three-part approach to advance a preferred strategy to manage the krill fishery by:

(i) developing a stock assessment to estimate precautionary harvest rates (Tables 2 and 3)

(ii) developing updated biomass estimates, initially at the subarea scale, but potentially at multiple scales (Tables 4 to 6)

(iii) advancing the risk assessment framework to inform the spatial allocation of catch (Tables 7 and 8).

2.19 The Working Group discussed several aspects of this work plan, noting requests from the Scientific Committee to develop a risk assessment for spatial allocation of the catch, the expiration of CM 51-07 in 2021 and the limited time available for progress, and the extent to which other CCAMLR working groups and subgroups would need to engage with WG-EMM to fulfil the specified commitments.

2.20 Given CCAMLR's prioritisation of the development of a management strategy for the krill fishery, the Working Group agreed that developing the preferred strategy outlined in Tables 1 to 8 and Figure 1 was a matter of urgency. The Working Group recommended that the Scientific Committee prioritise and endorse this work, noting that it may have implications for other working group timetables.

2.21 To progress the work plan, the Working Group requested that the Scientific Committee task the Subgroup on Acoustic Survey and Analysis Methods (SG-ASAM) to develop integrated methods for estimating krill biomass and associated confidence intervals on the subarea scale from available survey data in line with the proposed work plan.

2.22 The first step towards the goal specified in paragraph 2.21 is compiling all available regional biomass estimates. The Working Group requested Members to submit these estimates with associated metadata (Table 6) to the SG-ASAM-2019 meeting. A list of contacts who will coordinate the effort for each subarea is provided in Table 5.

2.23 The Working Group agreed that, in parallel with the work to estimate krill biomass on a subarea scale, a risk assessment should be progressed with an emphasis on finalising data layers on the distribution of krill consumption by critical life-history stages of penguins, Antarctic fur seals (*Arctocephalus gazella*), cetaceans and pack-ice seals. Additionally, consideration should be given to flying seabirds and other cetacean and pinniped species as data become available and time permits. The Working Group further agreed that an analogous data layer for the fishery be developed from C1 catch and vessel monitoring system (VMS) data.

2.24 The Working Group noted that there was a need to review and agree standard methods for the development of layers for the risk assessment. Such standard methods would improve incorporation of new data and allow efficient updating to future risk assessments.

2.25 The Working Group recommended that the Scientific Committee coordinate a focus topic for WG-EMM-2020 to address the development of data standards and quality control if data are to be used to develop risk assessment layers, recognising that such methods may need review by the Working Group on Statistics, Assessments and Modelling (WG-SAM) (paragraphs 9.1 to 9.5).

2.26 The Working Group agreed that, in order to merge the risk assessment and the updated krill biomass estimates, the generalised yield model (GYM) should be further developed to update precautionary catch limits. The Working Group agreed that this development required, inter alia, a re-parametrisation of growth, recruitment and natural mortality, and agreed on an intersessional work plan (Tables 2 and 3).

2.27 The Working Group discussed several aspects of the work plan to develop the GYM and noted extensive simulation studies that have recently been undertaken to explore the values and modelling choice for recruitment and natural mortality (e.g. Kinzey et al., 2013, 2015, 2019; Thanassekos et al., 2014; Murphy and Reid, 2001).

2.28 The results of the series of studies suggested that:

(i) the level of natural mortality used in the GYM of 0.8 to estimate the catch limit based on the CCAMLR 2000 Krill Synoptic Survey of Area 48 (CCAMLR-2000 Survey) is likely to be the lower end of the plausible range of natural mortality. Based on analyses such as those shown in Kinzey et al., 2013 an estimate of M in the range of 0.8–2.0 should be evaluated for use in future assessments. The Working Group noted that the value of natural mortality at the subarea scale and smaller scales would be confounded with the movement of krill

(ii) the current level of recruitment variability reflected by the effective coefficients of variation (CVs) from the base-case Beta model in Kinzey et al., 2013 is lower than the observed effective CVs from field studies. The Working Group agreed that the use of recruitment variability based on empirical data be developed to allow the serially auto-correlated nature of recruitment variability to be included in the assessment process

(iii) growth models used to re-parameterise the growth rate used in the GYM should include both the growth rate and the seasonality of growth, taking account of the time interval used in the risk assessment (i.e. winter and summer).

2.29 The Working Group noted the extensive amount of length-frequency time series existing from different sources (nets, fisheries, predator diets) in Subareas 48.1, 48.2 and 48.3, in which the relative proportion of krill for example less than 40 mm, considered as new recruits, could be used to derive a recruitment index. Size selectivity may be different between these sources but if the selectivity is consistent within the sources, then recruitment indices from these sources can be used for deriving recruitment variability.

2.30 The Working Group also noted that the GYM should be run using different options for recruitment distribution models (proportional or lognormal distribution) or recruitment vectors, and average these outputs by weighting according to available information.

2.31 The Working Group highlighted the nature of the intersessional work which will involve extensive data sharing with various external groups and requested the Secretariat to assist Members with coordinating collation of key datasets. Noting the timeline for the work plan, relatively strict deadlines for data submission need to be set, on the understanding that any data that were not submitted by the deadline could not be used for the intersessional work undertaken up to the 2021 revision of CM 51-07. It also stressed the importance of clarifying the format of datasets to be submitted so that the data processing can be undertaken as efficiently as possible.

2.32 The Working Group agreed that alternative implementation of current decision rules should be considered in the updated GYM simulations. For example, the stock assessments for CCAMLR icefish fisheries, which use short-term (e.g. <5 years) model projections and regular biomass updates may provide a useful framework for the preferred krill fishery management strategy.

2.33 For all three components of this preferred strategy, Members to coordinate progress have been identified. The Working Group encouraged wider collaboration and participation of all interested Members to improve the development of the preferred strategy.

2.34 The Working Group noted the ambitious nature of this work plan. Uncertainties about the appropriate scaling of biomass estimates from disparate survey areas and methods, and the pathologies in the GYM related to the parameterisation of recruitment variability (Kinzey et al., 2013) represent important hurdles to be overcome if this preferred strategy for the management of the krill fishery is to be implemented in a timely fashion.

2.35 The Working Group also noted that subdivision of the catch into smaller spatial scales may have impacts on catch reporting requirements for the krill fishery. The Working Group recalled the practice for forecasting closure of the toothfish fishery in Area 88, where the capacity of the fishing fleet can result in catches achieving catch limits in very short periods of time. Currently, catch reporting for the krill fishery is required in a staged approach, transitioning from monthly reporting to five-day reporting according to the requirements of CM 23-06.

2.36 The Working Group agreed that the practical implementation of a subdivision of the krill catch into smaller spatial scales required further consideration of catch reporting requirements. The Working Group therefore requested that the Secretariat generate risk profiles of overrunning catch allocations across a range of vessel capacity (or catch) and fleet sizes, as it has done for the toothfish fishery in Area 88. Such risk profiles would help understand whether reporting requirements for the krill fishery require revision in the future. To circumvent potential overruns, the Working Group recommended that the Scientific Committee take pre-emptive action to increase the frequency of catch reporting above that specified in CM 23-06.

2.37 Recognising that in the past WG-EMM was not able to deliver advice on a preferred management strategy in agreed timelines, the Working Group noted several factors that may improve its ability to deliver a krill management strategy. Firstly, agreement on a work plan to develop the management strategy is now apparent within the Working Group. Secondly, the preferred strategy is largely empirically based and many aspects of the approach are well parameterised by historical and ongoing data collection efforts at multiple scales. Thirdly, an inclusive approach to foster collaboration and share the burden has been clearly articulated (Tables 1 to 8).

2.38 The Working Group recommended that the Scientific Committee coordinate and agree a work plan for the working groups over the next two years to facilitate the work required to progress the preferred management strategy outlined in Tables 1 to 8.

Data layers for risk assessment of spatial and temporal distribution

2.39 WG-EMM-2019/23 provided data layers for use in a risk assessment framework for krill fisheries management in Area 48.1, i.e. data layers describing the distribution and krill consumption by krill-dependent predators. The paper described the analysis of at-sea cetacean observations from two surveys undertaken by the PROANTAR (Brazilian Antarctic Program) carried out from the Polar vessel *Almirante Maximiano*, in order to estimate the abundance, distribution and consumption of krill by humpback whales (*Megaptera novaeangliae*). Model outputs presented suggest that humpback whales consume relatively large amounts of krill along the coastline of the Western Antarctic Peninsula (WAP) and the South Shetland Islands. WG-EMM-2019/24 described the use of tracking data to provide corresponding data layers for penguin species in Subarea 48.1 and described progress-to-date in developing relevant data layers to input into the risk assessment framework.

2.40 The Working Group noted WG-EMM-2019/26 which was a description of the Mapping Application for Penguin Populations and Projected Dynamics (MAPPPD). The database underlying MAPPPD includes all publicly available (published and unpublished) count data on emperor (*Aptenodytes forsteri*), gentoo (*Pygoscelis papua*), Adélie (*P. adeliae*) and chinstrap (*P. antarcticus*) penguins in Antarctica.

2.41 The Working Group noted WG-EMM-2019/30 which provided a progress report and presented preliminary results for marine Important Bird and Biodiversity Areas (mIBAs) for penguins within CCAMLR MPA planning domains. A total of 64 definitive sites were identified as mIBAs. The Working Group noted that further results would be presented in forthcoming papers to CCAMLR.

2.42 The Working Group noted WG-EMM-2019/23, 2019/24, 2019/26 and 2019/30 which significantly enhanced the available data layers required for future risk assessments. Especially welcome was the new information on baleen whales; in this respect, some participants informed the Working Group that further information would be forthcoming. Further communication with the experts from the International Whaling Commission Scientific Committee (IWC-SC) and from national programs was encouraged. The authors noted advice to develop standardised methods, but also highlighted that all available data sources should be explored and used in order to consider recovering populations of cetaceans, given their importance as consumers of krill, not only in Subarea 48.1, but also at the Antarctic scale. The Working Group also noted that several taxa of krill consumers were still under consideration for inclusion in the risk assessment, including, for example, pack-ice seals, fur seals and flying seabirds.

2.43 The Working Group noted WG-EMM-2019/42 which was a thorough report from a 53-day multidisciplinary ecosystem survey in the eastern Indian Ocean sector of the Antarctic (Division 58.4.1) with a focus on Antarctic krill (*Euphausia superba*) carried out by the vessel *Kaiyo-maru* during 2018/19. A number of analyses using the data and samples obtained are in preparation and the results will be presented to the expert groups of the Scientific Committee. Narrowband echosounder (38, 70, 120 and 200 kHz) data to estimate biomass of Antarctic krill were recorded along predetermined track lines for 2 519 n miles. Broadband echosounder data were recorded at 24 targeted research midwater trawl (RMT) stations to estimate length distribution and swimming angles of Antarctic krill acoustically. The Working Group noted that SG-ASAM would discuss the acoustic krill survey and the broadband methodology adopted. Australia informed the Working Group on plans for a survey in the same area, and the intention was also to have that considered by SG-ASAM.

2.44 The study reported in WG-EMM-2019/20 had as a first goal to produce quantitative distribution maps of all six ontogenetic life stages of krill (eggs, nauplii plus metanauplii, calyptopes, furcilia, juveniles and adults) within Area 48, based on a compilation of all available post-1970s data. Input data spanning 41 years (1976–2016) from the existing KRILLBASE-abundance and KRILLBASE-length-frequency databases were analysed. Although adult males and females of spawning age were widely distributed, the distribution of eggs, nauplii and metanauplii indicated that spawning is most intense over the shelf and shelf slope. This contrasts with the distributions of calyptope and furcilia larvae, which were concentrated further offshore, mainly in the southern Scotia Sea. Juveniles, however, were strongly concentrated over shelves along the Scotia Arc. From the early to late part of the austral season, juvenile distribution moves from ocean to shelf, opposite in direction to that for adults. Such habitat partitioning may reduce intraspecific competition for food, which has been suggested to occur when densities are exceptionally high during years of strong recruitment. It also prevents any potential cannibalism by adults on younger stages. The Working Group appreciated the broad-scale approach of this study. This study would enhance understanding of recruitment patterns and processes which is presently a major gap. Temporal variation studies are in progress. It was noted that there is still limited understanding of what happens in oceanic waters.

2019 multinational synoptic large-scale krill survey

2.45 WG-EMM-2019/07, 2019/43, 2019/46, 2019/47, 2019/61, 2019/69 and 2019/78 summarised the multi-Member contributions towards the International Synoptic Krill Survey in Area 48, 2019 (hereafter the 2019 Area 48 Survey), as earlier outlined by Norway (SC-CAMLR-XXXVII/12).

2.46 The Working Group highlighted the successful completion of the field work for the 2019 Area 48 Survey, noting that it was a major undertaking amongst multiple Members (Table 9; Figure 2) and was brought to fruition within a fairly short time frame of planning. The Working Group noted the coordination efforts by Norway and the significant contribution by the Association of Responsible Krill harvesting companies (ARK).

2.47 The Working Group noted that there was extensive involvement from fishing vessels, that all vessels had calibrated their echosounders using the standard sphere technique, and that all the vessels collected data at multiple frequencies. This represents a marked increase in the capacity to collect krill stock assessment information and demonstrated a beneficial level of engagement by the krill fishing industry. The Working Group recalled that efforts by the krill fishing industry to implement standardised acoustic methods were relatively recent (since WG-EMM-2011) but had developed very rapidly.

2.48 WG-EMM-2019/55 highlighted four methodological differences between the CCAMLR-2000 Survey and the 2019 Area 48 Survey: (i) the method used to identify krill targets in the acoustic data, (ii) the different trawls used on the various vessels, (iii) conducting acoustic transects during the night, and (iv) the synopticity and direction of the survey. Dr S. Kasatkina (Russia) expressed that it is necessary to develop appropriate methods for the survey analysis and to provide biomass estimates and associated uncertainties arising from the points given above.

2.49 The Working Group considered these and other areas of methodological differences between the 2000 and 2019 surveys and, while recalling that the 2019 Area 48 Survey had been conducted to address the priority science objectives agreed by the Scientific Committee (SC-CAMLR-XXXVII, paragraph 2.13), it noted that some assessment and quantification of these differences could be undertaken by SG-ASAM, including by reviewing the items listed in Table 10. The Working Group encouraged participation in the SG-ASAM-2019 meeting, particularly by those with outstanding concerns.

2.50 The Working Group recalled that the 2019 Area 48 Survey proposal specified the use of swarms-based identification techniques for extracting krill acoustic backscatter from survey data (e.g. SG-ASAM-2018 report, paragraphs 3.4 to 3.8). However, it noted that, where acoustic data were collected at the three frequencies necessary to apply the CCAMLR dB-difference method (as was used for the CCAMLR-2000 Survey analysis), this would enable a comparison of the different identification methodologies at different spatial and temporal scales.

2.51 The Working Group noted that use of a similar krill length clustering method to the CCAMLR-2000 Survey (WG-EMM-2019/47) had identified three clusters of krill length-frequency distribution, with one cluster containing data from only two trawls. The Working Group identified that appropriate techniques to cluster data and use it in the acoustic analyses would benefit from advice by WG-SAM. The Working Group noted that such considerations should include the influence of gear selectivity on measured krill length distributions amongst the 2019 vessels, and between the 2019 and 2000 surveys.

2.52 The Working Group noted that krill length information for the 2018/19 season was available from a variety of additional sources, such as from CEMP predator monitoring and from national scientific surveys (e.g. a 2019 Peruvian survey), in addition to the large-scale survey. It noted that such data could be used to augment and inform on the selectivity of the net surveys and provide information on the wider krill population length-frequency distribution. The Secretariat offered to coordinate the observer and CEMP data for this, for input to SG-ASAM-2019.

2.53 The 2019 Area 48 Survey occupied transects that were undertaken both during day and night, in contrast to daylight only during the CCAMLR-2000 Survey. WG-EMM identified that differences in acoustic estimates of krill density between day and night could arise through both changes in krill tilt angle, as well as krill migrating above the hull-mounted transducer depth and 20 m blind zone. Members were encouraged to make observations of krill orientation and use upward-looking echosounder moorings and other platforms to examine these effects to further understand the impact of this on the swarms-based identification technique and general behaviour.

2.54 The Working Group noted that the 2019 Area 48 Survey was undertaken over a period of three months, compared with one month in 2000. It therefore discussed how krill flux and oceanographic flow could influence whether the survey was truly synoptic. It noted in addition that successive survey transects consistently progressed from east to west in 2000 (perpendicular to the prevailing current), whilst transects during 2019 progressed from west to east. The Working Group identified that oceanographic flow and particle tracking models (e.g. WG-EMM-2019/21) could be used to understand some of the effect of this issue.

Risk-assessment for the krill fishery

2.55 WG-EMM-2019/22 highlighted issues to be considered if CCAMLR is to progress krill management to smaller spatial and temporal scales than its current procedure. It highlighted that the oceanography of the region encompassed by the Bransfield Strait, South Shetland Islands and the tip of the Antarctic was dominated by three major inflows – the relatively cold Weddell Sea outflow around the tip of the Peninsula, and warmer inflows from the Gerlache and Boyd Straits. Oceanographic models indicate that the relative influence of these features supports hypotheses as to why large aggregations of krill occur in the region, the species-specific distribution of penguin colonies, and how the fishery has been able to consistently reach the Subarea 48.1 trigger limit in recent years despite fishing in a relatively small area.

2.56 The Working Group encouraged ongoing development and analysis using oceanographic models of the Bransfield Strait region, as this was likely to continue to provide important insights into physical drivers of the distribution of krill, krill predators and the krill fishery. It further noted that the contribution of the three main inflows into Bransfield Strait was likely to vary under climate change and El Niño Southern Oscillation (ENSO) fluctuations and encouraged development of model scenarios that included these phenomena. It further noted that tides, eddies and embayments were likely to contribute to the accumulation of krill in this region. It noted that as the fishery and predators target krill aggregations within 30 km of the coastline, extending acoustic transects and glider or sail buoy missions inshore would therefore be important to understand this portion of the krill stock.

2.57 WG-EMM-2019/58 summarised results from three experiments conducted to estimate rates of flux of acoustic krill targets with respect to geostrophic circulation at different scales in Subarea 48.3 in 1990, in Subarea 48.2 near Coronation Island in 1992 and again in Subarea 48.2 in 1996. Dr Kasatkina noted that the results of these field experiments across time showed that movement of krill biomass was complex and variable on study areas and demonstrated the effect of krill flux on fishing performance in areas of fleet operations. She also noted that in the past, vessels fishing in Area 48 had drifted with patches of krill for large distances. Summarising data from field experiments and estimating krill flux from the Russian large-scale surveys and CCAMLR-2000 Survey it was noted that krill flux intensity and structure are characterised by different spatial and temporal variability across Area 48. Dr Kasatkina emphasised that an understanding of the influence of krill flux at a range of temporal and spatial scales was important to consider in developing biomass estimates for stock assessment and data layers for risk assessment.

2.58 The Working Group agreed that krill flux was an important source of uncertainty in modelling krill biomass and distribution, and noted that the results in WG-EMM-2019/58 indicated the relative impact of flux increases in importance at smaller scales, particularly at the 10s of km scale. It noted that improved estimates of flux would be likely to substantially improve understanding of the impact of the fishery at the scale of fishing grounds. It noted that disregarding flux at these scales is likely to result in underestimates of biomass. However, it noted that, as methods for assessing stock dynamics at the scale of fishing grounds are still at an early stage of development, using conservative estimates of biomass is consistent with CCAMLR's precautionary approach. It also noted that in synoptic surveys at the subarea and area scales, it was reasonable to assume that the impact of krill flux was relatively small compared to other sources of uncertainty inherent in acoustic biomass estimates (WG-EMM-2019/22). It agreed that new technologies such as moorings, gliders and sail buoys are likely to hold significant promise for understanding krill flux and swarm behaviours. It also noted that oceanographic models indicate that krill transport and retention is likely to be influenced by a combination of mechanisms, including tides, eddies, inshore bathymetry, geostrophic flow and krill behaviours such as diel vertical migration.

2.59 The Working Group recognised that enhanced management of the krill fishery, moving from the current situation to a more dynamic, science-based management procedure including stock assessments and risk assessments, would improve understanding across a range of spatial and temporal scales.

Advice to the Scientific Committee on the development of a preferred option for the management of the krill fishery in Area 48

2.60 The Working Group recalled the task it was given by the Scientific Committee and the Commission to make the development of a preferred option for the management of krill in Area 48 a priority in 2019 and to advise the review of CM 51-07. The Working Group recalled that on 30 November 2021, CM 51-07 will expire, if agreement has not been reached on an update or replacement of the conservation measure.

2.61 The Working Group defined a preferred option for management of the krill fishery in Area 48 based on data which are currently available or will become available before 2021 (Tables 1 to 6). This preferred option would take a subarea-based approach, nested within an overall large-scale approach, for Subareas 48.1 to 48.4 based on subarea-scale stock assessment models and biomass estimates from regular surveys within subareas, to determine precautionary catch limits. The spatial distribution and scaling of the catch limits would then be based on the risk assessment framework. This will require the development of:

(i) an implementation of the GYM and the krill decision rules that is appropriate for estimating area and subarea catch limits

(ii) methods to estimate area and subarea biomass or density based on available surveys

(iii) data layers and implementation of the risk assessment framework to evaluate catch distribution options at the area, subarea and fishing ground scales

(iv) a management strategy evaluation (Table 1).

2.62 The Working Group agreed on a work plan toward a preferred management strategy for the krill fishery by 2021 (Figure 1 and paragraphs 2.20 and 2.38). This strategy consists of three components:

(i) a stock assessment to estimate precautionary harvest rates (Table 2)

(ii) updated biomass estimates, initially at the subarea scale, but potentially at multiple scales (Tables 4 to 6)

(iii) a risk assessment to inform the spatial allocation of catch (Tables 7 and 8).

2.63 The Working Group requested that the Scientific Committee evaluate and endorse the preferred strategy and the work plan.

2.64 The Working Group highlighted the potential need to extend the provisions of CM 51-07 beyond its current expiry date as a default management position for the krill fishery if there is no agreement on the development and implementation of the preferred management strategy for the krill fishery (paragraphs 2.14 to 2.20).

Krill fishery

Fishing activities (updates and data)

3.1 The Working Group welcomed the update on krill fishing activities for the 2017/18 season (1 December 2017 to 30 November 2018) and for the 2018/19 season up to 25 June 2019 provided by the Secretariat and noted that:

(i) the total catch of krill reported in catch and effort reports was 312 743 tonnes, the highest catch since the early 1990s and that fishing had taken place in Subarea 48.2 in the period from July to October for the first time

(ii) so far in 2018/19, catches are higher than up to the same time last year and, in particular, there has been an increase in the level of catch in Subarea 48.2 in the period December to March, with 160 532 tonnes taken in 2018/19 compared to 96 110 tonnes in the same period in 2017/18

(iii) at the time of the Working Group meeting, the Secretariat closure forecast indicated that the fishery in Subarea 48.1 would close on 15 July 2019 when the catch limit of 155 000 tonnes is reached

(iv) as in the two previous years, there had been small catches (12 tonnes) of krill in Division 58.4.2 in 2018/19.

3.2 The Working Group noted that five Members had notified their intention to fish for krill in 2019/20 and that the 14 vessels notified included two new, purpose-built, krill fishing vessels. The increase in the number of vessels represents an increase in processing capacity from 4 620 to 5 750 tonnes per day compared to 2018/19.

3.3 The Working Group recalled that the Scientific Committee had noted that this increase in catches and the changes in the seasonal distribution of the fishery underlined the timeliness of progressing the development of the management scenarios for the krill fishery (SC-CAMLR-XXXVII, paragraph 3.2).

3.4 The Working Group welcomed the updated information in the Krill Fishery Report 2018 (www.ccamlr.org/node/103782).

3.5 The Working Group noted that, although current data reporting requirements are for monthly catch and effort reporting for Subarea 48.2 until catch once reaches 80% of its trigger limit, operators are already voluntarily reporting at five-day intervals. The Working Group suggested, for the consistency with current operation and operational simplicity, this could be reflected in CM 23-06 (see also paragraph 2.36).

Krill fishery data

3.6 The Science Manager briefly described the ongoing work in the Secretariat on improving the quality, documentation and availability of data related to the krill fishery. The work so far this year had focussed on documenting the changes over time in the catch reporting requirements, and hence the availability of individual haul-by-haul data as well as catch data aggregated by 10-day or monthly time periods.

3.7 The Working Group recognised that this work was of importance as the C1 data include a mixture of time and space scales of catch reporting that are important when used in historical analysis. For example, most of the catch data from the late 1980s is from 1° longitude by 0.5° latitude cells aggregated by monthly and/or 10-day time periods, whereas catch data since the early 2000s has been reported at a haul-by-haul level.

3.8 The Working Group noted that the comparison of the catch data from the krill fishery gridded at 1° longitude by 0.5° latitude scale from 1988–1991 and 2015–2018 (Figure 3) that included the aggregated and the haul-by-haul data, clearly showed the spatial concentration of the fishery in the more recent years.

3.9 The Working Group welcomed the update on the data management work being carried out in the Secretariat and looked forward to receiving further updates and data products.

Net monitoring cable trials

3.10 WG-EMM-2019/16 described the outcomes of trials with a net monitoring cable aimed at developing real-time monitoring of the fishing gear on the *Saga Sea* that were first presented in WG-EMM-16/06. A derogation from the prohibition on the use of net monitoring cables in CM 25-02 was provided for this trial. Because the trials on the *Saga Sea* were unsuccessful with the existing rigging configuration, the vessel has introduced the same trawl rigging as used on the *Antarctic Sea* and has also introduced the same operating approach for the net monitoring cable.

3.11 The Working Group noted that the net monitoring cable was integral to the approach to improving catch data reporting (see paragraphs 3.16 to 3.21) and was positioned close to the trawl warp and may simply appear as a single warp in terms of the risk to seabirds. However, recognising the efforts that had been introduced in CCAMLR to avoid the incidental mortality of seabirds associated with fishing, the use of net monitoring cables in a manner not consistent with previously agreed best practice should not be allowed.

3.12 The Working Group noted that in 2016 a one-year derogation on the prohibition of the use of a net monitoring cable was given on the basis of the trial described in WG-EMM-16/06 (SC-CAMLR-XXXV, paragraphs 4.10 to 4.13; SC-CAMLR-XXXVI, paragraphs 3.10 and 3.11), this was extended in 2017 but was apparently no longer in place when the trial was conducted (SC-CAMLR-XXXVII, paragraphs 3.14 and 3.15). As WG-EMM-2019/16 indicated that the operating approach for the net monitoring cable remained in use, the Working Group requested the advice of the Scientific Committee and the Standing Committee on Implementation and Compliance (SCIC) on the status of the trial. It further requested the authors of the paper to provide the Scientific Committee with a clarification of the sequence of events involved in the trial.

3.13 Dr Bergstad informed the Working Group that communication with the author of WG-EMM-2019/16 and the vessel owner had revealed that the suggestion in the paper that the trials had continued into the 2018/19 season was incorrect. The experiments on the *Saga Sea* were conducted in 2016/17 and 2017/18 as reported in WG-EMM-2019/16. He noted the suggestion to have the Scientific Committee and SCIC evaluate the trials as reported and will provide additional information as required. He also informed the Working Group that:

(i) When the trials were completed in 2017/18, no satisfactory solution had been found. The vessel therefore decided to change the rigging of the vessel prior to the 2018/19 season. The *Saga Sea* now has the same rigging as the *Antarctic Sea* and the *Antarctic Endeavour*.

(ii) The vessels use a cable connection to the net sensors. This cable runs along the single trawl warp and is aligned with that warp. Dr Bergstad recognised the need to describe and illustrate this rigging to the Scientific Committee in order to enhance clarity. It is emphasised that this rigging is very different from that used on classical double-warp trawlers where the cable normally runs freely between the warps as a third cable. He provided a full description of the use of cables in an information document submitted during the Working Group meeting. The intention is to develop this as a working paper to the Scientific Committee.

(iii) The alternative to the current system now harmonised on the three vessels is a cable-free system with battery-powered sensors on the trawl. This would imply having to retrieve the trawl frequently to recharge batteries and is thus considered an inferior solution at this time. A battery-powered solution will not permit implementation of an acoustic catch sensor and the possibility of running long-term monitoring of the trawl for catch efficiency, by-catch and krill behaviour studies.

Net-mounted acoustic data collection

3.14 WG-EMM-2019/15 described the testing of net-mounted acoustics devices to collect data on the amount of krill entering the net on vessels using the continuous fishing system. The authors indicated that following some difficulties in the development of the system, there was now a plan to trial the system during the Norwegian survey in Subarea 48.2 in 2020 and then on commercial gear later that year.

3.15 The Working Group noted the update on net-mounted acoustics, recognising that the integration of data on acoustics and catch data could provide important information on krill density and swarm structure, as well as improvements in catch reporting, and looked forward to further updates on this project.

Continuous trawl catch recording

3.16 WG-EMM-2019/06, which was presented in response to SC-CAMLR-XXXVII, paragraphs 3.7 to 3.13 and the WG-EMM-2018 report, paragraphs 2.44 to 2.54, provided an update on the methods described in WG-EMM-18/22 on using the holding tank volume recorded at two-hour intervals to estimate the green weight of krill. WG-EMM-18/22 described experiments where the relationship between tank volume and krill biomass was estimated for individual holding tanks. This allows estimation of catch weight by two-hour intervals based on the monitoring of the change in filling level during fishing.

3.17 WG-EMM-2019/06 described the method for how estimates based on tank filling recordings during two-hour periods were obtained. It confirmed that the same method was now used on all Norwegian krill fishing vessels. Every day, the sum of the two-hour estimates for the previous 24-hour period is compared with the corresponding 24-hour catch recorded by the flow scale, since there may be minor discrepancies between the sum of two-hour catch estimates and the 24-hour flow-scale readout, i.e. the best record of the 24-hour catch. When this occurs, the officer in charge adjusts the two-hour catch records proportionally so that they sum up to the 24-hour catch recorded by the flow scale. The adjusted two-hour catches are thus regarded as the best estimates of two-hour catches and are reported on the C1 forms.

3.18 The Working Group recalled its previous discussion on catch reporting for vessels using the continuous fishing system (WG-EMM-2018 report, paragraphs 2.44 to 2.54). The overall catch data were precise and unbiased at 24-hour time periods. Those previous discussions (in 2018, based on WG-EMM-18/22) concluded that historical catches for two-hour periods were also likely unbiased, but the precision was rather lower than expected. The Working Group recognised that the precision of historical two-hour catches could not be enhanced. The Working Group accordingly reiterated the request made in 2018 to the Secretariat for information to be provided to Members requesting access to C1 data from vessels using the continuous trawling method (WG-EMM-2018 report, paragraph 2.49).

3.19 The descriptions of the current methods for estimating the green weight of krill are specified in CM 21-03, Annex 21-03/B. The method described in WG-EMM-2019/06 is a combination of two methods. The Working Group requested those Members using this method to provide a description of the method that would allow the appropriate changes to CM 21-03, Annex 21-03/B. The Working Group further requested that the Scientific Committee consider this revision to the conservation measure.

3.20 The Working Group recommended that, in the interim of the full documentation and analysis of the method described in WG-EMM-2019/18, Norway should report the two-hour catch estimates derived from monitoring of filling levels in the holding tanks and the 24-hour catches from the flow scale to allow the scale of any correction of the two-hour catch estimates to be evaluated. The Working Group agreed that this would also provide a better understanding of the catch data, including from other vessels that only use the tank volume method.

3.21 The Working Group recalled that the spatial concentration of krill fishing highlights the importance of accurate catch reporting and that the issues associated with catch reporting from the continuous fishing system have a long history (e.g. WG-EMM-2009 report, paragraph 3.43). Some disappointment was expressed that historical catch data from the continuous fishing system cannot be reconstructed and that this is not a satisfactory position as it impedes the ability of CCAMLR to understand the impact of the fishery. It was, however, also noted that the issue was discussed in 2018 (WG-EMM-2018 report, paragraphs 2.46 to 2.48) and the Working Group at that time agreed, with reference to the analyses in WG-EMM-18/22, that historical analyses were possible but that analyses at the finest spatial and temporal scale were likely to be affected by the low precision and lack of consistency in catch reporting methods between vessels using the continuous fishing system in the past.

Scientific observation

Glider-based estimates of Antarctic krill biomass

3.22 WG-EMM-2019/13 explored the feasibility of using gliders to replace vessel-based biomass surveys of krill at several temporal and spatial scales in the Bransfield Strait and the western shelf of Livingston Island, Antarctica, between mid-December 2018 and mid-March 2019. The authors of the paper concluded that acoustically equipped glider surveys can provide estimates of krill density and distribution, sufficient to inform management, and should allow the continuation of time series monitoring that has historically been conducted by ships.

3.23 The Working Group welcomed the use of this new technology and noted that consideration should be given to the acoustic frequencies and data standardisation for the estimation of krill biomass. The Working Group suggested undertaking comparisons between glider-based biomass estimates and the results from the 2019 Area 48 Survey. The Working Group suggested a need for observing shallower coastal areas that are important predator habitat by using additional gliders (paragraphs 2.27 and 2.28).

3.24 WG-EMM-2019/17 described initial trials with a sail buoy, a wind-propelled vehicle with solar-powered scientific sensors including an echosounder, to map krill distribution. Operational and functional tests were trialled from the end of January to mid-February 2019, demonstrating its capability to run survey transects, observe variability at a location and survey predator prey fields. The presence of an iceberg prevented the sail buoy survey area overlapping with concurrent predator tracking locations, this will be pursued in future surveys. The Working Group welcomed the use of automated surface devices to conduct detailed surveys of areas that are otherwise inaccessible due to logistical reasons and noted that the application of this technology will help improve fishery management as well as to increase the efficiency of searching for fishing grounds.

3.25 The Working Group noted that advances in the use of automated surface and underwater vehicles means that we are in a period of rapid change, and there is a need to promote this work more widely. The Working Group further noted that coordination between Members will enhance and optimise the use of these vehicles and subsequent data analysis.

Krill length composition

3.26 WG-EMM-2019/56 discussed the importance of reliable estimations of the spatial–temporal distribution of krill length composition in Subarea 48.1 required for integrated stock assessment models, developing management advice, FBM and revision of CM 51-07. The authors noted that krill flux from the Bellingshausen Sea and Weddell Sea across Subarea 48.1 may create spatial and temporal variability of krill length compositions. The authors also noted that gear selectivity and potentially the CCAMLR Scheme of International Scientific Observation (SISO) observer sampling procedure used may affect krill length estimation from commercial catches. The authors indicated that they would analyse the size composition in different temporal scales to improve the sampling procedure used by SISO observers.

3.27 The Working Group highlighted that a review of the sampling regime used to obtain krill biometric data could be conducted in the context of the intended purpose of the data collected as part of SISO. An analysis would then be needed to develop the most appropriate sampling regime, i.e. to estimate the mean length or length-frequency distribution in the catch.

3.28 The Working Group noted that previously conducted analyses have been used for a range of different purposes, and the sampling regime should be reviewed in the context of current research and management priorities. The Working Group also noted that an increase in the number of biometric samples may be beneficial, and particularly when acoustic transects are conducted.

Scientific observation

SISO observer manual and sampling requirements

3.29 The Working Group endorsed the updated SISO manuals and logbooks presented in WG-EMM-2019/75 and thanked the Secretariat for providing these in a fishery-specific format.

3.30 The Working Group highlighted the importance of krill length data collected by scientific observers as this is one of the most important data sources for understanding dynamics of krill and pursuing stock assessment to develop management advice for the krill fishery.

3.31 The Working Group recalled that a sampling requirement specified in the observer logbook instructions is to measure 200 krill from one randomly selected haul every three days or five days depending on the period of the season. This requirement for 200 krill per haul is based on the sample size required to allow evaluation of the overall length-frequency distribution rather than the mean length (WG-EMM-2008 report, paragraph 4.48).

3.32 An analysis of the number of krill measured per sample from 2015 to 2019 indicated that the number ranged between 50 and 400, with some vessels regularly measuring 100 krill per haul, while other vessels measured 200 individuals. However, it was noted that since 2018 all vessels were measuring 200 krill per sample.

3.33 During the meeting it was explained that these differences were caused by different interpretations of the SISO instruction.

3.34 The Working Group noted that at the 2017 SISO workshop (SC-CAMLR-XXXVI/08) one of the objectives was the development of a standard set of krill measuring instructions to ensure consistency of measurements between SISO observers. The Workshop had included a review of the sampling instructions and it appears that this was indeed very useful in creating the consistency required.

3.35 The Working Group also agreed that the current instructions may not provide sufficient detail on krill sampling from a trawl to ensure unbiased sampling as there may be a tendency to select larger krill for measurement. Given the importance of sampling across the entire size range, the Working Group suggested that this might be better achieved by requesting observers to collect a subsample and to measure all krill in the subsample. This approach should be designed to provide a sufficient sample size and remove the potential bias in selecting the individuals for measurement.

3.36 The Working Group recommended that in order that the sampling requirements in the SISO manual and instructions be updated from specifying 200 krill per trawl to measuring all of the krill in a random sample of krill from a trawl, those Members deploying observers in the krill fishery were requested to evaluate sampling approaches that would achieve this objective.

3.37 The Working Group agreed that, given the priority of understanding the dynamics of the krill population in the area of the fishery, having sampling frequencies of sampling one trawl every three days throughout the year would simplify the instruction for the observers. The Working Group noted that this may have some implications for other tasks that the observers are required to undertake (e.g. fish by-catch sampling).

3.38 The Working Group acknowledged the progress made towards development of krill fishery management this year, and that recruitment has been identified as a priority parameter for stock assessment. Given that krill observer coverage will reach 100% from the 2020 fishing season, the Working Group stressed the timeliness of holding a focused workshop on the priorities for data collection, information sharing and overall tasking for observers in the krill fishery. The Working Group welcomed the offer from China to host such a workshop in 2020 and asked Dr G. Zhu (China) to develop draft terms of reference and a budget for the workshop to be considered by the Scientific Committee.

3.39 The Working Group noted the importance of providing SISO observers with feedback from the analyses conducted using observer data to provide a wider perspective and understanding of the krill fishery and thanked the SISO observers for their hard work and acknowledged the important resource they provide for research and management of the krill fishery.

CPUE and spatial dynamics

3.40 WG-EMM-2019/09 provided a description of the operations of the Chilean krill fishing vessel *Antarctic Endeavour* throughout its first year of operation (2017/18) including the fishing locations, CPUE and the length-frequency distributions of krill.

3.41 The Working Group noted the information provided in WG-EMM-2019/09 and that the increases in CPUE over the year and the variability in green weight to meal conversion factors probably reflect the development of the processing capabilities of the vessel during its first season in operation. The Working Group encouraged other Members participating in the krill fishery to provide similar reports as this was helpful in better understanding data from individual vessels.

3.42 The Working Group noted WG-EMM-2019/41 which provided an analysis of the krill fishery in the context of the northwestern Antarctic Peninsula (NWAP) zones of the D1MPA proposal (with the addition of a main fishing hotspot within the current regular fishing zone). A suite of indicators, including total catch and measures of CPUE, were used to characterise how the fishing fleet used the different zones. CPUE was generally stable and showed low interannual and spatial variability in the different D1MPA zones, particularly in the main fishing hotspot, however, a decreasing trend in CPUE was observed in the Gerlache Strait zone in 2017 while it was stable in other years.

3.43 The Working Group noted that this analysis could be useful in the design of reference areas proposed in the D1MPA proposal and should be regularly updated to examine if the trends observed reflect natural variability in the krill population or changes that arise from increased spatial concentration of fishing activity.

3.44 The Working Group agreed that the analysis clearly showed the change in operation of the fishery in Subarea 48.1 and in particular the concentration of the fishery in Bransfield Strait and in the increased level of catch in the Gerlache Strait since 2006. In respect to the increase in catches in the Gerlache Strait, and a decreasing daily CPUE during 2017, the Working Group noted the need for precaution as this is an important area for predators.

3.45 The Working Group noted that the introduction of voluntary buffers in 2019, analysed in WG-EMM-2019/41, has the potential to cause the krill fishery in the area to further concentrate fishing effort in space and time.

3.46 The Working Group noted that there was relatively little variability in many of the indices of CPUE in WG-EMM-2019/41 and considered that spatial concentration of large krill swarms and the fishery in the fishing hotspot could lead to hyper-stability in CPUE.

3.47 The Working Group recalled earlier discussions (WG-EMM-2017 report, paragraphs 3.96 to 3.100) on the potential to use acoustics data from krill fishing vessels along with the CPUE to better understand the relationship between CPUE and krill abundance. Furthermore, increases in swarm density and increasing modal length of krill have been observed over the period March to May in Subarea 48.1 (WG-EMM-2017 report, paragraphs 3.15 and 3.18).

3.48 The Working Group encouraged continued analysis of simultaneous acoustic data and catch data across a range of vessels and gear types to further progress the interpretation of CPUE data.

3.49 Dr Zhu informed the Working Group that observers on a Chinese krill fishing vessel were conducting instantaneous growth rate experiments to examine growth rates during the period of operation of the fishery and that the results from these experiments would help elucidate the causes of changes in modal length observed and provide an additional source of information with which to examine CPUE dynamics.

Fishing vessel surveys

3.50 WG-EMM-2019/32 provided information on a Norwegian study into the use of stationary echosounders mounted on moorings to assess the effects of krill vertical distribution on vessel-derived survey results. Data obtained from the South Orkney Islands during the 2019 survey using a Nortek broadband echosounder indicated substantial temporal and geographical variation in diel vertical migration (DVM) with 13% of the macro zooplankton backscatter found in a depth shallower than ~20 m during daytime, while 24% was found above ~20 m during the night. The Working Group noted that such upward-looking devices are useful for acoustic sampling in near-surface waters where the use of research and fishing vessel-mounted devices is difficult.

3.51 The Working Group noted the development of studies to assess diurnal movement of krill using stationary echosounders and noted their value in assisting with interpretation of output from vessel-borne surveys. The Working Group recommended that SG-ASAM consider the use and analysis of data derived from stationary moorings to provide information on krill DVM. It noted that similar devices have been deployed in Subarea 48.1, including in the Bransfield Strait. Collection of data from stationary echosounders in areas with high predator densities could provide information on how predator presence influences krill distribution and behaviour.

Krill-based ecosystem interactions

Krill biology, ecology and population dynamics

4.1 WG-EMM-2019/03 outlined Australia's plan to conduct a krill survey in Division 58.4.2, east of 55°E, from 23 January to 25 March 2021 to estimate biomass of krill. The main objectives of the survey are to update the krill biomass estimate in Division 58.4.2, east of 55°E, and to design a tractable and sustainable long-term monitoring plan and evaluate spatial management of the krill fishery. The project also plans to understand distribution and structure of krill swarms and its relation to predator activities, as well as contribution of deep-sea krill to the overall krill biomass and its dynamics.

4.2 The Working Group welcomed the development of the survey by Australia. It noted the importance of liaising with SG-ASAM, including intersessionally through e-groups, on technical issues to ensure consistency of methods with CCAMLR standard protocols, as well as choice of echosounder frequencies concerning observation of deep-sea krill. It also noted that results and experience from the recent Japanese survey in Division 58.4.1 will provide useful insights for this survey.

4.3 WG-EMM-2019/79 outlined the planned survey by India from December 2019 to February 2020 in the Prydz Bay region. Specific goals of the survey are to understand the distribution and biomass of krill in the western Indian Ocean sector of the Southern Ocean, and to relate larval/adult krill with the prevailing oceanography and the environment to examine the drivers that control the krill ecosystem. The ultimate goal of the survey is to assess impacts of changing climate or long-term variations into the future. The Working Group welcomed this planned survey and looked forward to the report of the voyage in coming years.

4.4 WG-EMM-2019/12 Rev. 1 reported on the second annual meeting of the SCAR Krill Action Group (SKAG) which took place on 15 and 16 June 2019 in Concarneau, France, and was attended by 24 scientists from 10 nations.

4.5 At the meeting the group:

(i) formalised its structure

(ii) identified 'recruitment' and 'krill's plasticity to climate change' as two important knowledge gaps in krill research that provide critical scientific information for krill fishery management

(iii) identified a list of actions that can be taken within the remaining 18 months (until the end of the current SKAG phase)

(iv) ensured and encouraged active participation of young scientists by assigning young scientists roles as well as plans to establish links through existing platforms for early career scientists.

4.6 The Working Group highlighted SKAG's important role as a conduit between CCAMLR and the wider krill research community to assist in providing critical scientific information, such as on recruitment and mortality, in light of the Working Group's plan in progressing improvement of the krill fishery management (paragraphs 2.26 to 2.29).

4.7 Dr T. Ichii (Japan) drew the Working Group's attention to an important opportunity for SKAG for testing the theory of intraspecific competition for food as the main driver of the krill population dynamics (Ryabov et al., 2017), in which their model suggested that an increase of predators initially drives down and then stabilises the high oscillation of krill biomass within a five- to six-year cycle. He noted that, given the high predator abundance and increasing fishing pressure on krill in the Bransfield Strait, such models should be investigated as a priority. Dr Kawaguchi, as the Vice-Chair of SKAG, clarified that such hypothesis testing using the Ryabov et al. (2017) model is a candidate research priority for SKAG.

4.8 WG-EMM-2019/70 outlined a current project that uses metabolomic and transcriptomic approaches to better understand the mechanisms that govern geographic distributions and metabolic responses generated by an environmental stress (i.e. temperature) in krill species. The information to be generated from this project deepens the understanding of the mechanisms of the adaptation of Euphausiids to cold environments. The ultimate goal of the project is to enable prediction of the responses of organisms that are affected by the impact of global warming and an increasingly intensive fishery, especially for Antarctic krill.

4.9 The Working Group welcomed the presentation of the project noting its importance to evaluating how climate change might change the structure of the Southern Ocean ecosystems and looked forward to future updates on the progress of the project.

4.10 WG-EMM-2019/76 considered krill length data collected through both SISO and CEMP, focusing on length-frequency distributions in the Bransfield Strait and their potential use to support krill fisheries management. Differences in mean lengths and length frequencies were apparent but both data sources appeared to be tracking similar processes. The paper stressed the importance of using long-term data collected by different sources to gain an adequate understanding of trends in krill population structure and dynamics for use in fisheries management.

4.11 The Working Group thanked the Secretariat and underscored the importance of such analyses, especially given the recent suspension of several time series based on predator diets. It suggested publishing all the composite length-frequency series from various sampling sources in the Krill Fishery Report. The Working Group also noted the importance of taking account of sample size when generating composite length-frequency distributions.

4.12 The Working Group noted the recent paper (Fuentes et al., 2016) indicating that suspended particles released from glacial melting being ingested by krill may be the cause of krill stranding and mass mortality, and suggested the importance of data collection on krill length-frequency distribution from stranded krill to monitor the effect of glacier melting on the krill population into the future. 'Krill spill' (i.e. undigested krill spilt by returning foragers in penguin colonies) might also be a useful source of length-frequency distribution information, and an alternative to stomach lavage (WG-EMM-2018 report, paragraphs 4.14 to 4.16).

4.13 WG-EMM-2019/P03 and 2019/P04 presented the results of stable isotope studies of adult krill in the austral autumn and winter. In both studies $\delta^{15}N$ values were strongly associated with krill size, indicating increased carnivory in larger animals, especially in winter. Carnivory was also higher in the South Shetland Islands than the Bransfield Straight and might be associated with feeding closer to shore. At South Georgia, size differences in $\delta^{13}C$ in June suggest lower feeding success in larger animals at this time. Variation in $\delta^{13}C$ occurred only between April and May in Subareas 48.1 and 48.2 suggesting an increase in primary production in autumn.

4.14 The Working Group welcomed this additional information on variability in the trophic status of krill, which corresponds with previous studies showing a switch from filter feeding to predatory behaviour and corresponding dietary switching from diatoms to zooplankton as they grow, including winter cannibalism at South Georgia, which could be one of the important overwintering strategies under food-poor environments (Nishino and Kawamura, 1994). Cannibalism has also regularly been observed for krill in captivity. It was further noted that analysis of individual body parts might provide additional information about recent versus longer-term feeding patterns and $\delta^{13}C$ values may be useful to indicate latitudinal movement.

4.15 WG-EMM-2019/20 presented maps of egg, larval, juvenile and adult life stages of Antarctic krill in Area 48. The distribution of eggs, nauplii and metanauplii indicated that spawning is most intense over the shelf and shelf slope. Calyptope and furcilia larvae were concentrated further offshore, mainly in the southern Scotia Sea and juveniles occurred over shelves along the Scotia Arc. Contrasts between early and late season suggests habitat partitioning with juveniles moving on-shelf while adults move off-shelf.

4.16 WG-EMM-2019/21 presented the results of a study which contrasts models of krill transport to Subarea 48.2 with and without ice-associated behaviour in addition to simple krill advection on ocean currents. Models which included ice-associated behaviour permitted transport from much of the northern Antarctic Peninsula and reduced retention time on the South Orkney Plateau due to rapid ice-associated off-shelf transport.

4.17 The Working Group noted these two papers and discussed the relative contribution of movement versus differential survival to the observed distributions, recognising that both may play a role. The contrast between model results with and without ice-associated behaviour highlighted the differences that behaviour might make to krill distribution, and it is likely that models which represent krill as exclusively passive drifters are insufficient to explain patterns observed. The success of krill in an environment in which food sources are patchily distributed suggests that behavioural interactions with food sources are also an important influence on distribution. Further work on the behaviour and physiology of krill will be useful to help identify the underlying mechanisms and to improve the utility and interpretation of models.

4.18 WG-EMM-2019/P01 presented a model of the potential flux of particulate organic carbon originating from Antarctic krill in the marginal ice zone. Krill swarming behaviour could result in carbon export to depth through their rapid exploitation of phytoplankton blooms and bulk egestion of rapidly sinking faecal pellets. The model results suggested a seasonal export flux of 0.039 giga-tonnes of carbon across the Southern Ocean marginal ice zone, corresponding to 17–61% of current satellite-derived export estimates for this zone. Thus krill may be important contributors to the Southern Ocean carbon sink.

4.19 The Working Group noted WG-EMM-2019/P01 which showed that krill make an important contribution to the global carbon cycle. It recommended that the Scientific Committee note this fact and promote the recognition of the role of krill in global and regional biogeochemical models.

4.20 WG-EMM-2019/P02 presented evidence of climate-related change in the Antarctic krill population in the southwest Atlantic based on analysis of density (number per m^2) and length-frequency data from scientific netting in the 1920s and 1930s and from 1976 to 2016. The results showed a poleward contraction in distribution associated with sharp changes in density north of 60°S which became less sharp further south. They also showed an increase in mean length affecting most latitudes and a relationship between recruitment and the Southern Annular Mode (SAM). Together, the results suggested that climate-driven changes in recruitment have restructured the krill population spatially and demographically since 1976.

4.21 WG-EMM-2019/28 reviewed evidence of change in indices of density and availability to predators. While many of these indices showed negative change, there was no direct evidence of a change in biomass. The paper presented power analyses of annual biomass indices from acoustic surveys in Subareas 48.1 and 48.3. It demonstrated that because these data series are relatively short and have high interannual variability, they have low power to determine whether systematic change has occurred, thus, the assumption that the krill stock has been stable since the 1980s might be inappropriate.

4.22 The Working Group welcomed these studies which evaluate indices of krill stock status and recognised that long-term information on large-scale biomass is not available. Furthermore, most of the available environmental and biological datasets have high levels of interannual variability, meaning that signals of change may take many decades to emerge from the noise. The high level of variability in the available indices of krill stock status emphasised the need for regular monitoring of krill biomass to inform management of the krill fishery. The Working Group also noted a discontinuity in scientific net-based length-frequency data around 2004.

4.23 Dr Ichii reminded the Working Group that annual biomass indices from acoustic surveys in a 10 640 km^2 survey box in Subarea 48.3 showed no evidence of change in krill biomass between 1997 and 2013 (Fielding et al., 2014).

4.24 The Working Group recognised that acoustic surveys generate more information than a single biomass or density estimate per year. In particular, they provide information on the distribution of krill within the survey area. Characteristics of this distribution, such as the availability of high-density swarms, might have a stronger influence than mean density on ecological interactions.

4.25 The Working Group noted that observed change and variability in krill populations might be the result of multiple impacts, including those of fishing, which require additional investigation.

Krill life-history parameters and population models

4.26 WG-EMM-2019/45 outlined the promise and the challenges of the krill ageing method using their eyestalks to make a significant contribution to the objectives of CCAMLR, highlighting some critical issues that need to be addressed before the method can be used reliably by the krill research community.

4.27 The Working Group stressed the urgency of standardising such a method as information on krill age is fundamental to establishing an accurate growth curve and to calculate a recruitment index; the parameters for a GYM to estimate a sustainable yield (γ).

4.28 The authors of WG-EMM-2019/45 clarified that using known-age krill is essential for calibrating the method, which is planned to be provided by the Australian Antarctic Division and/or Port of Nagoya Public Aquarium.

4.29 The Working Group welcomed this initiative and recognised the importance of the application of the method to the field samples, and recommended that the Scientific Committee identify resources that could be used to provide a workshop to bring together laboratories from different Member nations to conduct interlaboratory calibrations much like the ageing workshops that were conducted for toothfish in the mid-1990s, and asked the authors to develop draft terms of reference and a budget for the workshop for the Scientific Committee to consider.

Krill predator biology, ecology and population dynamics

4.30 WG-EMM-2019/33 reported on the existence of seasonal fish migrations into a krill hotspot through the analysis of acoustic mooring data north of the South Orkney Islands. The authors highlighted the potential for daytime acoustic estimates of krill to be confounded by the presence of planktivorous fish that exhibit similar backscattering levels. The occurrence of a deeper night-time scattering layer, indicative of vertically migrating fish, may serve as an indicator of potential bias of daytime estimates of krill.

4.31 The Working Group agreed that WG-EMM-2019/33 may be relevant to the Working Group on Fish Stock Assessment (WG-FSA) in the context of fish stocks recovering from overharvesting, and requested it be submitted to the next WG-FSA meeting for consideration.

4.32 WG-EMM-2019/34 demonstrated the use of moored echosounder data to identify air-breathing predators' diving activity just north of the South Orkney Islands. Using automated image recognition, the authors processed a one-year acoustic dataset to detect clear patterns in diving behaviour at short-term (diurnal) and longer-term (seasonal) time scales. However, at these timescales the authors could not detect a relationship between pelagic backscatter and diving activity in the vicinity of the mooring.

4.33 The Working Group agreed that this method would be valuable to improve understanding of how predators interact with krill swarms, and provide additional context to similar acoustic data collected by fishing vessels. The Working Group further agreed that environmental effects such as the presence of sea-ice over the mooring during winter should be considered when interpreting acoustically derived patterns of predator diving.

4.34 WG-EMM-2019/49 identified spatio–temporal overlap between the fishery for krill, breeding monitored penguins and non-breeding unmonitored male Antarctic fur seals. Tracking data covering the entire austral autumn and winter showed male fur seals moving into the Bransfield Strait before the fishery and occupying foraging grounds utilised by chinstrap penguins during the latter stages of breeding and as chicks fledged. The authors recommended that the potential competitive interactions between numerically abundant male Antarctic fur seals and monitored penguin species should be considered when interpreting penguin monitoring indices, particularly those relating to fledging.

4.35 The Working Group agreed that male Antarctic fur seals should be considered as important predators of krill in this area, although the difficulty in estimating abundance makes developing spatially resolved consumption estimates challenging. Furthermore, it was acknowledged that it would be difficult to detect an impact of fishing on this demographic given the polygynous mating system in Antarctic fur seals.

4.36 WG-EMM-2019/67 presented the distribution and areas of mixing of two stocks of humpback whales (Western and Eastern Australian stocks or ‘D’ and ‘E1’ stocks) in the Indo–Pacific region of Antarctica (Division 58.4, Subareas 88.1, 88.2, south of 60°S). Using genetic markers and genetic samples from both low (winter) and high (summer) latitudes, the authors demonstrated that the geographical boundaries of the IWC Management Areas broadly correspond to the boundaries of biological stocks, although there is some evidence of stock mixing in the eastern parts of Area III (Subarea 58.4) and Area V (Subarea 88.1). The data also suggested that both stocks do not distribute in Area VI (Subarea 88.2) in summer. Additional analyses considering a finer geographical scale in the Antarctic are planned. The authors therefore advised caution in attributing abundance estimates in Area VE (160°E–170°W) (Subarea 88.2) solely to the eastern Australian humpback stock.

4.37 The Working Group welcomed the study and acknowledged that in light of the results, linking abundance estimates of cetaceans at feeding grounds with breeding ground estimates would be important for ensuring appropriate risk assessment updates into the future. The Working Group further noted that differences in the abundance and distribution of krill at the feeding grounds may be setting the different carrying capacities of the two stocks.

4.38 The Working Group discussed WG-EMM-2019/10 and additional analysis submitted as a presentation to Agenda Item 4.3. The paper spatially and temporally matched pygoscelid penguin foraging areas with 37 years of annual fishing catch and SAM index values within a modelling framework to assess corresponding penguin population change rates. The paper showed significant decreases in population of chinstrap penguins in high catch years. The paper concluded that there is likely an additional negative stress for penguins from the increased concentration of krill fishing, and emphasised priority areas of conservation like the proposed D1MPA.

4.39 The Working Group congratulated the authors and agreed that exploring additional modelling parameters may strengthen the analysis presented in WG-EMM-2019/10, including regional concentration of sea-ice or colony-specific conditions. The Working Group noted both the danger of over-simplifying models (e.g. Melbourne-Thomas et al., 2013), and the need for an upper limit to the number of parameters for a population model.

4.40 The Working Group noted that, when identifying the effects of fishing on predators, differentiating between correlation and causation is important. The Working Group further agreed that fishing and non-fishing reference areas or integrated models could be established to more directly measure the effects of fishing. The Working Group drew attention to previous discussions about the potential for krill vessels to disrupt swarming behaviour (paragraph 2.5). However, the Working Group recalled that previously submitted acoustic data from fishing vessels indicate limited effects on swarm densities and thickness. The authors of WG-EMM-2019/10 offered to incorporate any provided acoustic data into their modelling.

4.41 The Working Group noted that two separate modelling approaches using different assumptions (WG-EMM-2019/10 and 2019/11) came to the same conclusions regarding probable impacts of concentrated krill fishing on the penguin populations and emphasised the need for precautionary management approaches. The Working Group agreed that WG-EMM-2019/10 and 2019/11 demonstrate that krill fishing at current levels and concentration in the Bransfield and Gerlache Straits are likely to have had a negative effect on localised predator populations in years with unfavourable environmental conditions. The Working Group further noted that the exact temporal and spatial scale of that impact is unknown and requires further study.

4.42 The Working Group emphasised the importance of Members working collaboratively to assess the best available data to better understand fishery–predator interactions. The Working Group drew attention to the value of empirical models for interpreting the best science in a precautionary approach.

4.43 The compendium of seven published papers in WG-EMM-2019/72 was discussed by the Working Group together, as they all related to comparing levels of health threats to pygoscelid penguins along the WAP. The paper demonstrated significant increases in a variety of health stress indicators with increasing latitude, including: humoral and immune system indicators, parasites, stress levels and trace contaminants. The authors suggested that such information about the spatial distribution of threatening processes to penguins may be useful for the planning of the D1MPA.

4.44 The Working Group highlighted the importance of such indicators of environmental stress to inform risk assessments of penguins and other krill predators. The Working Group agreed that the outputs of WG-EMM-2019/72 could be integrated into D1MPA planning. Additionally, the Working Group stressed that demonstrated variable impacts along latitudinal gradients such as these, highlight the need to distribute the krill catch in space and time.

4.45 WG-EMM-2019/35 Rev. 1 summarised cetacean observations collected in Subareas 48.1 and 48.2 on board the Ukrainian vessel *More Sodruzhestva* from December 2018 to January 2019. Species and behaviour were recorded from 66 sightings of baleen whales totalling 207 minke whales and 59 humpback whales. Behaviours were similar, although minke whales were more often observed feeding and humpback behaviour was more diverse, including nursing and breaching events.

4.46 The Working Group noted that even with relatively limited spatial and temporal coverage in this survey, abundance and photo ID data were collected that contribute to describing the spatial and temporal distribution of cetaceans and the possibility of re-sighting.

4.47 The Working Group discussed WG-EMM-2019/68 which outlined a Japanese research plan to study the abundance/abundance trends and stock structure/movement of large whales in the Indo–Pacific Southern Ocean (JASS-A) (Subareas 48.6, 58.4, 88.1, 88.2, south of 60°S). The study was designed to align with previous studies including JARPA/JARPA-II and NEWREP-A, and will feature only non-lethal sampling. JASS-A is planned for the next eight years, and also includes secondary objectives related to oceanographic and marine debris surveys, use of genetic data for abundance estimates and feasibility studies on non-lethal techniques for whale research. The first survey will be conducted in the western part of IWC management Area III (0–35°E) (Subarea 48.6) in 2019/20. JASS-A welcomes participation of external scientists in both field and analytical works, following established protocols for collaboration.

4.48 The Working Group welcomed the undertaking from Japan that data from the proposed marine debris monitoring data in WG-EMM-2019/68 will be submitted to the Secretariat.

4.49 The Working Group highlighted the value of the cetacean observation data that were collected during multiple 2019 research surveys (WG-EMM-2019/07, 2019/08, 2019/22, 2019/23, 2019/24, 2019/27, 2019/35 Rev. 1, 2019/38, 2019/46, 2019/67, 2019/68, 2019/80). The Working Group noted the increase in papers submitted to WG-EMM this year assessing the abundance and distribution of whales and acknowledged that this represented increasing consideration within WG-EMM of their role in the ecosystem as consumers of krill.

4.50 In order to assess data availability for cetacean studies, the Working Group invited Members to contribute available metadata describing data that could be used for current and future issues with consultation and permission of data managers as appropriate. The Working Group established its initial priorities as to:

(i) consolidate the available data for the Area 48 risk assessment layer, and more broadly, for evaluation of the impact of krill fisheries on cetaceans

(ii) agree on standard methods to be used during future cetacean observations to facilitate combining datasets for future analyses (e.g. considering IWC protocols for line-transect monitoring)

(iii) expand the spatial coverage of cetacean data available to WG-EMM, particularly to areas outside of Area 48

(iv) discuss the collection of data on cetacean behaviour.

4.51 The Working Group noted that the important marine mammal areas (IMMAs) program (WG-EMM-2019/80) could be considered by WG-EMM to support management of marine living resources, as they have been developing a science-based approach in an area of interest for CCAMLR. Further, the Working Group agreed that a mechanism to merge current risk assessment or spatial planning efforts with emerging IMMA data layers could be considered by the Scientific Committee. Finally, the Working Group encouraged Members with photo ID data to use existing science platforms currently in use by Antarctic scientists, such as Happy Whale (https://happywhale.com).

4.52 In order to facilitate efficiency of the Working Group and its cetacean related collaboration with external organisations, the Working Group requested the Scientific Committee to provide advice and an endorsement to proceed with the following potential steps forward: (i) contact existing organisations with pre-existing datasets and ongoing work that may provide natural collaborations or analytical advice such as the International Whaling Commission Southern Ocean Research Partnership (IWC-SORP) or the IWC-SC, and (ii) appeal to appropriate Scientific Committee on Antarctic Research (SCAR) bodies that could potentially provide both data and scientific advice directly to WG-EMM such as the SCAR Expert Group on Birds and Marine Mammals (EG-BAMM).

Ecosystem monitoring and observation

CEMP monitoring

5.1 WG-EMM-2019/04 detailed CEMP data submissions for the 2018/19 monitoring season and an update to the Area 48 spatial analysis using combined standardised indices (CSIs). It was noted that the e-forms and CEMP database had been updated intersessionally following recommendations made at WG-EMM-18, to facilitate submission of krill length data collected from predator diets, as well as standardised breeding population size data collected at sub-optimal times (WG-EMM-2018 report, paragraphs 4.4 to 4.6).

5.2 The Secretariat informed the Working Group that Australia had registered eight new CEMP sites from Mac Robertson Land, Wilkes Land and Princess Elizabeth Land, and had submitted breeding success data collected from camera monitoring at these sites prior to WG-EMM-2019. The Working Group thanked Australia for its work to expand monitoring efforts and increase the spatial range of data submitted to the CEMP database.

5.3 The Working Group recommended the relevant CSIs be included in the annual Krill Fishery Report for Area 48. It also recommended that future analyses look at individual parameters by sites in addition to the multivariate analysis to explore emerging temporal trends.

5.4 The Working Group noted inconsistencies in data collection for some sites where logistics of data collection are more complicated, such as Laurie Island, and discussed the importance of continuing data collection at long-established CEMP sites with historical data series. The Working Group noted that Laurie Island was an important CEMP site to measure predator performance in relation to krill variability, and expanding the camera network to this site may assist with consistent data collection.

5.5 The Working Group noted that there was a positive relationship between the krill densities in the time series in the South Orkney Islands in WG-EMM-2019/69 and the CSIs from the CEMP monitoring at both Signy and Laurie Islands (WG-EMM-2019/04).

5.6 WG-EMM-2019/36 Rev. 1 analysed Adélie penguins' response to unmanned aerial vehicles (UAVs) at Cape Hallett in the Ross Sea region, as a response to Members' concerns that UAVs used for monitoring purposes may have negative side effects and disturbances on the colony. Vertical and horizontal flights for UAVs (using quadcopters and hexacopters) were flown at four specific altitudes, with behavioural response of the penguins categorised and recorded. Based on the behavioural response from visual approaches and noises by UAVs, it was suggested that minimum flight altitudes be set to 50 m for quadcopters and 100 m for hexacopters.

5.7 The Working Group thanked Dr J.-H. Kim (Korea) and others for their efforts to improve understanding surrounding the effects of UAV technology on penguin behaviour and welcomed the discussion of new methodologies that could minimise disturbance from monitoring while increasing data collection.

5.8 The Working Group considered how data collected using UAV technology might be incorporated into CEMP standard methodology and suggested that noise and size characteristics of the specific device used, rather than specification to a particular product, would be easier to develop into standard methodology.

5.9 The Working Group noted the importance of conducting work to support policy development in regard to emerging technologies that can be used in monitoring of predators and encouraged further work to develop standard methods to enable submission of data collected using drones. The Working Group also noted the recent agreement by the Antarctic Treaty Consultative Meeting (ATCM) of environmental guidelines for operation of remotely piloted aircraft systems (RPAS) in Antarctica (ATCM Resolution 4, 2018).

5.10 WG-EMM-2019/44 reported on the final stage of the CEMP Special Fund project for 'Developing an image processing software tool for analysis of camera network monitoring data' that was initiated with support from the CEMP Fund in 2015/16. The software, which has been updated since it was first presented in 2015 (WG-EMM-2015 report, paragraphs 2.181 and 6.8) with additional image-processing, data-processing and data-reporting features that, combined with the new R code written to reformat generalised output tables for specific CCAMLR needs, will allow for a seamless transition from image processing to estimation of CEMP parameters consistent with recently agreed changes to estimation methods and CEMP data e-forms. The Seabird & Penguin Population Dynamics Camera Analysis & Monitoring Software (SPPYCAMS) has been made available for use by the CCAMLR community (https://data.aad.gov.au/aadc/sppycams).

5.11 The Working Group thanked Dr C. Southwell (Australia) and others involved in the development of SPPYCAMS for their collaborative effort to complete this project and noted that the updated software would assist in the timely delivery of CEMP data to the Secretariat.

5.12 The Working Group noted that the CEMP Special Fund has funded several projects resulting in advances to monitoring work and is a useful mechanism to develop monitoring efforts and to enhance cooperation with CEMP. The Working Group encouraged the submission of proposals to the CEMP Special Fund, noting that the Fund provides opportunities to increase the number of CEMP sites and to enable other Members to begin their own monitoring programs.

5.13 WG-EMM-2019/59 and 2019/60 reported on monitoring activities at Galindez Island for gentoo penguins, including the CEMP camera data validation experiment as well as data collected in relation to behaviour and population dynamics during the 2018/19 season.

5.14 The Working Group considered the importance of conducting work to improve validation estimates arising from variability between camera-sourced data and visual-sourced data. The Working Group noted that the variability reported in WG-EMM-2019/59 was consistent with previously published results (Hinke et al., 2018) but that the ongoing validation work was critical for understanding the accuracy of results from camera sites where validation work is not possible.

5.15 The Working Group thanked Dr G. Milinevskyi (Ukraine) for his presentation and work to expand data collection at the Ukraine monitoring sites. The Working Group noted that Galindez Island is the southernmost CEMP site on the Antarctic Peninsula and highlighted the importance of continuing monitoring at this site. The Working Group noted that the biological data, including penguin population dynamics census, collected on a year-around basis at Vernadsky Station area, and organised in an accessible database, will be useful for monitoring ecosystem status and changes.

CEMP Special Fund

5.16 The Chair of the CEMP Special Fund, Dr Santos, presented updates to the CEMP Special Fund procedures and informed the Working Group that a call for applications for funding will be sent out in July via an SC CIRC, with applications to close in August.

5.17 The Working Group endorsed the changes to the CEMP Special Fund procedures, which included incorporating the priority to maintain ongoing monitoring programs within the scope of the assessment procedure for project proposals.

5.18 The Working Group highlighted the success of the CEMP camera monitoring network, financed by the CEMP Special Fund, which has enabled several Members to either initiate or sustain monitoring efforts at CEMP sites, and noted that ongoing expansion and maintenance of the network will continue to increase capacity and engagement in CEMP.

5.19 The Working Group agreed that developing a dedicated mechanism of funding to support the camera monitoring network (e.g. to assist in costs of repairs, battery replacements) through the CEMP Special Fund would enable maintenance and expansion of these important monitoring programs and facilitate increased participation by interested Members. The Working Group recommended that the Scientific Committee support such a mechanism, noting that a simple request form submitted to the Secretariat may be a suitable approach which could be included in the administrative processes of the CEMP Special Fund.

Other monitoring data

5.20 WG-EMM-2019/37 described methods to engage citizen scientists in searching for Weddell (*Leptonychotes weddellii*) and crabeater (*Lobodon carcinophagus*) seals on satellite images, and reported that the false positive rate was high (67%) and false negative low (1.7%). This approach is proposed to further the sampling of potential habitats and reduce the search time for seal presence. Weddell seals seem to occupy less than 1% of habitat available to them.

5.21 The Working Group noted that new technologies may produce huge datasets. The development of machine learning techniques, and the use of citizen science approaches, may help increase research capacity by processing emerging datasets more quickly, and may help raise awareness of the work of CCAMLR.

5.22 WG-EMM-2019/38 provided a preliminary report on the research activities undertaken by the *Tangaroa* between 8 January and 16 February 2019. Researchers undertook a multidisciplinary research survey to collect environmental and biological data, principally from the seabed, in the eastern area of the continental slope.

5.23 The Working Group commented that such research observation efforts are extremely valuable to the objectives of CCAMLR, particularly as information for the Ross Sea region (RSR) MPA evaluation.

5.24 WG-EMM-2019/50 described the use of baited remote underwater video (BRUV) to study toothfish in areas where extractive methods cannot be used. A preliminary report on this project was presented at WG-FSA-2018 (WG-FSA-18/62). BRUVs were deployed from the fast-ice of McMurdo Sound and Terra Nova Bay as a tool to estimate abundance and length distribution of toothfish. Beyond toothfish, observations include the collection of data for various environmental factors such as depth, substrate and coverage of benthos. Various metrics are used as proxies for toothfish abundance.

5.25 The Working Group noted this method and suggested that future work may include the identification of benthic taxa and communities, protocols for identification of tagged fish and tracking fish approach angle with respect to smell plume to determine bait decay effect on abundance calculations.

5.26 WG-EMM-2019/51 Rev. 1 provided background information about mercury (Hg) cycling. It also summarised a geographical comparison of Hg levels in seawater, snow/snowmelt and biota. Results show that Hg levels in lichen and moss are 3–5 times higher in Terra Nova Bay compared to the South Shetland Islands. The paper also reported increasing levels of Hg in krill and krill predator tissues that were positively correlated with trophic position. Global change may modify the Hg cycling. This effect could be quantified with the monitoring of Hg concentration in the environment, which can be considered as an indicator of environmental health. Furthermore, the paper recommended adding Antarctic krill as a new CEMP species.

5.27 The Working Group agreed on the importance of tracking environmental Hg, but noted that the influence of volcanic activity and establishing baseline Hg levels by sampling ancient biological archives, like corals, may be considered in future work.

5.28 WG-EMM-2019/53 and 2019/54 described four different barcoding programs in the Southern Ocean. Two were conducted within the French Kerguelen exclusive economic zone (EEZ): a fisheries observer ID quality control study and a large-scale barcoding project of invertebrates collected during the POKER 4 cruise that will provide a molecular reference database for the area. The third project extended barcoding to mitogenomes for fish, and the fourth used standardised autonomous reef monitoring structures for micro-fauna colonisation study using metabarcoding in Terre Adélie. New sequencing approaches decrease costs and open new study opportunities for multiplex barcoding, mitogenome sequencing and metabarcoding. These projects will provide reference sequences for future projects such as environmental DNA studies or diet identification. The Working Group noted the remarkable amount of work done and congratulated the authors for their significant effort.

5.29 WG-EMM-2019/62 and 2019/64 reported on research projects conducted on board the *More Sodruzhestva* during the 2019 Area 48 Survey when the vessel continuously recorded various physical and biological parameters, including phytoplankton and mesozooplankton from station 1735 of the survey. Additionally, persistent pollutants in the water column near Vernadsky Station were monitored using passive samplers. The baseline dataset accumulated during this survey will be valuable in understanding the effects of climate change in the area. Furthermore, a bacterial metagenomics study is planned.

5.30 The Working Group commended the collaborative and multifaceted nature of the Ukrainian research efforts this year (WG-EMM-2019/61) and reflected that it has resulted in an increase of Ukrainian engagement in Antarctic research and contribution to WG-EMM.

5.31 WG-EMM-2019/65 reported on a census of Antarctic fur seal pups from the San Telmo Islands in December 2018 using a medium-range, vertical take-off and landing (VTOL) drone. The corrected census highlighted a dramatic decrease in the fur seal population at San Telmo Islands (90% since 1997). The paper concluded that the Antarctic fur seal population in the South Shetland Islands should be reassessed.

5.32 The Working Group noted that VTOLs provide a minimally invasive, inexpensive and accurate (error rates <2%) survey tool for Antarctic predators, including ice seals. The Working Group discussed how leopard seal predation is negatively affecting Antarctic fur seal populations in this area, but is unlikely to have caused the regional decrease of penguin populations.

Review of CCAMLR research and monitoring design and implementation

5.33 WG-EMM-2019/57 outlined components to be considered in further refining CCAMLR's management of the krill fishery, including:

(i) can fishery at its present level really affect krill resources and the status of populations of dependent predators and, if so, where, in what spatial–temporal scales and under what conditions?

(ii) development of scientifically based indicators of the status of dependent predators. After how many years can response of such indicators to the impact of the fishery be revealed?

(iii) research on ecosystem and competitive relationships between dependent predator species, instead of the proposed approach based on consideration of the penguin species only

(iv) development of scientifically based criteria and diagnostics to assess the possible ecosystem impact of the fishery, taking into account the mixed effects of fishing, environmental variability (or climatic changes) and the competitive relationship between predator species

(v) development of target points for the status of populations of dependent predators and decision rules on the krill fishery management, taking into account these target points.

5.34 Dr Kasatkina further noted that CEMP, acoustic survey and fishery data should be combined to address these components, and that changes in predator populations and krill availability around South Georgia and the Bransfield Strait provided ‘natural experiments’ that could be used to understand the ecosystem impact of the krill fishery and hence likely responses to the fishery. She also noted that the suggested candidate data provide the possibility to develop time series data for the further integrated analysis to understand whether there is only a spatial overlap between the predators and the fishery or if this is a functional overlap.

5.35 The Working Group noted that the outcomes of the focus topic (Agenda Item 2) had reached similar conclusions to the authors of WG-EMM-2019/57 on the key components that need to be addressed to provide revised management advice for the krill fishery in 2021. The Working Group noted that work in several papers presented at the current meeting specifically addressed many of these components (paragraphs 2.3, 2.4, 3.42, 3.45 and 4.41). It encouraged Members to continue such analyses to further enhance understanding of key processes that may impact on the krill stock and dependent predators, including fishing and environmental variability. It further noted that the relative importance of different processes was likely to be highly dependent on spatio–temporal scales, and that long-term datasets were critical to interpreting observations.

Spatial management

New Antarctic Specially Protected Area (ASPA) proposals

6.1 The Working Group considered draft management plans for new Antarctic Specially Protected Areas (ASPAs) at the Rosenthal Islands, Anvers Island, Palmer Archipelago, proposed by the USA (WG-EMM-2019/01) and Inexpressible Island and Seaview Bay, Ross Sea, proposed by China, Italy and Korea (WG-EMM-2019/40).

6.2 Recalling previous occasions on which it had discussed draft ASPA proposals (e.g. WG-EMM-2012 report, paragraph 3.7), the Working Group noted that prior approval from the Commission is required for the adoption of ASPAs: (i) in which there is actual harvesting or potential capability of harvesting of marine living resources which might be affected by site designation, or (ii) for which there are provisions specified in a draft management plan which might prevent or restrict CCAMLR-related activities (ATCM Decision 9, 2005). The Working Group agreed that it would restrict its advice to consideration of these points, but noted that further clarification could be sought from the Scientific Committee on the process for engagement with the ATCM on the development of ASPAs, if required.

6.3 The Working Group noted that the proposed ASPA at the Rosenthal Islands lies within the existing Southwest Anvers Island Antarctic Specially Managed Area (ASMA), which includes the Palmer long-term ecological research (LTER) study area. The primary reasons for designation of the area are its large and diverse colonies of breeding birds which are of exceptional ecological and scientific interest, its rarely visited and almost pristine condition, and its potential role as a reference area for comparisons with localities that have been affected by human activities. The marine component of the proposed ASPA extends up to 1 km seaward from the outer shores of the Rosenthal Islands, and to a maximum depth of less than 100 m.

6.4 Dr Zhao suggested that the proponents could consider providing further details on the link between the marine and terrestrial environments and the characteristics of the marine component to facilitate consideration of the inclusion of a marine component in the proposal.

6.5 The Working Group noted the importance of the Rosenthal Islands as a minimally impacted reference area of exceptional scientific interest.

6.6 The Working Group agreed that there is currently no harvesting in the Rosenthal Islands and the area is not of interest for harvesting activities, therefore it recommended approval of the draft management plan for a new ASPA in this area by the Scientific Committee.

6.7 In considering the proposed ASPA at Inexpressible Island, the Working Group noted that this area contains a distinctive ecosystem hosting one of the oldest known colonies of Adélie penguins and an important breeding site for south polar skuas, and is listed as an Important Bird Area (IBA). The area is adjacent to the Terra Nova Bay polynya, and is a reference site allowing comparison with nearby areas for studies on the effect of sea-ice dynamics on the ecosystem. The marine component of the proposed ASPA extends less than 1 km from the coast, and does not exceed 50 m in depth.

6.8 The Working Group noted the importance of the unique ecosystem at Inexpressible Island for ongoing, comparative scientific research.

6.9 The Working Group agreed that there is currently no harvesting at Inexpressible Island and the area is not of interest for harvesting activities, therefore it recommended approval of the draft management plan for a new ASPA in this area by the Scientific Committee.

6.10 Dr L. Krüger (Chile) indicated that Chile intends to submit a revised management plan for ASPA No. 146, South Bay, Doumer Island, Palmer Archipelago, for consideration at WG-EMM-2020, with updated information from scientific research conducted in the area.

MPA research and monitoring

6.11 WG-EMM-2019/77 described updates made by the Secretariat to the proposed data structure and implementation of the MPA Research and Monitoring Plan (RMP) Project List database. This forms part of the CCAMLR MPA Information Repository (CMIR), which will allow Members to interact with RMPs, including project lists. Updates to the database structure have been made based on recommendations from the Workshop on Spatial Management (WS-SM-2018), and following analysis of the common elements of existing RMPs. The Secretariat informed the Working Group that it would continue to develop elements of the CMIR and would update Members on progress intersessionally.

6.12 The Working Group thanked the Secretariat for its work in developing this important resource, which will help to increase transparency and accessibility of data, particularly as further information is generated through developing RMP activities. The proponents of the Weddell Sea MPA (WSMPA), D1MPA and the South Orkney Island southern shelf (SOISS) MPA indicated that they would work with the Secretariat in the intersessional period to provide links to relevant data layers and to populate the Project List database.

6.13 WG-EMM-2019/08 described research on habitat use of Type C killer whales (*Orcinus orca*) in the Ross Sea, which revealed discrete, largely non-overlapping areas of restricted search (ARS) along the coastline, indicating possible feeding grounds. The Working Group congratulated the authors, noting that this type of predator foraging data, especially for killer whales, is difficult to obtain, and agreed that this is a valuable contribution to the RSRMPA RMP. The Working Group further noted that this project is a good example of work to be included in developing the CMIR.

6.14 The Working Group considered WG-EMM-2019/31, outlining a revised draft RMP for the SOISS MPA. This draft plan takes account of recent work and general recommendations by the Scientific Committee on the development of RMPs, and sets out research and monitoring topics that address questions relevant to the specific MPA objectives. The draft plan also includes a Project List with information on completed and underway research activities, and details of relevant datasets, including (i) baseline data used in the designation of the MPA, and (ii) additional data available subsequent to the adoption of the MPA. Further information, including an updated MPA Report, will be provided to the Scientific Committee as part of the MPA review scheduled to be undertaken in 2019.

6.15 The Working Group welcomed this update, recalling that WS-SM-2018 had provided useful recommendations on the presentation of RMPs. It suggested that additional information on research fishing in Subarea 48.2, krill catch distribution and cetaceans could be added to the list of relevant data in Annex 1 of the RMP. In considering the role of this MPA as a reference area, the Working Group also noted that further information on the requirements for comparison with other areas in Domain 1 would be useful. However, it noted that this is not the only objective of the SOISS MPA, and that signals of change may not be evident over short time periods.

6.16 Dr Kasatkina suggested that the proposed two indicator species would not be sufficient for monitoring and assessing the effectiveness of MPAs in terms of marine ecosystem and biodiversity. Dr Kasatkina noted that additional indicator species would be needed and these indicators would be accompanied by their characteristics at the time of the establishment of the MPA.

6.17 The Working Group considered WG-EMM-2019/14, the Report of the Workshop on data and modelling issues relevant to the planning of a potential MPA east of the zero meridian in the Weddell Sea (Maud). The workshop objectives were: (i) to discuss the available data, gaps in data and future priorities for data collection, including ways to openly share existing and new data, and (ii) to decide on a candidate list of realistic modelling options to support a scientifically sound future MPA proposal appropriate to the available data and scientific knowledge. The workshop considered and discussed the current understanding of ecosystem connectivity and ecoregion representativeness within and beyond the Maud area, and candidate analytical tools to consider ecoregions and potential connectivity.

6.18 The Working Group welcomed progress towards the development of an MPA in the Maud region, which includes important bioregions that are not present elsewhere in the Convention Area. It discussed the use of different modelling options in the development of MPAs, noting that appropriate options could be selected based on the characteristics of different regions.

6.19 Dr Kasatkina noted that future further information on dominant fish species and krill would be useful for planning an MPA in the Maud region to designate areas for protection and potential fishing activity in the frame of this MPA.

6.20 WG-EMM-2019/71 outlined a study on connectivity patterns along the Antarctic Circumpolar Current (ACC) in the sub-Antarctic region. The review aimed to characterise dynamical mechanisms structuring primary production and trophic hotspots at a regional scale, and cross-boundary dispersal patterns of water between and beyond island groups. Methods such as Lagrangian tools and observations from high-resolution remote sensing provide new approaches for identifying physical connectivity pathways structuring the pelagic ecosystem, and could be integrated in ongoing pelagic spatial planning activities for the eastern sub-Antarctic region.

6.21 The Working Group noted the development of these techniques in linking physical ocean processes to ecological dynamics at various trophic levels, will be useful in identifying areas of importance at smaller spatial scales and understanding connectivity between regions.

6.22 Dr Lowther noted that a scientific experts workshop will be held in Cape Town from 26 to 30 August 2019 to examine pelagic connectivity across the sub-Antarctic region.

6.23 WG-EMM-2019/80 described recent work by an IUCN SSC/WCPA Joint Task Force on Marine Mammal Protected Areas (MMPA Task Force) to identify IMMAs. These areas are defined as 'discrete portions of habitat, important to marine mammal species, that have the potential to be delineated and managed for conservation'. An experts workshop held by SCAR in 2018 identified candidate IMMAs based on criteria including vulnerability, distribution and abundance, key life-cycle areas, distinctiveness and diversity. The next stage of the process will be to finalise the candidate IMMAs based on peer review by an expert panel.

6.24 The Working Group noted the development of this work, particularly in the context of its other work on cetaceans (paragraphs 2.39, 4.37, 4.45 to 4.52) and looked forward to the presentation of the IMMA scientific protocol at the Scientific Committee meeting in 2019. The Working Group noted that IMMAs are designed to inform policy makers about general management and conservation processes.

D1MPA

6.25 Dr Santos informed the Working Group that during this intersessional period the D1MPA proponents have been working with Members to progress the development of a D1MPA proposal in line with a comprehensive krill fisheries management approach. This has included an informal meeting with colleagues from Norway (report shared with the D1MPA Expert Group), participation in krill fishery management discussions during this Working Group meeting and at the Workshop on Krill-fishery Management for Subareas 48.1 and 48.2 (WG-EMM-2019/25 Rev. 1). In all these processes, similarities have been observed, and the proponents are working towards consolidating them in a single vision. In order to progress to a revised version of the proposal, Members with outstanding issues are invited to provide their comments to the proponents.

Data analysis supporting spatial management approaches in CCAMLR

6.26 WG-EMM-2019/05 described WSMPA data layers that have been deposited with the data repository PANGAEA. The following DOIs link to the corresponding datasets:

(i) Flying seabird and penguins: https://doi.org/10.1594/PANGAEA.899520
(ii) Demersal and pelagic fishes: https://doi.org/10.1594/PANGAEA.899591
(iii) Pelagic regionalisation approach: https://doi.org/10.1594/PANGAEA.899595
(iv) Seals: https://doi.org/10.1594/PANGAEA.899619
(v) Zoobenthos: https://doi.org/10.1594/PANGAEA.899645
(vi) Zooplankton: https://doi.org/10.1594/PANGAEA.899667.

6.27 The Working Group agreed that the interlinkage of such data from MPA developments through the CMIR (see WG-EMM-2019/77) using the relevant DOIs would be appropriate.

6.28 The Working Group considered two papers on the development of a marine area for protection at the Argentine Islands. WG-EMM-2019/19 described acoustic and underwater studies of the seabed off the Argentine Islands, continuing observations that have been made at a network of marine sites since 2012. WG-EMM-2019/63 outlined progress on the development of small-scale MPAs in the Argentine Islands Archipelago. Dr Milinevskyi confirmed that Ukraine intends to propose the designation of long-term environmental monitoring sites around the Argentine Islands, including relevant CEMP sites, as a new ASPA under the provisions of the Environmental Protocol to the Antarctic Treaty.

6.29 The Working Group encouraged the continuation of data collection and the further development of an ASPA proposal in the Argentine Islands Archipelago, which was highlighted as an important area in the D1MPA planning process.

6.30 WG-EMM-2019/48 described the recent Norwegian cruise to Kong Håkons VII Hav. The study area was the ocean south of 65°S east of 0° meridian and 13.5°E, with a focus on Astrid Ridge, and the cruise included work packages on bird and marine mammal observations, fish community, benthic mapping, zooplankton, primary production, oceanography, ocean carbon chemistry and ocean acidification. The Working Group recognised the importance of multidisciplinary cruises in regions where data are currently limited, and looked forward to receiving further results next year.

6.31 Dr Belchier noted that the UK had undertaken a physical oceanographic cruise (ANDREX II) to the east of the prime meridian at around the same time, which might provide additional information of interest for this region.

6.32 WG-EMM-2019/39 reviewed changes in environmental conditions of the Southern Ocean observed by satellites and data-assimilating models between 1981 and 2019. This data showed heterogenous patterns of environmental change across the Southern Ocean over the last four decades, including warming of the ocean surface north of the southern limit of the ACC and slight cooling to the south, and gradual loss of sea-ice in the Amundsen Sea and increasing sea-ice in the Weddell, Bellingshausen and Ross Seas.

6.33 The Working Group recognised the importance of such analyses in informing management strategies that are robust to the uncertainties produced by a changing climate. It noted that warming may not have occurred in some regions (e.g. Subareas 48.1 and 48.2) during recent decades, but that variability and unpredictability of environmental conditions are likely to increase across all regions. In addition, understanding the signals and impacts of change becomes more difficult at smaller scales, as highlighted by the recent Integrating Climate and Ecosystem Dynamics in the Southern Ocean (ICED) Krill Projections Workshop (WG-EMM-18/09, WG-EMM-2019/02 and paragraph 7.7).

6.34 WG-EMM-2019/20 on habitat partitioning in Antarctic krill, including spawning hotspots and nursery areas, and WG-EMM-2019/30, on the development of mIBAs for penguins in Antarctica, were also submitted under this agenda item, but were discussed in paragraphs 2.44, 4.15 and 2.41 and 2.42 respectively.

VME data and spatial planning approaches

6.35 WG-EMM-2019/52 described a method to assess the probability of vulnerable marine ecosystem (VME) indicator species reaching the CM 22-07 trigger threshold given the number of hooks, number of specimens and average weight of specimens using sea pens collected from research block 5844b_2 as a case study.

6.36 The Working Group noted from this case study that even though this region has the highest by-catch of this taxon ever recorded in the Convention Area, the trigger level in CM 22-07 had not been reached and no VME risk area had been designated. In this instance, reducing the threshold limit by a factor of four would lead to areas of highest density being designated a risk area. Hence, the Working Group agreed that further exploration of taxa and/or morphology-specific trigger limits be evaluated. To expedite this work, it was noted that protocols to collect taxa-specific weights would assist, noting that as vessels collect VME by-catch data, any data collection protocol needs to be practical and easy to realise on board vessels with a minimum of technical training. For example, specimens from a bucket may be spread on a checkered mat and photographed so measurements and identifications can be made by a trained taxonomist, or using image analysis algorithms that are under development.

6.37 WG-EMM-2019/73 Rev. 1 described habitat suitability of the VME indicator species, *Ptilocrinus amezianeae*, over the Kerguelen Plateau in Divisions 58.5.1 and 58.5.2. The methods used, repeated boosted regression tree (BRT) helped identify areas suitable for *P. amezianeae*, some of which are already protected, and others such as areas in the northeast of the Kerguelen Plateau in Division 58.5.1, and William's Ridge which extends to the east beyond Division 58.5.2 into the Southern Indian Ocean Fisheries Agreement (SIOFA) area, are not. The Working Group noted that Australia was planning a research voyage to study the geomorphology of William's Ridge, including video transects along bathymetric gradients, and looked forward to confirming whether *P. amezianeae* is present in the area as predicted.

6.38 The Working Group agreed that modelling the habitat of VME taxa is useful to put by-catch observation in a broader context. It noted that VME taxa such as *Ptilocrinus*, which are likely to be relatively easy to recognise on the vessels, would be a good example of species to use to collect data to generate larger-scale species distribution models and identify areas of special interest. It is, however, necessary to check that the minimum number of occurrence data is available, across a suitable scale, to allow useful extrapolation and interpolation. The Working Group also noted that in any modelling approach, using a subset of data to 'train' the model, and comparing predictions into areas with data, was an important step in model evaluation. The Working Group discussed the relevance of predicting habitat suitability over unsampled areas and agreed that sampling outside the model area is ideal to ground truth such predictions.

6.39 The Working Group also noted that the Scientific Committee had considered a focus topic on VMEs be considered for WG-FSA-2019. The Working Group considered the possibility to discuss VMEs during WG-FSA-2019 in parallel to fish stock assessments and suggested that this could be done during the second week of WG-FSA.

6.40 The Working Group requested that the following topics be considered during the VME focus topic:

(i) procedures for developing taxon-specific thresholds for triggering move on rules and risk areas

(ii) revision and updates of exploratory fishing footprint estimates

(iii) case studies of best practice in modelling benthic biodiversity including species, assemblages and functional groups

(iv) identification of protocols for evaluating VME risk areas after they have been declared, such as camera surveys to establish nature and extent of VME indicators.

Climate change and associated research and monitoring

7.1 The Working Group revisited WG-EMM-2019/22 with a presentation emphasising the complex hydrographic circulation patterns around the Antarctic Peninsula and the disparate patterns of impact on glacier melting rates and their indirect effects on levels of productivity between the northern and southern regions. The Working Group thanked the authors of the source papers (Cook et al., 2016; Moffat and Meredith, 2018), noting that circulation patterns influence the distribution of krill and can impact the development of egg and larval stages of krill and agreed that including considerations of physical hydrography was important when developing a krill fisheries management strategy. More studies are encouraged in the study area given its oceanographic and ecosystem complexity.

7.2 WG-EMM-2019/66 reported on the analysis of the international Southern Ocean continuous plankton recorder (CPR) survey data between 1971 and 2018. BRT models were used to investigate the relationships between the abundance of key zooplankton groups and their occurrences and environmental conditions. Analyses suggested that trends on the environmental suitability for copepods may lead to increased abundances between 0.59% and 0.83% per annum across the Southern Ocean but with variability across regions. In contrast, suitability for pteropods is predicted to decrease in the Ross Sea. Sub-Antarctic zooplankton communities have either remained stable or decreased over the study period, whereas Polar Frontal and southern sea-ice associated communities have expanded and decreased respectively. The authors place their results in the context of evaluating the conservation value of the RSRMPA against its specific objectives.

7.3 The Working Group acknowledged the value of assembling long-term datasets across large areas, particularly in highlighting the non-uniform reaction of zooplankton to climate change. The Working Group noted that there are additional modelling methods that could be applied to model the CPR data at the assemblage level (e.g. Hill et al., 2017), which is likely to provide additional context on how zooplankton is distributed and responds to environmental variability in the Southern Ocean.

7.4 WG-EMM-2019/74 reported on the extinction risk of Adélie, chinstrap and gentoo penguins under present-day and future environmental scenarios to identify the most endangered colonies. The extinction risk was estimated for twelve colonies from environmentally contrasting areas, such as the Antarctic Peninsula, Ross Sea and East Antarctica. Intraspecific competition as an endogenous process was identified as the most important driver of extinction probabilities across all colonies, while responses to climate change were more varied and related to local conditions. The authors showed that the most vulnerable Adélie penguin colonies are distributed along the South Shetland Islands on the Antarctic Peninsula and at Syowa Station in East Antarctica, and that for sub-Antarctic gentoo penguin colonies at Marion Island demographic predictions appeared to be governed by the SAM index.

7.5 The Working Group noted that while some colonies of penguins were predicted to decline, others have been observed to be increasing in numbers, in particular the presented at-risk areas for Adélie penguins at Syowa Station contrasting with observed increases in population sizes over the preceding three decades. The Working Group agreed that migration to new areas and decreasing demographic trends in others may be parallel processes. The Working Group further agreed that studies such as these are useful to highlight to the Scientific Committee the implications of climate change in its work. The Working Group also noted that, given the different responses of Adélie penguin populations in the eastern and western Antarctic Peninsula, and the remaining large colonies that are still being observed in areas near the northern tip of the Peninsula, it is important to consider an extra level of protection to that area.

7.6 The Working group discussed WG-EMM-2019/P02 (paragraph 4.20) in the context of the climate change influence on the whole structure of the Antarctic ecosystem, including krill stocks, noting that the paper provides a graphical summary of potential effects. The Working Group agreed that the presentation of scientific data from the paper was useful and is well summarised. The Working Group noted that there is ongoing debate on trends in net-based estimates of krill density (e.g. Cox et al., 2019; Hill et al., 2019). The Working Group advised that efforts should be focused on collating all available information and providing balanced summaries. The Working Group further agreed that the climate change associated risks to krill and the ecosystem it supports emphasise the need for precautionary management of the krill fishery.

7.7 WG-EMM-2019/02 highlighted recent ICED research and activities on Southern Ocean ecosystems and changes, focusing on areas of interest to CCAMLR and joint ICED–CCAMLR activities, and suggested ways to continue to strengthen the links between ICED and CCAMLR. The Working Group encouraged CCAMLR involvement in relevant ICED activities to jointly identify, prioritise and address key scientific issues with respect to the management of Southern Ocean ecosystems in the face of changes being observed and expected.

7.8 The Working Group welcomed the updated activities of ICED and expressed interest in seeing the published results from the joint ICED–CCAMLR workshop held in 2018. The Working Group agreed that communicating to ICED the outcomes of WG-EMM-2019 in terms of developing a krill fisheries management strategy would be useful, highlighting areas where ICED can contribute, for example (i) developing data layers for the risk assessment in the context of climate change, (ii) time frames and scales for climate change information to be included in a krill stock assessment. In this context, the Working Group also welcomed the continuing collaboration between ICED and SKAG to ensure the potential for the duplication of work between the two groups was minimised.

7.9 Dr Santos highlighted that the proponents of the D1MPA had considered climate change in the design of the MPA model and incorporated the impacts of climate change as key priorities for research. The proponents would continue to work with ICED to develop research priorities for the D1MPA RMP.

Other business

8.1 The Working Group considered the discussion by WG-SAM-2019 on the crab research results (WG-SAM-2019 report, paragraphs 6.101 to 6.111), and noted that 45 pots were lost during operations, as well as a further 30 damaged. The Working Group considered the potential impacts of these pots as abandoned, lost, or otherwise discarded fishing gear (ALDFG), and the effect they may have on the benthos and seabed area, as well as the potential for ghost fishing into the future.

8.2 The Working Group noted that previous fishing activities targeting toothfish using pot fishing gear were required to use biodegradable netting panels to minimise impacts on the environment in the case that pots were lost, and requested clarification from Russia on the materials used for their pots.

8.3 Dr Kasatkina noted that the report on implementation of the Russian research program was provided to WG-SAM and highlighted that each pot was equipped by special biodegradable cotton netting panels (WG-FSA-18/32 Rev. 1, Figure 3).

8.4 The Working Group further noted the discussion at SC-CAMLR-XXXVII (SC-CAMLR-XXXVII, paragraph 4.3) which recommended that the crab research proposal proceed with the use of benthic cameras to document and examine the impact of pots on benthic habitats. The Working Group highlighted the importance of having an agreed approach for research to proceed and strongly recommended that cameras are used to assess impacts on the ecosystem.

8.5 Dr Kasatkina clarified that benthic cameras were not obtained in time for use during the research trip, but that Russia would endeavour to implement all the recommendations made at

WG-FSA-2018 (WG-FSA-2018 report, paragraphs 4.210 to 4.217) and SC-CAMLR-XXXVII (SC-CAMLR-XXXVII, paragraph 4.3) for this next season, including any new recommendations made at WG-FSA-2019. Dr Kasatkina further noted that the research represented a pilot program on the investigation of crab biology and spatial distribution, and that the number of by-catch species was very small, that the total weight of by-catch of Antarctic toothfish (*Dissostichus mawsoni*) was 434 kg from a catch limit of 5 tonnes and the total weight of the retained catch of targeted crabs was 569 kg for the catch limit of 500 tonnes.

Future work

9.1 The Working Group agreed that a clear priority for its future work was to implement the workplan for the krill fishery management as described in paragraph 2.62 according to the timelines in Figure 1.

9.2 The Working Group agreed that having a one-week focus topic on the krill fishery management strategy had allowed it to make significant progress and recommended that the meeting follow a similar schedule in 2020.

9.3 The Working Group noted that this structure and scheduling of the meeting provided flexibility in the attendance of relevant experts and requested that the Secretariat provide a means for attendees registering for the meeting to indicate whether they would be attending all or part of the meeting as this would greatly assist the meeting coordinators and the hosts in preparing facilities and support for the meeting.

9.4 The Working Group recognised that there had been a number of proposals for additional workshops/focus topics over the next 12–18 months and requested the Scientific Committee find a mechanism that would allow the tasks outlined to be included, to the extent possible, within the existing time commitment of the intersessional meetings of the Scientific Committee.

9.5 The Working Group also noted the need to develop sustained funding streams for the work required to deliver and maintain the krill fishery management strategy. This is likely to include, but not be limited to, the use of the CEMP Fund and the General Science Capacity Fund.

9.6 The Working Group encouraged those with an interest in proposing additional workshops/focus topics to submit terms of reference for those meetings to the Scientific Committee in order that it can coordinate the work required.

Advice to the Scientific Committee and its working groups

10.1 The paragraphs containing the advice of the Working Group to the Scientific Committee (and its working groups) are summarised below; these advice paragraphs should be considered along with the body of the report leading to the advice:

(i) outcomes of a Workshop on Krill-fishery Management for Subareas 48.1 and 48.2 (paragraph 2.2)

(ii) prioritisation of the work required for the development of a management strategy for the krill (paragraphs 2.20 and 2.38)

(iii) request to SG-ASAM to prioritise estimation of krill biomass and associated confidence intervals on the subarea scale (paragraph 2.21)

(iv) focus topic for WG-EMM-2020 on data standards for use in risk assessment layers (paragraph 2.25)

(v) operational considerations and catch reporting frequency for the krill fishery (paragraphs 2.36 and 3.5)

(vi) summary of advice to the Scientific Committee on the development of a preferred option for the management of the krill fishery in Area 48 (paragraphs 2.60 to 2.64)

(vii) use of net monitoring cables (paragraph 3.12)

(viii) continuous trawl catch recording (paragraph 3.19)

(ix) proposed workshop on priorities for data collection, information sharing and overall tasking for observers in the krill fishery (paragraph 3.38)

(x) proposed workshop on krill ageing methods standardisation (paragraph 4.29)

(xi) collaboration with external organisations on cetaceans (paragraph 4.52)

(xii) use of the CEMP Special Fund to support to the camera monitoring network (paragraph 5.19)

(xiii) ASPA proposal reviews (paragraphs 6.6 and 6.9)

(xiv) VME Focus Topic at WG-FSA-2019 (paragraphs 6.39 and 6.40)

(xv) a mechanism to allow additional tasks to be completed in intersessional workshops and focus topics (paragraph 9.4).

Adoption of the report and close of the meeting

11.1 At the close of the meeting Dr Cárdenas thanked all participants for their positive engagement in the meeting and the rapporteurs for their great work in preparing the report including the careful consideration of some sensitive discussions. He also thanked the Secretariat for their support prior to and during the meeting. Dr Cárdenas thanked the local MNHN hosts, in particular Mr Jonathan Blettery who had provided fantastic support that had ensured the smooth running of meeting.

11.2 Dr Cárdenas also thanked the Commission for the agreement in 2018 to support the funding of conveners to Working Groups and he was delighted to have been the first convener to be supported in this way.

11.3 On behalf of the Working Group, Dr Zhao congratulated Dr Cárdenas on his first meeting as convener being a very productive working group meeting that had also provided very clear advice on the management of the krill fishery. He also thanked Dr Cárdenas for facilitating the diverse engagement in plenary discussions and in subgroups that had engendered a strong spirit of cooperation.

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Table 1: Action plan to develop advice to enable revision of Conservation Measure (CM) 51-07. This and subsequent tables are designed to outline the process whereby the Scientific Committee may provide advice on CM 51-07, as per SC-CAMLR-XXXVII, paragraph 13.2. The highest priority work areas identified sit within the remit of WG-EMM, however, other elements are also important and can be worked on in parallel. Members/groups are proposed coordinators for work, but all Members are welcome to contribute to progressing work. Detailed work plans for the highest-priority elements are provided in Tables 2 to 8. CEMP – CCAMLR Ecosystem Monitoring Program; AMLR – US Antarctic marine living resources program; NEMO – Nucleus for European Modelling of the Ocean; ROMS – Regional Ocean Modeling System; SKAG – SCAR Krill Action Group; MSE – Management strategy evaluation.

Action	Priority	Timeframe	Spatial scale	Temporal scale	Data input	Coordinating Members/groups	Scientific Committee body reviewing
Updated time series of biomass estimates of krill	Highest	WG-EMM-2021	Area, subarea and fishing grounds	Interannual	Synoptic surveys, industry and AMLR transects, sail buoy and glider missions	Norway, USA, China (48.1, 48.2, 48.4) UK (48.3)	SG-ASAM, WG-EMM, WG-SAM
Estimate of krill flux	Medium		Fishing grounds	Monthly	Industry and AMLR transects, moorings, sail buoy and glider missions, NEMO and ROMS outputs	Norway, USA, UK, Russia	SG-ASAM, WG-EMM, WG-SAM
Preliminary risk assessment including predator, krill and by-catch data layers	Highest	WG-EMM-2021	Area, subarea and fishing grounds	Seasonal	Predator tracking, at-sea observations, expert opinion (fish and squid)	UK (predator layers), Norway, SKAG (krill life stages)	WG-EMM-2020
Review CEMP to ensure effective coverage of fished and non-fished areas, and development of indices for rapid assessment of predator responses	Medium		Area, subarea	Seasonal	CEMP observations, camera and tracking data	All	WG-EMM
Develop a harvest strategy for krill fishing, including catch limits and spatial distribution of catch	Highest	WG-EMM-2021	Area, subarea	Interannual	Biomass estimates, stock assessment, risk assessment, ecosystem models, fleet dynamics, MSE	All	WG-EMM, WG-SAM, WG-FSA
Recommendations for process to develop scientific basis for revision of CM 51-07	Highest	SC-CAMLR-38	Area, subarea	Interannual	Biomass estimates, stock assessment, risk assessment, ecosystem models, fleet dynamics, MSE	All	SC-CAMLR

Table 2: Work plan for GYM reparameterisation. LTER – US long-term ecological research program; AMLR – US Antarctic marine living resources program; BAS – British Antarctic Survey; MODIS – Moderate resolution imaging spectradiometer; SST – sea-surface temperature; POC – particulate organic carbon; VB – von Bertalanffy; AUS – Australia; UK – United Kingdom; USA – United States of America

GYM parameter	Spatial Scale	Information (e.g. relevant papers)	Data series	Method for parametrisation	Responsible Members/groups
Recruitment	48.1	Kinzey et al., 2013, 2015, 2019,	LTER, AMLR, combined German-US regional survey, predator diets, fishery data	E.g. extract <40 mm krill as recruits, at monthly scale.	Secretariat and external data contribution
	48.2	Thanassekos et al., 2014	German cruise Norway 2009, AMLR survey in 2008, BAS penguin diet, fishery observer data	Check the size range of age-1 with growth models (subarea dependent).	
	48.3		BAS Western core box survey series, penguin, fur seals, fish diet, fishery observer		
	48.4		No time series available, only occasional net data in 2000, 2008 and 2019 synoptic surveys	To be informed by recruitment series from Subareas 48.1, 48.2 and 48.3.	
Growth	48.1 48.2 48.3 48.4	Atkinson et al., 2006, Constable and Kawaguchi, 2017	Use LTER krill length data as a base case to reality check/performance check the seasonal growth model. Chlorophyll from MODIS or Aquarius (level 4). SST: optimally interpolated dataset (e.g. less than 20 km)	Simulate growth using available growth model that can handle environmental factors (e.g. Atkinson et al., 2006, Constable and Kawaguchi, 2017) by using climatology of seasonal temperature and chlorophyll (possibly POC) at subarea scale, weighted by krill distribution, and determine parameters for seasonal VB that approximates these patterns.	Secretariat, UK, AUS
Mortality	48.1 48.2 48.3 48.4	Kinzey et al., 2013, 2015, 2019; Murphy and Reid, 2001		Estimate M Seasonal variation (Scaling of season to be informed by risk assessment group outcome)	Secretariat, USA

Table 3: Actions to combine risk assessment and biomass estimates to evaluate and revise the krill harvest strategy in Area 48. GYM – generalised yield model; AUS – Australia; CHL – Chile; CHN – China; KOR – Republic of Korea; NOR – Norway; UK – United Kingdom; USA – United States of America; UKR – Ukraine; ARK – Association of Responsible Krill harvesting companies.

Action	Inputs	Priority	Coordinating Members/groups
Recompile GYM model in open-source code	Current GYM functions	High	AUS, Secretariat
Collate best estimates of growth, recruitment and natural mortality, and variability at subarea scales	Existing studies of parameter estimates e.g. Atkinson et al., 2006, Constable and Kawaguchi, 2017, Kinzey et al., 2013, 2015, 2019, AMLR time series, catch and length from research and fishery hauls, productivity and source-sink relationships between subareas	High	USA, NOR, UK, AUS
Evaluate alternative implementation of decision rules, e.g. short-term projections with regular biomass updates	GYM or other assessment model with updated parameters	High	USA, UK
Update estimate(s) of gamma (γ, biomass exploitation rate) for krill in Subareas 48.1–48.4	GYM or other assessment model with updated parameters	High	USA, NOR, UK, AUS
Estimate of area and subarea catch limits	Subarea and area biomass estimates, subarea and area gamma estimates	High	UK, USA, NOR
Estimate risk associated with catch distribution scenarios	Estimate of area and subarea distribution of catches, risk assessment populated with key predator layers	High	UK, AUS
Canvas expectations of the fishing industry of size and variation in fishery yields	Discussions with industry stakeholders	Medium	ARK, NOR, CHN, CHL, UKR, KOR
Evaluate current fishery reporting and closure mechanisms under future harvest scenarios	Catch limit and fleet size scenarios	Medium	Secretariat

Table 4: Priority elements and timeline to progress the estimation of krill biomass for use in a stock assessment.

Action	2019	2020	2021	2022+
Updated time series biomass estimate of krill				
Large-scale survey krill density (e.g. Area 48)	Data validation and biomass estimate (SG-ASAM), taking into account recommendations from WG-EMM-2019	Refine biomass estimates as necessary, taking into account recommendations from SC-CAMLR-38.		Identify recommended frequency of large-scale survey Evaluate how these surveys can be made more robust.
Subarea survey krill density (e.g. Subareas 48.1, 48.2, 48.3)	Compilation of existing data and comparison of methods (WG-EMM-2019, SG-ASAM-2019)	New data contribution (SG-ASAM).	New data contribution (SG-ASAM).	New data contribution (SG-ASAM)
Transect-scale krill density by fishing vessels (data from one or more CCAMLR-nominated transect collected within a fishing season)	First density estimates (SG-ASAM-2019)	New data contribution (SG-ASAM). Method development for inclusion in subarea stock assessment	New data contribution (SG-ASAM). Analysis for subarea stock assessment	New data contribution (SG-ASAM). Implementation in subarea stock assessment
Fishing-area scale data		New data contribution (SG-ASAM) Method development and analysis for biomass estimation	New data contribution (SG-ASAM) Method evaluation	New data contribution (SG-ASAM) Method recommendation
Coherent biomass estimates (primarily based on large-scale and subarea survey scale time series biomass)		SG-ASAM-2020 or a dedicated workshop on subarea biomass estimation method	WG-SAM/WG-EMM evaluation of the biomass estimation method and the first subarea biomass estimate	

Table 5: List of available acoustic data for krill biomass estimation in Area 48 to be submitted to SG-ASAM-2019.

2019 Area 48 survey		
Member	Vessel	Contact
Norway	*Kronprins Haakon*	Gavin Macaulay, gavin.macaulay@hi.no
	*Cabo de Hornos**	Gavin Macaulay, gavin.macaulay@hi.no
UK	*RRS Discovery*	Sophie Fielding, sof@bas.ac.uk
China	*Fu Rong Hai*	Xinliang Wang, wangxl@ysfri.ac.cn
Ukraine	*More Sodruzhestva*	Victor Podgorny, pvv04111970@i.ua
Korea	*Kwang Ja Ho*	Seok-Gwan Choi, sgchoi@korea.kr
Subarea krill survey		
Subarea	Member	Contact
48.1	USA	George Watters, george.watters@noaa.gov
	Peru	George Watters, george.watters@noaa.gov
	Germany	George Watters, george.watters@noaa.gov
	China	Xinliang Wang, wangxl@ysfri.ac.cn
	Korea	Seok-Gwan Choi, sgchoi@korea.kr
48.2	Norway	Gavin Macaulay, gavin.macaulay@hi.no
	USA	George Watters, george.watters@noaa.gov
	Russia	Svetlana Kasatkina, ks@atlantniro.ru
48.3	UK	Sophie Fielding, sof@bas.ac.uk
	Russia	Svetlana Kasatkina, ks@atlantniro.ru

* Chilean-flagged vessel conducted the survey for the Association of Responsible Krill harvesting companies (ARK).

Table 6: Metadata requirements for krill biomass time series.

Variable	Unit/format	Description
Year	YYYY	The year the survey took place. If the survey took place over a split year (e.g. December to January), please use the starting year
Month	MON	The month the survey took place. If the survey took place over multiple months (e.g. January to March), please use starting month
Vessel	Free text	Name of vessel or unique maritime call sign
Contributor	Free text	Country who conducted the survey and/or person who analysed the data
Subarea	48.1, 48.2, 48.3, 48.4	CCAMLR subarea where survey was undertaken
Survey name	Free text	Name of survey during which estimate made, e.g. CCAMLR-2000 Survey
Density estimate	g m^{-2}	Estimate of krill density in g m^{-2} for the survey/stratum
CV of density estimate	%	Estimate of CV of the krill density estimate
CV estimation method	Free text	Explanation of method used to derive CV estimate of survey
Survey area	km^2	Area survey represents in km^2
Echosounder model	Free text	Manufacturer and model of echosounder used to collect data
Frequency used for biomass estimate	kHz	Frequency used to collect acoustic backscatter converted to krill density
Other frequencies available	kHz	Other frequencies of acoustic backscatter collected using the same echosounder
Method used for target identification	List	Method used to identify krill targets in the acoustic data, allows for no identification, manual identification, dB-difference (variety of frequency combinations) and swarm-based identification
dB-difference window	List	Indicate dB-difference window used if applicable
TS model used	List	Indicate TS model used to convert NASC to krill density. Allows for Greene et al., 1991, simplified SDWBA parameterised using (11, 4) orientation or full SDWBA parameterised using (–20, 28) orientation (SG-ASAM-2010). New conversions can be added.
Depth range integrated	m	Depth range (m) over which data was integrated
Time of day sampled	List	Identifies data collected solely during daytime, solely during night time, or both
Stratum name	Free text	Stratum name if used
Survey design description	Free text	Design of survey, e.g. parallel vs random transects; methods for data processing, etc.
Reference	Free text	If the data is published, provide full citation information on the paper or book

Table 7: Priority data layers (potential data providers are identified in parentheses) and time line to progress a risk assessment in Area 48. ARG – Argentina; AUS – Australia; BRA – Brazil; CHL – Chile; CHN – China; ESP – Spain; FRA – France; GER – Germany; JPN – Japan; KOR – Republic of Korea; NOR – Norway; POL – Poland; UKR – Ukraine; UK – United Kingdom; USA – United States of America; URY – Uruguay; IWC-SORP – International Whaling Commission - Southern Ocean Research Program; MEOP – Marine Mammals Exploring the Oceans Pole to Pole; RATTD – Retrospective Analysis of Antarctic Tracking Data; SG-ASAM – Subgroup on Acoustic Survey and Analysis Methods; SKAG – SCAR Krill Action Group.

Action	2019	2020	Comments	Priority
Risk assessment data layers	Models complete	Models to do		
Chinstrap penguins				
Incubation (UK, NOR, CHL, USA)	48.1, 48.2	48.1	Tracking data	
Brood (UK, USA, KOR, JPN, CHL, NOR, ESP)	48.1, 48.2	48.1, 48.4	Tracking data	
Crèche (UK, USA, JPN, CHL, NOR)	48.1, 48.2	48.1, 48.4	Tracking data	
Fledging (USA, POL, ARG)		48.1	Tracking data	High
Winter (UK, USA, ARG, POL)		48.1, 48.2	Tracking data	High
Adélie penguins				
Incubation (UK, USA, JPN, NOR, ESP)		48.1, 48.2	Tracking data	
Brood (UK, USA, JPN, ESP, URY, NOR)	48.1, 48.2		Tracking data	
Crèche (UK, USA, JPN, ARG, NOR)	48.1, 48.2		Tracking data	
Non-breeders (NOR, ARG, POL)		48.1		
Fledging (USA, ARG)		48.1	Tracking data	High
Winter (USA, UK, ARG)		48.1, 48.2	Tracking data	High
Gentoo penguins				
Incubation (NOR, CHL, UKR)	48.1		Tracking data	
Brood (UK, USA, KOR, JPN, NOR, UKR)	48.1, 48.2	48.3	Tracking data	
Crèche (UK, USA, JPN, NOR, UKR)	48.1, 48.2	48.3	Tracking data	
Fledging (USA, ARG, UKR)		48.1	Tracking data	High
Winter (USA, UK, ARG, POL)		48.1, 48.3	Tracking data	High
Macaroni penguins				
Incubation (UK, JPN)	48.3	48.3	Tracking data	
Brood (UK, JPN)	48.3	48.3	Tracking data	
Crèche (UK, JPN)	48.3	48.3	Tracking data	
Fledging (UK)				
Winter (UK)	48.2, 48.3		Tracking data	High
Pack-ice seals (UK, USA, ARG, AUS)		48.1, 48.5	Tracking data, at-sea data	
Elephant seals (UK, USA, ARG, GER, AUS, FRA, MEOP, RAATD)		48.1, 48.2, 48.3	Tracking data	

(continued)

Table 7 (continued)

Action	2019	2020	Comments	Priority
Antarctic fur seals				
Female (UK, USA, NOR, ESP)		48.1, 48.2, 48.3	Tracking data, at-sea data	
Male (UK, USA, NOR)		48.1, 48.2, 48.3	Tracking data, at-sea data	High
Humpback whales* (BRA, USA, NOR, UK, ARG, GER, AUS, IWC-SORP)	48.1	48.1, 48.2, 48.3, 48.4	At-sea, tracking, catch history	High
Fin whales* (IWC-SORP, GER, AUS, ARG)		48.1, 48.2, 48.3, 48.4	At-sea, tracking, catch history	High
Blue whales* (IWC)		48.1, 48.2, 48.3, 48.4	Catch history	
Minke whale* (USA, ARG)		48.1	Tracking data, at-sea data	
Flying seabirds (USA, NOR, UK)		48.1, 48.2, 48.3, 48.4	Tracking data, at-sea data	
Fishing fleet dynamics (Secretariat, NOR, UK, CHN, AUS, ARK, CHL)		48.1, 48.2, 48.3, 48.4	VMS, catch data, fishing masters, environmental data	High
Fish (USA, ARG, GER, UKR, UK, 2019 Area 48 Survey)		48.1, 48.2, 48.3	Survey data, catch data, observer data	High
Euphausia species by-catch (Secretariat, 2019 Area 48 survey)		48.1, 48.2, 48.3	Survey data, catch data	
Larval and juvenile fish by-catch (Secretariat, 2019 Area 48 Survey)		48.1, 48.2, 48.3	Survey data, catch data	
E. superba stock (SG-ASAM)				High
E. superba spawning areas (SKAG)		48.1, 48.2, 48.3, 48.4	Survey data, observer data, KRILLBASE	High
E. superba nursery areas (SKAG)		48.1, 48.2, 48.3, 48.4	Survey data, observer data, KRILLBASE	

* Presence absence data for cetaceans may be feasible using passive acoustic devices.

Table 8: Tools and mechanisms required to advance the risk assessment for subdivision of the krill fishery catch in Area 48. UK – United Kingdom; TBA – to be announced; SKAG – SCAR Krill Action Group.

Action	Primary tools	Mechanisms
Risk assessment (UK)	Compare R code implementation for the Risk Assessment	Make available to WG-EMM-2020
Fishery dynamics	Behavioural models	Focus topic at WG-EMM-2020 to consider models for each data layer
Penguins, pack-ice seals, fur seals	Compare R code for implementing models each data layer; develop standard methods, including considerations of scale and associated limitations; data quality control	Focus topic at WG-EMM-2020 to consider models for each data layer
Cetacean data layers	Consideration of appropriate cetacean layers; develop standard methods, including considerations of scale and associated limitations; data quality control	Focus topic at WG-EMM-2020 to consider models for each data layer
Fish layers	Determine relevant species	WG-FSA-2019; generate support for multi-Member analyses of existing data; published review papers
Krill spawning and nursery layers	TBA	SKAG

Table 9: Overview of vessel-based effort in the 2019 survey.

Vessel	*Cabo de Hornos*	*RRS Discovery*	*Fu Rong Hai*	*Kronprins Haakon*	*Kwang Ja Ho*	*More Sodruzhestva*
Flag	Chile	United Kingdom	China	Norway	Korea	Ukraine
Type	Stern trawler	Research	Stern trawler	Research	Stern trawler	Stern trawler
Available echosounder frequencies (kHz)	38, 120	70, 120, 200	38, 70, 120	18, 38, 70, 120, 200, 333	38, 120	120, 200
Survey start	16 Jan 2019	26 Jan 2019	05 Feb 2019	18 Jan 2019	08 Mar 2019	13 Dec 2018
Survey end	02 Mar 2019	07 Feb 2019	10 Feb 2019	15 Feb 2019	15 Mar 2019	18 Dec 2018
Total transect distance (n miles)	3 928	1 130	875	2 969	940	692
Trawl type	Macroplankton trawl	RMT8+1	Krill trawl	Macroplankton trawl	Krill trawl	Krill trawl
No. trawl stations	68	14	10	59	n/a	8
No. CTD stations	68	20	57	48	48	8

Table 10: Summary of actions to address methodological differences between the 2000-CCAMLR Survey and the 2019 Area 48 Survey.

Detail	Action	
dB-difference in 2000, swarms-based detection in 2019	Compare dB-difference and swarms-based approach from 2019 data from ships with the relevant frequencies at SG-ASAM-2019	
Differences in selectivity between commercial trawls, research trawls, and RMT8+1. If available, utilise other sources of krill LF in survey area and period	Analysis of 2019 krill catches from vessels presented to SG-ASAM-2019	
Daylight acoustic transects in 2000, day and night transects in 2019	Use moored echosounder data to evaluate day/night differences in krill backscatter close to the surface	
One vessel surveyed approx. 1 month before the others	Consider using current models to assess the effect of an extended survey period	
Allocation of krill length distributions to backscatter data	Clustering in 2000	Sensitivity analysis of the effect of varying krill lengths on biomass estimates

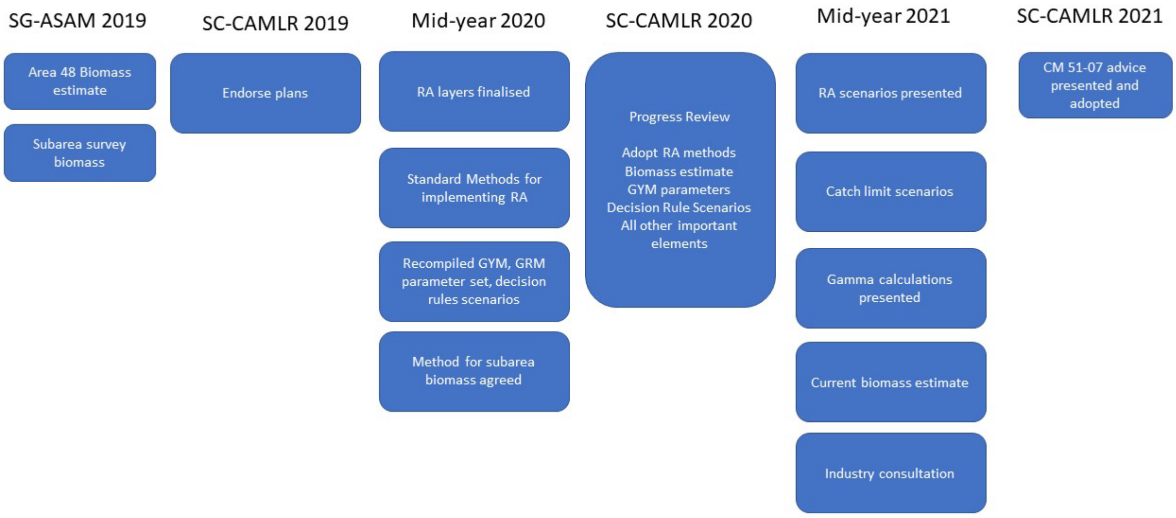

Figure 1: Timeline for progression priority elements identified in Table 1.

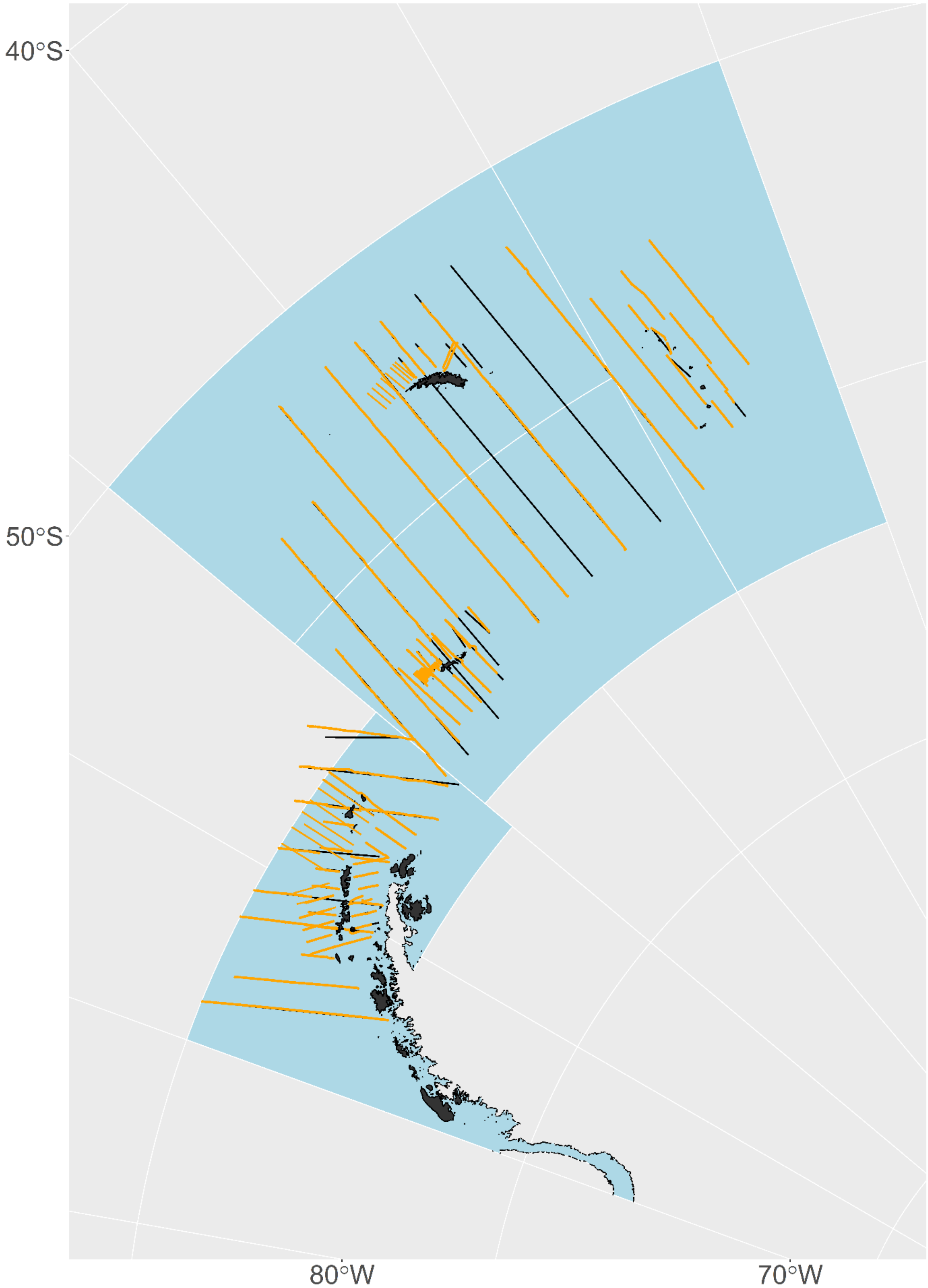

Figure 2: Occupied (orange) and unoccupied (black) transects for the 2019 survey.

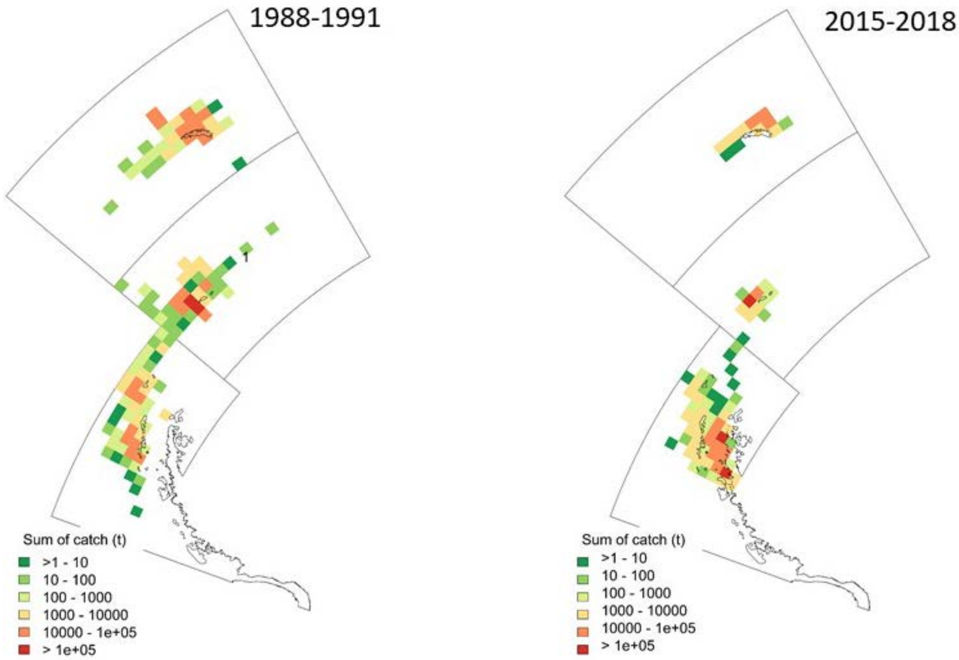

Figure 3: Distribution of krill catches in Subareas 48.1, 48.2 and 48.3 during the periods 1988–1991 and 2015–2018.

Appendix A

List of Participants

Working Group on Ecosystem Monitoring and Management
(Concarneau, France, 24 June to 5 July 2019)

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Appendix B

Agenda

Working Group on Ecosystem Monitoring and Management
(Concarneau, France, 24 June to 5 July 2019)

1. Introduction

    1.1 Opening of the meeting
    1.2 Adoption of the agenda and appointment of rapporteurs, proposed schedule for the meeting

2. Focus Topic on krill fishery management

    2.1 Data layers for risk assessment of spatial and temporal distribution
        2.1.1 2019 multinational synoptic large-scale krill survey

    2.2 Risk-assessment for the krill fishery
    2.3 Development of a preferred option for the management of the krill fishery in Area 48
    2.4 Advice to the Scientific Committee on the management of the krill fishery in Area 48

3. Krill fishery

    3.1 Fishing activities (updates and data)
    3.2 Scientific observation
    3.3 CPUE and spatial dynamics
    3.4 Fishing vessel surveys

4. Krill-based ecosystem interactions

    4.1 Krill biology, ecology and population dynamics
    4.2 Krill life-history parameters and population models
    4.3 Krill predator biology, ecology and population dynamics

5. Ecosystem monitoring and observation

    5.1 CEMP monitoring
    5.2 Other monitoring data
    5.3 Review of CCAMLR research and monitoring design and implementation

6. Spatial management

    6.1 Data analysis supporting spatial management approaches in CCAMLR
    6.2 Integration of existing measures in spatial management approaches
    6.3 VME data and spatial planning approaches

7. Climate change and associated research and monitoring

8. Other business

9. Future work

10. Advice to the Scientific Committee and its working groups

11. Adoption of the report and close of the meeting.

Appendix C

List of Documents

Working Group on Ecosystem Monitoring and Management
(Concarneau, France, 24 June to 5 July 2019)

WG-EMM-2019/01	A Proposal for a new Antarctic Specially Protected Area (ASPA) P. Penhale
WG-EMM-2019/02	Integrating Climate and Ecosystem Dynamics in the Southern Ocean (ICED) programme: a report on recent joint activities and links between ICED and CCAMLR R.D. Cavanagh, N.M. Johnston and E.J. Murphy
WG-EMM-2019/03	Proposal for a krill biomass survey for krill monitoring and management in CCAMLR Division 58.4.2-East S. Kawaguchi, M. Cox, N. Kelly, L. Emmerson and D. Welsford
WG-EMM-2019/04	CEMP 2018/19 data and updated spatial analysis of Area 48 Secretariat
WG-EMM-2019/05	Weddell Sea MPA data layers have been deposited with the data publisher PANGAEA K. Teschke, H. Pehlke and T. Brey
WG-EMM-2019/06	Reporting procedures for the continuous fishing method F. Grebstad
WG-EMM-2019/07	Report from a krill- focused survey with RV *Kronprins Haakon* and land-based predator work in Antarctica during 2018/19 B. Krafft, K. Bakkeplass, T. Berge, M. Biuw, J. Erices, E. Jones, T. Knutsen, R. Kubilius, M. Kvalsund, U. Lindstrøm, G.J. Macaulay, A. Renner, A. Rey, H. Søiland, R. Wienerroither, H. Ahonen, J. Goto, N. Hoem, M. Huerta, J. Höfer, O. Iden, W. Jouanneau, L. Kruger, H. Liholt, A. Lowther, A. Makhado, M. Mestre, A. Narvestad, C. Oosthuisen, J. Rodrigues and R. Øyerhamn
WG-EMM-2019/08	Habitat use of type – C killer whales (*Orcinus orca*) in the Ross Sea, Antarctica G. Lauriano, E. Pirotta, T. Joyce, R. L. Pitman and S. Panigada
WG-EMM-2019/09	Analysis of the Chilean operation in the Antarctic krill fishery, years 2017/18 P.M. Arana and R. Rolleri

WG-EMM-2019/10	Pygoscelid penguins vulnerabilities to spatio-temporal changes of the krill fisheries in the Antarctic Peninsula L. Krüger, F. Santacruz, L. Rebolledo and C. Cárdenas
WG-EMM-2019/11	Long-term observations from Antarctica demonstrate that mismatched scales of fisheries management and predator–prey interaction lead to erroneous conclusions about precaution G.M. Watters, J.T. Hinke and C.S. Reiss
WG-EMM-2019/12 Rev. 1	Update of the activities of the SCAR krill action group (SKAG) since last year's WG-EMM B. Meyer and C. Reiss
WG-EMM-2019/13	Glider-based estimates of Antarctic krill in Bransfield Strait, and the West shelf off Livingston Island, Antarctica C. Reiss, A. Cossio, G. Cutter, J. Walsh and G. Watters
WG-EMM-2019/14	Report of the Workshop on data and modelling issues relevant to the planning of a potential Marine Protected Area (MPA) east of the zero meridian in the Weddell Sea (MAUD) Delegation of Norway
WG-EMM-2019/15	Development of an acoustic sensor to estimate catch directly from the trawl during continuous krill harvesting O.R. Godø, B. Krafft and F. Grebstad
WG-EMM-2019/16	Trials with net monitoring cable during the 2017/18 and 2018/19 seasons onboard FV *Saga Sea* O.R. Godø
WG-EMM-2019/17	Supporting industry sustainability and CCAMLR monitoring with Sailbuoy operations R. Øyerhamn, O.R. Godø and A. Lowther
WG-EMM-2019/18	Empirically-driven feedback management incorporating multi-scale risk assessment and an experimental framework to facilitate adaptive improvement A.D. Lowther, B. Krafft, O.R. Godø, C. Cardenas, X. Zhao and O.A. Bergstad
WG-EMM-2019/19	Acoustic and underwater survey of the Argentine Islands (West Antarctic) water area for development of network of testing sites in the summer season of 2019 A. Utevsky, D. Smyrov, E. Sinna, M. Shrestha and S. Utevsky

WG-EMM-2019/20	Habitat partitioning in Antarctic krill: spawning hotspots and nursery areas F. Perry, A. Atkinson, S.F. Sailley, G.A. Tarling, S.L. Hill, C.H. Lucas and D.J. Mayor
WG-EMM-2019/21	The importance of sea ice association of Antarctic krill for transport and retention in the South Orkneys region: a modelling study S.E. Thorpe, E.F. Young, E.J. Murphy and A.H.H. Renner
WG-EMM-2019/22	Considerations about managing the krill fishery at small spatial and temporal scales P.N. Trathan, V. Warwick-Evans and E. Young
WG-EMM-2019/23	Developing layers for a Risk Assessment for Subarea 48.1 using data from at-sea sightings V. Warwick-Evans, L. Dalla Rosa, E. Secchi, E. Seyboth, N. Kelly and P.N. Trathan
WG-EMM-2019/24	Developing a Risk Assessment for Subarea 48.1 using tracking data V. Warwick-Evans, A. Friedlaender, J.T. Hinke, N. Kokubun, J.H. Kim and P.N. Trathan
WG-EMM-2019/25 Rev. 1	Report from the Workshop on Krill-fishery Management for Subareas 48.1 and 48.2 G. Watters and P. Trathan
WG-EMM-2019/26	The Mapping Application for Penguin Populations and Projected Dynamics (MAPPPD) database: a tool for helping stakeholders monitor penguin population trends in Antarctica G.R.W. Humphries, P. Trathan, R. Naveen, C. Che-Castaldo and H.J. Lynch
WG-EMM-2019/27	Density and abundance estimates of baleen whales recorded during the 2019 DY098 cruise in the Scotia Sea around South Georgia and the South Sandwich Islands M. Baines, M. Reichelt, C. Lacey, S. Pinder, S. Fielding, N. Kelly, E. Murphy, P. Trathan and J.A. Jackson
WG-EMM-2019/28	Advances are urgently needed in providing regular estimates of krill stock status based on the available data S. Hill, J. Hinke, N. Ratcliffe, P. Trathan and G. Watters
WG-EMM-2019/29	Evidence of change to the environment, ecosystem and fishery within Area 48 indicates the need for continued precaution S. Hill and A. Atkinson

WG-EMM-2019/30	Towards the development of Marine Important Bird and Biodiversity Areas (mIBAs) for penguins in Antarctica – an update on progress J. Handley, M.-M. Rouyer, L. Pearmain, V. Warwick-Evans, P. Trathan and M.P. Dias
WG-EMM-2019/31	Draft Research and Monitoring Plan for the South Orkney Islands Southern Shelf Marine Protected Area (MPA Planning Domain 1, Subarea 48.2) S.M. Grant and P.N. Trathan
WG-EMM-2019/32	Using stationary acoustic platforms to assess precision and accuracy of acoustical krill surveys T. Klevjer, G. Skaret and B.A. Krafft
WG-EMM-2019/33	Annual migrations of pelagic fish stocks into a krill hotspot T. Klevjer
WG-EMM-2019/34	Detection of predator dive patterns from stationary echosounder data T. Klevjer and G. Skaret
WG-EMM-2019/35 Rev. 1	Preliminary results on the observations of cetaceans in the CCAMLR Statistical Subareas 48.1 and 48.2 K. Vishnyakova and L. Pshenichnov
WG-EMM-2019/36 Rev. 1	Adélie penguins’ response to unmanned aerial vehicle at Cape Hallett in the Ross Sea region, Antarctica J.-H. Kim, Y.-S. Kim, J.-W. Jung, W.Y. Lee, H.-C. Kim, J.H. Kim, H. Chung and H.C. Shin
WG-EMM-2019/37	Engaging ‘the crowd’ in citizen science and remote sensing to learn about habitat affinity of two Southern Ocean seals M.A. LaRue, D.G. Ainley, J. Pennycook, K. Stamatiou, M. Dozier, J. Saints, L. Sales, N. Nur, S. Stammerjohn and L. Barrington
WG-EMM-2019/38	Ross Sea Environment and Ecosystem Voyage 2019 R.L. O’Driscoll, D. Bowden and M.H. Pinkerton
WG-EMM-2019/39	Change in environmental conditions of the Southern Ocean observed by satellites and data-assimilating models between 1981 and 2019 M. Pinkerton
WG-EMM-2019/40	A Proposal for a new Antarctic Specially Protected Area (ASPA) at Inexpressible Island and Seaview Bay, Ross Sea Delegations of China, Italy and the Republic of Korea

WG-EMM-2019/41	Exploring trends of the krill fishery indicators among the NWAP D1MPA zones in the Subarea 48.1 F. Santa Cruz, L. Krüger, L. Rebolledo and C. Cárdenas
WG-EMM-2019/42	Cruise report of multidisciplinary ecosystem survey in the eastern Indian sector of the Antarctic (CCAMLR Division 58.4.1) with a focus on Antarctic krill during 2018/19 season by the Japanese survey vessel, *Kaiyo-maru* H. Murase, K. Abe, R. Matsukura, H. Sasaki, R. Driscoll, S. Driscoll, F. Schaafsma, M. van Regteren, Q. Yang, H. Ohshima, K. Ohshima, R. Sugioka, J. Tong, N. Yamamoto, H. Doiguchi, E. Briggs, K. Doi, D. Hirano, K. Katsumata, M. Kiuchi, Y. Ko, D. Nomura, M. Orui, H. Sato, S. Toyoda, K. Yamazaki, T. Ishihara, K. Hamabe, S. Kumagai, T. Miyashita, N. Yamada, Y. Koyama and H. Sasaki
WG-EMM-2019/43	Implementation and preliminary results from the synoptic krill survey in Area 48, 2019 conducted by the Chinese krill fishing vessel *Fu Rong Hai* X. Wang, X. Zhao, B. Zou, G. Fan, X. Yu, J. Zhu, J. Zhang and Y. Ying
WG-EMM-2019/44	Final report of the CEMP Special Fund project to develop an image processing software tool (SPPYCAMS) for analysis of camera network monitoring data C. Southwell, A. Sikka, J. Cusick, H. Achurch, A. Lashko, K. Newbery, M. Salton, J. Kool, J. Hinke, G. Watters, M. Santos, G. Milinevsky, M. Korczak-Abshire, N. Ratcliffe, P. Trathan, A. Barbosa and L. Emmerson
WG-EMM-2019/45	Revisiting krill ageing method using eyestalk cuticles S. Kawaguchi, T. Barnes, N. Waller, B. Farmer, D. Hayes, R. Kilada, C. Reiss, G. Zhu, B. Krafft, A.-L. Agnalt, T. Ichii and T. Matsuda
WG-EMM-2019/46	Summary of monitoring and research effort and preliminary results from the 2019 Scotia Sea krill monitoring survey with FV *Cabo de Hornos* G. Skaret, M. Martinussen, G. McCallum, R. Pedersen, J. Rønning, A.L. Donoso, O.A. Bergstad and B.A. Krafft
WG-EMM-2019/47	Preliminary results from the International Synoptic Krill Survey in Area 48, 2019 G. Macaulay, G. Skaret, T. Knutsen, O.A. Bergstad, B. Krafft, S. Fielding, S.G. Choi, S. Chung, K. Demianenko, V. Podhornyi, K. Vishnyakova, L. Pshenichnov, A. Chuklin, A. Shishman and M.J. Cox

WG-EMM-2019/48	Norwegian Cruise to Kong Håkons VII Hav 28 February – 10 April 2019 H. Steen
WG-EMM-2019/49	Adult male Antarctic fur seals: tourists, trouble makers or marine ecosystem sentinels? A. Lowther, C. Lydersen and K. Kovacs
WG-EMM-2019/50	On the use of baited remote underwater video to study Antarctic toothfish distribution under the sea-ice: from data collection to processing D. Di Blasi, S. Canese, E. Carlig, L. Ghigliotti, S.J. Parker and M. Vacchi
WG-EMM-2019/51 Rev. 1	Mercury in the coastal Antarctic ecosystem: Initial findings E. Kim, Z. Baumann, J.-H. Kim and J.-W. Jung
WG-EMM-2019/52	VME detection thresholds: preliminary results of a study on the case of the sea pens (Pennatulacea) of the CCAMLR sector 58.4.4b A. Martin and M. Eléaume
WG-EMM-2019/53	The Bendiker project: barcoding of the benthos by-catch from the fisheries survey of the French EEZ of Kerguelen A. Dettai, N. Ameziane, J. Blettery, G. Duhamel, M. Eléaume, M. Hautecœur, M. Norest, E. Sanson and A. Martin
WG-EMM-2019/54	Barcoding and beyond: applications and developments for biodiversity evaluation in the Southern Ocean A. Dettai, G. Duhamel, C. Gallut, M. Eléaume and A. Martin
WG-EMM-2019/55	Methodical aspects of a large-scale international krill survey in 2019: comments and proposals S. Kasatkina
WG-EMM-2019/56	On spatial-temporal variability of krill length composition in Subarea 48.1. Comments and proposals S. Kasatkina and A. Sytov
WG-EMM-2019/57	Approach to the study of the ecosystem effect in the krill fishery S. Kasatkina
WG-EMM-2019/58	Indicators of krill flux at various spatial-temporal based on the data of multi-year research carried out in the Scotia Sea. Comments on krill fishery management S. Kasatkina and V. Shnar

WG-EMM-2019/59	CEMP cameras data validation experiment at the Galindez Island gentoo penguin (*Pygoscelis papua*) colonies P. Khoetsky, A. Dzhulai, V. Smagol, G. Milinevsky, I. Dykyy, A. Simon, M. Telipska, E. Dykyi, I. Parnikoza and L.Pshenichnov
WG-EMM-2019/60	Galindez Island gentoo penguin (*Pygoscelis papua*) colonies at GAI CEMP site population behaviour/dynamics in the 2018/19 season P. Khoetsky, A. Dzhulai, G. Milinevsky, I. Dykyy, E. Dykyi, I. Parnikoza and L. Pshenichnov
WG-EMM-2019/61	Informational report on cruise of Ukrainian krill fishing vessel *More Sodruzhestva* within international synoptic survey in the Statistical Area 48 V. Podhornyi, K. Vishnyakova, L. Pshenichnov, K. Demianenko, A. Chuklin and A. Shishman
WG-EMM-2019/62	Ukrainian complex marine expeditions in the Southern Ocean E. Dykyi, V. Komorin and A. Fedchuk
WG-EMM-2019/63	Progress on development of small-scale marine protected areas in the Argentine Islands Archipelago A. Fedchuk and G. Milinevsky
WG-EMM-2019/64	Zooplankton studies during international krill synoptic survey in CCAMLR Subarea 48.1 in 2019 onboard Ukrainian fishing vessel *More Sodruzhestva* L. Samchyshyna, E. Dykyi and G. Milinevsky
WG-EMM-2019/65	A drone-based Antarctic fur seal (*Arctocephalus gazella*) census of the St. Telmo Islands, South Shetland Archipelago D.J. Krause and M.E. Goebel
WG-EMM-2019/66	Long-term change in zooplankton communities of the Southern Ocean between 1997 and 2018: implications for fisheries and ecosystems M.H. Pinkerton, M. Decima, J. Kitchener, K. Takahashi, K. Robinson, R. Stewart and G.W. Hosie
WG-EMM-2019/67	Distribution and possible areas of spatial mixing of two stocks of humpback whales, a krill predator, in the Indo-Pacific region of the Antarctic revealed by genetic analyses L.A. Pastene, M. Goto, M. Taguchi and K. Matsuoka

WG-EMM-2019/68	Outline of a research program to investigate the abundance, abundance trends and stock structure of large whales in the Indo-Pacific region of the Antarctic, including a survey plan for the 2019/20 austral summer season Delegation of Japan
WG-EMM-2019/69	Results from the 2019 annual acoustic krill monitoring off the South Orkney Islands G. Skaret, B.A. Krafft, G. Macaulay, T. Knutsen and O.A. Bergstad
WG-EMM-2019/70	Krill physiology and impact of temperature variations: a comparative approach J.-Y. Toullec and C.-Y. Lee
WG-EMM-2019/71	Unfolding connectivity patterns along the Antarctic Circumpolar Current in the sub-Antarctic region S. Sergi, G. Grizaud, C. Cotté and F. d'Ovidio
WG-EMM-2019/72	Population variability of biological parameters of penguins along the Antarctic Peninsula A. Barbosa
WG-EMM-2019/73 Rev. 1	Habitat suitability for the VME *Ptilocrinus amezianeae* over the Kerguelen Plateau M. Eléaume, A. Martin, L.G. Hemery, C. Chazeau, J. Blettery and N. Améziane
WG-EMM-2019/74	Extinction risk of Antarctic and sub-Antarctic colonies of Pygoscelid penguins under climate change context M. Huerta and S.A. Estay
WG-EMM-2019/75	New CCAMLR SISO Observer Manuals and updated longline logbook Secretariat
WG-EMM-2019/76	Using krill length data from fishery-dependent and fishery-independent data sources to measure changes in the Antarctic krill population structure in the Bransfield Strait Secretariat
WG-EMM-2019/77	Update to the proposed data structure and implementation of the Marine Protected Area (MPA) Research and Monitoring Plan (RMP) Project List database Secretariat

WG-EMM-2019/78	Preliminary report on the South Sandwich Island research cruise by RRS *Discovery* (DY098) in January–February 2019 S. Fielding, C. Manno, G. Stowasser, B. Apeland, D. Ashurst, A. Ariza, M. Baines, L. Cornwell, A.B. Hulbert, K.R. Jones-Williams, C. Lacey, E.G. Langan, E.D. McRae, F.A. Perry, S. Pinder, E.J. Rowlands, F. Saccomandi, C. Silverstri, M.E.S. Sørensen, A. Slomska, J. Jackson, E.J Murphy, M. Reichelt, S. Thorpe, P. Trathan and G. Tarling
WG-EMM-2019/79	Krill associated ecosystem studies in the western Indian Ocean sector of the Southern Ocean during austral summer B.R. Smitha, H. Manjebrayakath, C.R. Asha Devi, N. Saravanane and M. Sudhakar
WG-EMM-2019/80	Important marine mammal areas (IMMAs) – scientific protocol S. Gallon, P. Marras-Aït Razouk and Y. Ropert-Coudert

Other Documents

WG-EMM-2019/P01	Krill faecal pellets drive hidden pulses of particulate organic carbon in the marginal ice zone A. Belcher, S.A. Henson, C. Manno, S.L. Hill, A. Atkinson, S.E. Thorpe, P. Fretwell, L. Ireland and G.A. Tarling *Nature Communications*, 10 (2019): 889, doi: 10.1038/s41467-019-08847-1
WG-EMM-2019/P02	Krill (*Euphausia superba*) distribution contracts southward during rapid regional warming A. Atkinson, S.L. Hill, E.A. Pakhomov, V. Siegel, C.S. Reiss, V.J. Loeb, D.K. Steinberg, K. Schmidt, G.A. Tarling, L. Gerrish and S.F. Sailley *Nature Climate Change*, 9 (2019):142–147, doi: 10.1038/s41558-018-0370-z
WG-EMM-2019/P03	Stable isotope analysis reveals trophic variation in adult Antarctic krill (*Euphausia superba*) around the Antarctic Peninsula from austral fall to early winter H.T. Zhang, G.P. Zhu, Q. Song, S.Q. Wang, Y. Yang and Q.Y. Yang *Acta Oceanol. Sin*., 37 (6) (2018): 90–95, doi: 10.1007/s13131-018-1176-6
WG-EMM-2019/P04	How trophic dynamics of adult Antarctic krill *Euphausia superba* responses to the condition of no ice in the water during the winter: a case study at South Georgia? G.P. Zhu, H.T. Zhang, B. Deng and Q.Y. Yang *Fish. Res*., 215 (2019): 1–8, doi: 10.1016/j.fishres.2019.02.011

Report of the Meeting of the Subgroup
on Acoustic Survey and Analysis Methods
(Bergen, Norway, 26 to 30 August 2019)

Contents

Report of the Subgroup on
Acoustic Survey and Analysis Methods
(Bergen, Norway, 26 to 30 August 2019)

Opening of the meeting

Introduction

1.1 The 2019 meeting of the Subgroup on Acoustic Survey and Analysis Methods (SG-ASAM) was held at the Institute of Marine Research (IMR), Bergen, Norway, from 26 to 30 August 2019. The Convener, Dr X. Zhao (China), welcomed the participants (Appendix A) and noted that at its previous meeting in Bergen in 2012 the Subgroup had initiated a proof of concept for the use of krill fishing vessels to collect acoustic data on krill and that it was a great pleasure to return to the same venue for a meeting that would be discussing the results of a large-scale, multi-national acoustic krill survey in which fishing vessels from several Members had successfully participated.

1.2 In welcoming participants to the meeting, Prof. Sissel Rogne (CEO IMR) highlighted that the successful completion of the 2019 Area 48 Survey was a great example of scientific and cultural collaboration that exemplified the work of CCAMLR. She wished the meeting every success and looked forward to seeing the results of the survey and the broader outcomes of the Subgroup as these would contribute greatly to the sustainable management of marine living resources, particularly in the Antarctic.

1.3 The meeting’s provisional agenda was discussed, and the Subgroup adopted the proposed agenda without any changes (Appendix B).

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

1.5 This report was prepared by K. Abe (Japan), M. Cox (Australia), S. Fielding (UK), B. Krafft and G. Macaulay (Norway), K. Reid (Secretariat), G. Skaret (Norway) and X. Wang (China). 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’.

Krill surveys conducted in 2019

Area 48

2.1 The Subgroup welcomed the extensive engagement in the collection of acoustic data, including from all Members that participate in the krill fishery, noting this had involved large-scale transects based on the design of the CCAMLR 2000 krill synoptic survey of Area 48 (CCAMLR-2000 Survey) as well as smaller-scale surveys that contribute to the ongoing time-series of krill density estimates from Subareas 48.1, 48.2 and 48.3.

2.2 Preliminary results from these surveys were presented (SG-ASAM-2019/03 Rev. 1, 2019/07, 2019/08 Rev. 1 and 2019/09), comprising acoustic, trawl and oceanographic data from the six vessels that participated. These data were allocated to the following surveys and survey strata (Figure 1):

(i) 2019 Area 48 Survey –

The CCAMLR-2000 Survey transects (with strata of Antarctic Peninsula (AP), Scotia Sea (SS), Eastern Scotia Sea (ESS), South Orkney Islands (SOI), South Shetland Islands (SSI), South Georgia (SG), and South Sandwich Islands (Sand)) conducted by Norway, Ukraine, UK and the Association of Responsible Krill harvesting companies (ARK).

(ii) Subarea 48.1 –

The AMLR transects around the South Shetland Islands conducted by China and Korea (with strata of West, Bransfield, Elephant and Joinville).

(iii) Subarea 48.2 –

Two overlapping survey areas routinely carried out by Norway around the South Orkney Islands (strata of South Orkney Concentrated (SOC) and South Orkney Fixed (SOF)).

(iv) Subarea 48.3 –

The Western Core Box (WCB) survey carried out by the UK.

2.3 Initial estimates of nautical area scattering coefficients (NASC) from krill were obtained using the swarm discrimination method at 120 kHz and processed to yield standing stock estimates based on the 2019 Area 48 Survey and the AMLR transects and were presented in SG-ASAM-2019/08 Rev. 1. This analysis made several processing decisions and assumptions that were discussed and revised during SG-ASAM-2019. Some processing errors were also discovered. Implementing these revisions and correcting errors changed the results (see Table 1). The main changes/corrections were:

(i) The method to allocate krill length frequency to NASC values. The revised procedure is described in paragraph 2.39. These new length frequency data were then used to generate the conversion factor between NASC and krill areal density. The results presented in SG-ASAM-2019/08 Rev. 1 used the aggregated survey vessel krill lengths from all trawls per survey strata (13 in total).

(ii) The location of the boundary between the Scotia Sea and Eastern Scotia Sea strata. The precise location of the boundary between these two strata could not be found in CCAMLR-2000 Survey reports and analyses. The analysis in SG-ASAM-2019/08 Rev.1 used a boundary that coincided with the easternmost transect in the Scotia Sea stratum and this caused processing awkwardness for automated spatially based allocation of krill length data into strata. To remedy this, the boundary was positioned 25 km to the east of the location shown in SG-ASAM-2019/08 (consistent with the spatial design in SC-CAMLR-XVIII, Annex 4, Appendix E, paragraph 18).

(iii) Choice of calibration coefficients. A typographical error in SG-ASAM-2019/08 Rev. 1, Table 11, led to the wrong choice of calibration coefficients for the *More Sodruzhestva* acoustic data. This resulted in NASC values being approximately 5% too high. The data were re-integrated using the correct choice of calibration coefficients, leading to a corresponding decrease in the backscatter.

2.4 The Subgroup advised the Scientific Committee that the krill biomass estimate from the 2019 Area 48 Survey was 62.6 million tonnes with a coefficient of variation (CV) of 13%.

2.5 The Subgroup noted that the *Fu Rong Hai*, in addition to its designated AMLR transects, also carried out its regular annual transects to the west of the South Shetland Islands. These transects were used in SG-ASAM-2019/07 to estimate mean krill areal density, but were not used to calculate the mean krill areal density reported in SG-ASAM-2019/08 Rev. 1.

Cross-checking of the 2019 Area 48 Survey results

2.6 The scope of the cross-checking included the validation of the 2019 Area 48 Survey processing and analysis MATLAB code implemented by Dr Macaulay and the Echoview template (SG-ASAM-2017 report). The Subgroup agreed to check the following:

(i) the Echoview swarms-based template used

(ii) the MATLAB code developed by Dr Macaulay and used to produce the results in Tables 1 and 2 see (SG-ASAM-2019/08 Rev. 1 and 2019/10)

(iii) the transects were allocated to the correct stratum

(iv) the equations from SG-ASAM-2019/08 Rev. 1 were correctly implemented in MATLAB

(v) the equations and implementation for converting krill-attributed NASC to krill areal density (conversion factor)

(vi) the implementation of the random sampling theory estimator (Jolly and Hampton, 1990)

(vii) the applied Echoview calibration files (.ECS) against calibration values in SG-ASAM-2019/08 Rev. 1, Appendix B, Table 11).

Echoview swarms-based template

2.7 The Echoview template used in the 2019 Area 48 Survey was modified from the approved template https://github.com/ccamlr/CCAMLREchoviewR to use solely 120 kHz frequency data. Modifications were:

(i) corrected an export data error by the removal of the dB() operator from the formula operator virtual variable 'Krill NASC from mean S_v (export here for NASC values)'

(ii) corrected an echo integration error by revising the lower integration line from the virtual variable ‘Krill NASC from mean S_v (export here for NASC values)’

(iii) corrected a calculation error by revising the layer thickness calculation workflow to change the method used to calculate the proportion of water column sampled. This was implemented by the inclusion of ‘line bitmap’ and ‘mask’ virtual variables.

2.8 Each vessel’s echoview template implementation was checked to ensure that the swarms-based identification and resultant acoustic data were made on the 120 kHz frequency data. These implementations were uploaded to the 2019Area 48 Survey CCAMLR Secretariat public GitHub repository (https://github.com/ccamlr/2019Area48Survey) along with its associated calibration file (ECS file).

Check the MATLAB code used to produce the results in Tables 1 and 2

2.9 There were more than 1 000 lines of code in the GitHub repository provided by Dr Macaulay and the Subgroup agreed that line-by-line checking of the code was not viable within the meeting, nor would a line-by-line approach guarantee any code errors would be found. Consequently, R code provided by Dr Cox was used to check the output from a subset of the 2019 Area 48 Survey. The subset comprised acoustic data from three strata: AP; SS, and ESS. The krill length-frequency distributions from (SG-ASAM-2019/08 Rev. 1) for the three test strata were also used as validation data.

Transects were allocated to the correct stratum

2.10 Using custom R code, Dr Cox confirmed that the transects had been correctly allocated to the appropriate strata.

Equations in SG-ASAM-2019/08 Rev. 1 are correctly implemented in MATLAB

2.11 A comparison of the results generated by the MATLAB code was compared to the results of independently implemented R code and found to be in agreement.

Check the equations and implementation for converting krill-attributed NASC to krill areal density (conversion factor)

2.12 Using the by-stratum test length-frequency data, and krill target strength (TS) model results (WG-EMM-16/38), the conversion factors were checked using R code implemented by Dr Cox and found to be correct for the three test strata.

Check the implementation of the random sampling theory estimator

2.13 The equations and MATLAB implementation for krill biomass and associated variance estimates were correct. Identical biomass and variance estimates were obtained using the MATLAB and R-based code when using the test data. Specifically, checks were made using existing R functions jhF() and jhMultipleStrataF() available in the EchoviewR package.

Check the applied Echoview calibration files

2.14 The vessel calibration information (specifically TS gain and Sa correction), and environmental parameters of sound speed (c, m s^{-1}) and 120 kHz absorption coefficient (α, dB m^{-1}) were checked within the calibration files associated with each template. A discrepancy between SG-ASAM-2019/08 Rev. 1, Table 11 and the ECS files was identified. The original calibration files were checked and revised values were included in SG-ASAM-2019/08 Rev. 1. In addition, the updated ECS files were committed to the 2019 Area 48 Survey repository (https://github.com/ccamlr/2019Area48Survey).

Comparison of results using the dB window and the swarms-based methods

2.15 Four documents (SG-ASAM-2019/03 Rev. 1, 2019/06, 2019/09 and 2019/10) addressed the effect of krill identification techniques on krill biomass estimates using data from different survey areas collected by different vessels that participated in the 2019 Area 48 Survey.

2.16 SG-ASAM-2019/10 provided an analysis on the comparison between swarms-based and three-frequency (38, 120 and 200 kHz) dB-difference (as applied for the CCAMLR-2000 Survey analysis) krill identification methods from the *Kronprins Haakon* survey. The choice of krill identification method showed variable effect on krill biomass estimates, and in areas with well-defined krill schools, the estimated krill densities were least sensitive to the choice of identification method.

2.17 The Subgroup noted that the estimates of krill density per transect from the two methods were in good agreement.

2.18 SG-ASAM-2019/09 also compared the mean krill density between the swarms-based and three-frequency dB-difference identification techniques in the WCB region. The estimate of mean krill density was lower using the three-frequency method compared with the swarms-based method, but the CV of mean krill density is similar between the two methods.

2.19 The Subgroup noted that this difference, and the krill density estimates, were comparable to differences reported in SG-ASAM-2019/10 in strata containing few krill.

2.20 SG-ASAM-2019/03 Rev. 1 and 2019/06 also provided comparisons between the swarms-based method and two-frequency (38 and 120 kHz) dB-difference method with various identification windows using data collected from the South Shetland Islands.

2.21 SG-ASAM-2019/06 showed that the estimates of krill density from default (–20 20) dB window and without dB window (using 120 kHz data only) were in good agreement for the swarms-based method, whilst the mean areal krill biomass density estimates were lower when the (2 16) and (0.4 12) dB window were applied. SG-ASAM-2019/03 Rev. 1 also observed a lower estimate in the krill density when applying the dB-window in the swarms-based method.

2.22 The Subgroup noted that a dB window, for which the default setting was –20 to 20 dB in the Echoview template agreed at SG-ASAM-2017, has been applied to the swarms-based method in the above two analyses, and recalled that the intention to retain the dB window in the template was to enable research to be carried out on the sensitivity of swarms-based approaches to krill length-frequency data (SG-ASAM-2018 report, paragraph 3.4).

2.23 The Subgroup noted that most of the vessels participated in the 2019 Area 48 Survey did not have all the frequency channels required for applying the three-frequency dB-differencing method, whilst all the vessels collected 120 kHz data that enabled the data from all vessels to be used with the swarms-based method.

2.24 The Subgroup noted that the above analyses suggested that the estimates of krill biomass density from the swarms-based method and dB-difference method are generally in agreement and comparable.

2.25 The Subgroup also noted that the two methods have variable effects on krill density estimates under different survey conditions and encouraged efforts to investigate the factors that cause such effects.

Revised/refined analysis, including taking into account any issues raised during WG-EMM

2.26 SG-ASAM-2019/10 described methodological aspects of the 2019 Area 48 Survey, including the effects of:

(i) acoustic surveying being conducted during day and night

(ii) using non-standardised krill sampling gear with the potential for different krill selectivity between the vessels participating in the survey

(iii) using the swarms-based and the dB-window method for krill identification (see paragraphs 2.15 to 2.25).

Collection of acoustic data during day and night

2.27 The Subgroup recalled that during the 2019 Area 48 Survey acoustic data collection was carried out during both day and night whereas during the CCAMLR-2000 Survey acoustic data were only collected during the day (between civil dawn and dusk) (WG-EMM-16/38). WG-EMM had requested that the implication of this data collection approach in the 2019 survey be evaluated (WG-EMM-2019 report, paragraph 2.53).

2.28 The analysis presented in SG-ASAM-2019/10 indicated that removing the data collected at night resulted in a reduction in the number of NASC values included in the biomass estimation of 21% but only a 6% increase in the overall biomass estimate across the entire survey area. The direction of the effect was not consistent as in some strata the biomass estimate was lower when the data collected at night had been removed.

2.29 SG-ASAM-2019/05 investigated the potential effect of day/night surveying on the survey estimates from the *Fu Rong Hai* around the South Shetlands in February. Both during day (sunrise to sunset) and night (sunset to sunrise), krill were distributed closer to the surface than the 15 m surface exclusion layer which was applied, but the effect was stronger during night-time, with 5.7% and 16.6 % respectively of daytime and night-time backscatter was distributed closer than 15 m to the surface.

2.30 The Subgroup reviewed WG-EMM-2019/32 which contained an analysis based on data from two deployments of upward looking moorings off the South Orkney Islands. The moorings had been deployed for 1 year and 6 months respectively in two different years. The results from both deployments indicated that krill were distributed within 20 m of the surface in the period February and March. During the first deployment, 7% of krill backscatter was recorded closer than 20 m to the surface during daytime and 22% during night-time. During the second deployment the proportions were 13% and 24% for day and night respectively.

2.31 The Subgroup noted that differences in the acoustic estimates typically arise from the effects of diel vertical migration that increases the relative amount of krill shallower than transducer depth and/or the surface detection which was set to 20 m for the 2019 Area 48 Survey). The scale of the differences in biomass of krill from day and night survey data (SG-ASAM-2019/05 and 2019/10) are consistent with the observed changes in the relative amount of krill occurring shallower than 20 m that has been observed from mooring data (WG-EMM-2019/32). This indicates that any changes in swarming behaviour between day and night do not introduce a significant bias when using the swarms method.

2.32 The Subgroup agreed that while there are differences in the biomass estimates using all of the data and when restricting the data to that collected between civil dawn and dusk (i.e. during the day), these differences were not significant and the inclusion of all data in the estimation process results in a reduction in the CV of the resulting biomass. The Subgroup agreed that using data from day and night does not bias the results and agreed that all of the data should be used to estimate the biomass.

2.33 The Subgroup noted that changes in krill behaviour may introduce changes in the frequency response and TS of krill and encouraged Members to investigate these effects using broadband acoustics.

Biological data

2.34 The analysis presented in SG-ASAM-2019/08 Rev. 1 demonstrated that the choice of krill length distributions used to convert acoustic backscatter into krill density has a significant effect on the estimates of krill density.

2.35 Biological sampling was conducted once at midday and midnight by the vessels conducting the 2019 Area 48 Survey transects (following the timings used in the CCAMLR-2000 Survey). The Subgroup noted the WG-EMM discussion on the potential to use all krill length data available from a variety of sources to provide information on the wider krill population length-frequency distribution during the period of the survey (WG-EMM-2019 report, paragraph 2.52).

2.36 The potential effect of selectivity in the trawl meshes of the different gear used for the large-scale survey (RMT 8, a scientific trawl and a commercial trawl and gear used during the AMLR transects) was provided in SG-ASAM-2019/10 based on a comparison of the length distribution obtained by the different vessels and the theoretical length at which 50% of the krill were retained in the net (L_{50}, using the optimal body orientation during mesh penetration (Krag et al., 2014)). This indicated no overlap between L_{50} and the krill length distribution except for a single vessel (that contributed two trawl hauls used in the analyses).

2.37 The Subgroup agreed that, based on the analysis in SG-ASAM-2019/10, the nets were able to catch all size classes of krill representatively but noted that there might be a difference in catch efficiency for nets with different mouth size and volume of water filtered while towing.

2.38 The Subgroup agreed that the objective of using all available krill length data was to have the best representation of the krill length frequency in the survey area. The Subgroup further agreed that this was best achieved by aggregating the krill length data from within the external boundaries of the ESS, SS and AP strata of the 2019 Area 48 Survey.

2.39 The Subgroup noted that krill length data were collected during the period of the acoustic survey on the vessels conducting the survey, from scientific observers on krill fishing vessels and from krill-dependent predators as part the CCAMLR Ecosystem Monitoring Program (CEMP). For each strata all of the krill length data collected during the period that the acoustic survey was conducted in that strata were used to produce a strata-specific krill length-frequency distribution. Krill length frequencies from individual sampling platforms (survey vessels, fishing vessels and predators) were equally weighted, by using the proportion of krill in each length class for each sampling platform, and summing the proportions for each length class across all sampling platforms.

Area 58 Japanese survey

Review of preliminary survey results, including the use of broadband acoustic data

2.40 SG-ASAM-2019/02 was presented by Dr Abe and included the preliminarily estimate of the biomass of krill (*Euphausia superba*) in Division 58.4.1 in 2018/19 of 4.349 million tonnes based on the swarms-based method using data obtained by the *Kaiyo-maru*. The point estimate was comparable with the estimate from 1996 BROKE survey (4.83 million tonnes with CV = 17%). However, he cautioned that these estimates cannot be compared directly because the:

(i) biomass estimation methods were different

(ii) timing of the surveys was different (the *Kaiyo-maru* survey commenced about 40 days earlier than the BROKE survey)

(iii) areal coverages were different, primarily because of differences in the positions of the sea ice edge, especially in the western part of the division.

2.41 The CV reported in SG-ASAM-2019/02 was calculated using the formulas described in WG-EMM-16/28. However, some typographical errors were found in the formulas, as pointed out in SG-ASAM-2019/08 Rev. 1, consequently an updated biomass with CV will be estimated following formulas in SG-ASAM-2019/08 Rev. 1 and the results will be presented to the next SG-ASAM.

2.42 The Subgroup noted that the ice conditions in Division 58.4.1 during the survey meant that the vessels were unable to get close to the shelf, therefore, the occurrence of ice krill (*E. crystallorophias*) was minimal and the influence on the integration result is thought to be small. On the other hand, since the survey line was extended to the north, it should be noted that bigeye krill (*Thysanoessa macrura*) appeared, especially in the western area at the beginning of the survey.

2.43 Dr K. Amakasu (Japan) provided a preliminary report on broadband acoustic measurements conducted during the Japanese survey by the *Kaiyo-maru*. The broadband measurements were successfully performed with echo sampling using EK80 in FM mode conducted during rectangular midwater trawls (RMT) tows. The data collected indicated that the frequency response of Antarctic krill primarily depend on length distribution of targets but other factors, including orientation, should be investigated further.

2.44 The Subgroup very much appreciated and welcomed this first reported achievement in applying a broadband acoustic technique to krill.

2.45 The Subgroup noted that while the range resolution is increased by the pulse compression processing, the across-beam resolution due to the beam width has not improved, so it is actually difficult to detect a single target in the swarm. For this reason the broadband data for krill are proceeding using S_v spectra.

2.46 The Subgroup noted that acoustic data from around swarms may be of interest in understanding the broadband acoustic characteristics of salp. Dr Amakasu clarified that, at present, the analysis is being conducted mainly on krill, so analysis of the other organisms around swarms has not progressed, however, this will be analysed in the future.

2.47 Dr Abe provided a preliminary report on mass density contrast *g* and sound-speed contrast *h* measurements of *E. superba* and *T. macrura* that indicated that both material properties were related to species and maturity. The mass density contrasts, in case of *E. superba*, were affected by whether animals were gravid or non-gravid, and the mass density of *E. superba* was different from *T. macrura*. In case of *E. superba,* sound-speed contrasts were affected by the body size and maturity. Comparing the two species, the sound-speed of *E. superba* was higher than that of *T. macrura*. The estimates of both material properties were higher than the existing knowledge. Furthermore, as both material properties are likely to be influenced by lipid content (the results of lipid analyses are awaited), it will be important to investigate the relationship between lipid contents and material properties.

2.48 The Subgroup agreed that as growth stage, seasonal changes and regional characteristics are thought to be the cause of differences in *g* and *h*, it would be useful to consider this matter in a focused meeting on factors affecting *g* and *h*, including measurement methods.

Review of collection and analysis of krill acoustic data from fishing vessels

3.1 SG-ASAM-2019/01 provided an update on the nominated acoustic transects undertaken by fishing vessels in 2018 and 2019 and identified three areas for greater clarification from SG-ASAM:

(i) the timing and frequency of nominated acoustic transects undertaken by fishing vessels

(ii) the method for data transmission of the acoustic data and its exploration

(iii) whether the Secretariat should hold raw or processed data.

3.2 The Subgroup agreed that data from the nominated acoustic transects undertaken by fishing vessels was intended to provide intra-annual-scale biomass estimates during the period of the fishery that provide additional context to the subarea surveys. SG-ASAM recommended a minimum sampling frequency would require fishing vessels entering a subarea to undertake the nearest nominated acoustic transect (either prior to or within the first few days of fishing) and to complete the same transect immediately prior to leaving the subarea. The Subgroup noted that the completion of additional transects opportunistically in the intervening period would also be beneficial.

3.3 The Subgroup noted that communication between fishing vessels to coordinate the undertaking of nominated transects over a wider time period could be beneficial to interpreting intra-annual variability and requested that the Secretariat liaise with ARK to explore the best way for this communication to occur.

3.4 The Subgroup commended the collection of acoustic data by Chilean and Norwegian fishing vessels along the nominated transects that had been transferred to the Secretariat successfully through cloud-based electronic transfer and recommended the Secretariat work with ARK to provide instructions for using this transfer method to accompany the acoustic collection procedures.

3.5 SG-ASAM acknowledged the benefit of having a single repository of raw acoustic data enabling rapid analysis or changes to method resulting in re-interpretation. It recommended that raw data and requested metadata is submitted to the Secretariat. Submission of processed data in addition was also welcomed and the group noted that version control of the templates used to create processed data was essential and endorsed the use of the CCAMLR Secretariat GitHub repository to manage this process.

3.6 The Subgroup requested that all existing data that had been collected by krill fishing vessels along nominated transects be sent to the Secretariat in order to provide a complete catalogue of the transect data that has been collected. The Subgroup encouraged the annual submission of nominated transect data in the future.

3.7 The Subgroup noted the example of the interactive map-based exploration of data that Echoexplore™ provided in SG-ASAM-2019/01 and suggested that the Secretariat used this software to manage the acoustic data files and also add data layers of the location of acoustic data from nominated acoustic transects undertaken by fishing vessels to the CCAMLR GIS server.

3.8 The Subgroup recommended that processing of the nominated transects become a task of SG-ASAM, undertaken at the annual meeting. This would facilitate maintenance of version control of the processing template and provide up-to-date analysis of annual data.

3.9 Dr Wang presented an example of acoustic data collected from the Chinese *Long Teng* using a three-frequency EK60 echosounder during periods of transit from fishing grounds to transhipment locations. SG-ASAM noted the high quality of the collected data and agreed that it demonstrated the value of acoustic data from fishing vessels. The Subgroup agreed that the value of such data would be considerably enhanced when collected along the nominated transects.

Other technical aspects relevant to the krill acoustic surveys and data analysis

Supervised and unsupervised processing of acoustic data

4.1 Dr Fielding presented SG-ASAM-2019/09 which compared krill density estimates calculated using supervised processing of acoustic data applying Echoview with unsupervised processing using a custom-made python processing routine named RapidKrill. The development of RapidKrill has been financed by the Antarctic Wildlife Research Fund (AWR) and the routine is developed to enable fast and robust unsupervised processing of acoustic data from different platforms, including low power platforms and also transfer of results on condensed form requiring only low bandwidth.

4.2 The comparison between processing routines were done on 15 survey transects comprising the WCB survey and the South Sandwich area on EK60 data from the UK 2019 cruise on RRS *Discovery* (DY098), and the agreed Echoview template for data processing had been implemented in RapidKrill.

4.3 Overall there was good consistency between the outcome of the unsupervised RapidKrill and supervised Echoview approach, and results from the WCB showed that the difference in results due to choice of discrimination method (dB-difference or swarm-based) was much larger than the difference due to processing routines.

4.4 The Subgroup noted that the python-based toolbox (Echopy) to process acoustic data using the swarms-based approach is open source and available to CCAMLR and the wider community for download from the BAS-acoustics GitHub account (https://github.com/bas-acoustics) along with example datasets. The python-based toolbox (Rapidkrill) to summarise acoustic data in real-time and transmit over email should be available within the next month.

4.5 The Subgroup agreed that RapidKrill was a potentially very useful tool enabling processing of acoustic data in a consistent way. The group encouraged more testing of the software on already processed data, and noted that it had the potential to become a standard tool for the processing of acoustic data in CCAMLR and requested the Scientific Committee consider how further development of the software might be supported in the future.

Chinese acoustic krill biomass time series

4.6 Dr X. Yu (China) presented SG-ASAM-2019/04 Rev. 1 where krill biomass from 2013 to 2019 had been estimated from fishing vessel surveys in the previous US-AMLR survey area. Data were from echosounders most often calibrated and running 38, 70 and 120 kHz, and the swarms-based method was used for krill discrimination. The results showed a strong increasing trend in biomass over the period, but the authors remarked that the calibration of 38 kHz had not been of good quality during 2013 and 2015, and also that the survey had not been conducted during the same period every year.

4.7 The Subgroup strongly encouraged this survey effort to be continued. The Subgroup also encouraged further work to investigate whether other sources of information, for example from CEMP sites, supported the findings of an increasing biomass trend during this period.

4.8 The Subgroup further noted that due to the difficulties in repeating such surveys at the same time every year, the nominated transects visited over the fishing season (see paragraph 3.2) as well as moorings would be important to shed light on intra-annual variability in krill density. Ultimately, a nested approach combining krill density data on different temporal and spatial scales should be aimed at.

Technical aspects relevant to krill acoustic survey

4.9 The Subgroup noted that the TS estimates in the SG-ASAM-2010 report, Table 5, were produced by an SDWBA model package which was used for biomass estimation during that meeting, but which had later been updated (Calise and Skaret, 2011). The most recent model package uses a different, and assumed to be a more correct, krill shape representation at frequencies above 120 kHz, and the TS estimates at 200 kHz hence differ from those presented in the report of SG-ASAM-2010.

4.10 The Subgroup noted that the comparison of the swarms-based and dB-window identification method presented in both SG-ASAM-2019/09 and 2019/10 were undertaken using the TS estimates calculated during the SG-ASAM-2010 meeting (WG-EMM-11/20). The Subgroup recognised that this analysis was the closest comparison of methods between the 2010 and 2019 identification techniques. However, it recommended that the updated values calculated by Dr Macaulay are uploaded to the CCAMLR Secretariat GitHub repository. The Subgroup identified that any krill estimate made using 200 kHz acoustic data should use these 2019 TS estimates.

4.11 The Subgroup noted that the process prior to the SG-ASAM-2019 meeting with several Members producing krill biomass estimates had shown that there was a need for software that implements the standardised procedures to go from acoustic raw data through processing to a krill biomass estimate.

4.12 The Subgroup identified that there was not a current version-controlled Echoview template for undertaking the dB-difference identification method on acoustic data. SG-ASAM agreed that a version-controlled template, similar to that available for the swarms-identification method, would be useful and encouraged its development for the next SG-ASAM meeting. The Subgroup further agreed that revision control of the Echoview templates was required and recommended that agreed templates uploaded to the CCAMLR Secretariat GitHub repository are reviewed at each SG-ASAM meeting to register any further agreed developments.

4.13 The Subgroup noted that the open source software StoX (Johnsen et al., 2019) had been developed for this purpose for fish stock estimation in the north Atlantic and could potentially be applied for krill. The leader of the StoX project (Dr Johnsen, IMR) kindly presented the software during the meeting. It is built on java and R designed with a user-friendly interface. The software uses acoustic and biotic input data on standard .xml-format, and all processing steps and user choices are logged in a separate process file. An adjacent R-package called Rstox has been developed to enable processing independent of the GUI interface.

4.14 The Subgroup welcomed Norway’s offer to evaluate the use of StoX for krill biomass estimation, and further to test it on krill datasets if possible.

Other business

Subarea acoustic surveys metadata

5.1 SG-ASAM-2019/04 Rev. 1 described a five-year time series of krill estimates around the South Shetland Islands (2013–2019) made on the Chinese fishing vessel *Fu Rong Hai*. The Subgroup welcomed the continuation of existing time series along these well-defined transects and encouraged China and other Members to continue survey estimates in this region, thereby contributing to the time-series of regional biomass estimates in this subarea.

5.2 The Subgroup welcomed the submission of the metadata associated with the surveys described in SG-ASAM-2019/04 Rev. 1 as a contribution to the request by WG-EMM (WG-EMM-2019 report, paragraph 2.21) for compiling all estimates of regional biomass. The Subgroup also welcomed the provision of example metadata from the USA that had been provided to the Secretariat for surveys in Subarea 48.1.

5.3 The Subgroup recalled the metadata request for these regional estimates (WG-EMM-2019 report, Tables 5 and 6) and clarified that the request for survey area and strata name were optional metadata variables only recommended where an areal biomass had been previously calculated.

5.4 The Subgroup noted that there was a short period of time between the WG-EMM-2019 request and the SG-ASAM-2019 meeting, and recommended that Members submit additional metadata to the Secretariat prior to the next SG-ASAM meeting, in order to facilitate consistent formatting of the information.

CCAMLR Science

5.5 The Science Manager raised the possibility for a *CCAMLR Science* special issue on CCAMLR’s management of the krill fishery including the 2019 approach to krill biomass assessment. The Subgroup endorsed the concept, identifying it as an opportunity to collate and publish some of the methodological achievements in providing a new large-scale krill density estimate, new information from subarea time series and a place to describe the progress in fishing-vessel based science. The Secretariat's Science Manager offered to prepare a paper proposing the *CCAMLR Science* special issue to the Scientific Committee.

Convener of SG-ASAM

5.8 Dr Zhao identified his intention to step down as Convener of SG-ASAM and encouraged Members to consider potential candidates that could be proposed to the Scientific Committee to convene the SG-ASAM meeting next year.

Advice to the Scientific Committee and future work

6.1 The Subgroup identified the following items relevant to providing advice to the Scientific Committee and to its future work:

(i) krill biomass estimate from the 2019 Area 48 Survey (paragraph 2.4) including independent cross-checking of this result (paragraphs 2.4 to 2.14) and examination of survey methods (paragraphs 2.15 to 2.39).

(ii) preliminary krill biomass estimate in Division 58.4.1 (paragraph 2.40)

(iii) request for all existing data collected by krill fishing vessels along nominated transects be sent to the Secretariat to create a single repository of raw acoustic data (paragraphs 3.5 and 3.6)

(iv) development and support for tools for the processing of acoustic data in CCAMLR (paragraph 4.5)

(v) the Convener of SG-ASAM for its meeting next year (paragraph 5.8).

Adoption of the report and close of the meeting

7.1 At the close of the meeting Dr Zhao thanked all participants for their hard work and collaborative data analysis that had contributed greatly to the successful outcomes from SG-ASAM this year. In particular he thanked Dr Macaulay for his engagement with all Members that had made a substantial contribution to the meeting. Dr Zhao also thanked IMR for hosting the meeting in a very relaxed atmosphere and the Secretariat for its efficient support to the meeting.

7.2 On behalf of the Subgroup Dr O.R. Godø (Norway) thanked Dr Zhao for his focussed and inclusive convening of the meeting that had emphasised the engagement of all participants in providing clear outcomes from the meeting. Reflecting on Dr Zhao's retirement as Convener of SG-ASAM, Dr Godø applauded the developments made in the work of the Subgroup that have redefined the role of acoustic data in the toolbox of ecosystem understanding in CCAMLR.

7.3 Dr Zhao thanked Dr Godø and all of those that contributed to the collaborative work of SG-ASAM, noting that this included many contributors engaging in a wide range of activities from data collection to analysis and participation in subgroup meetings.

References

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Jolly, G.M. and I. Hampton. 1990. A Stratified Random Transect Design for Acoustic Surveys of Fish Stocks. *Can. J. Fish. Aquat. Sci*., 47 (7): 1282–1291.

Krag, L.A., B. Herrmann, S.A. Iversen, A. Engås, S. Nordrum and B.A. Krafft. 2014. Size Selection of Antarctic Krill (*Euphausia superba*) in Trawls. *PLoS ONE*, 9: e102168.

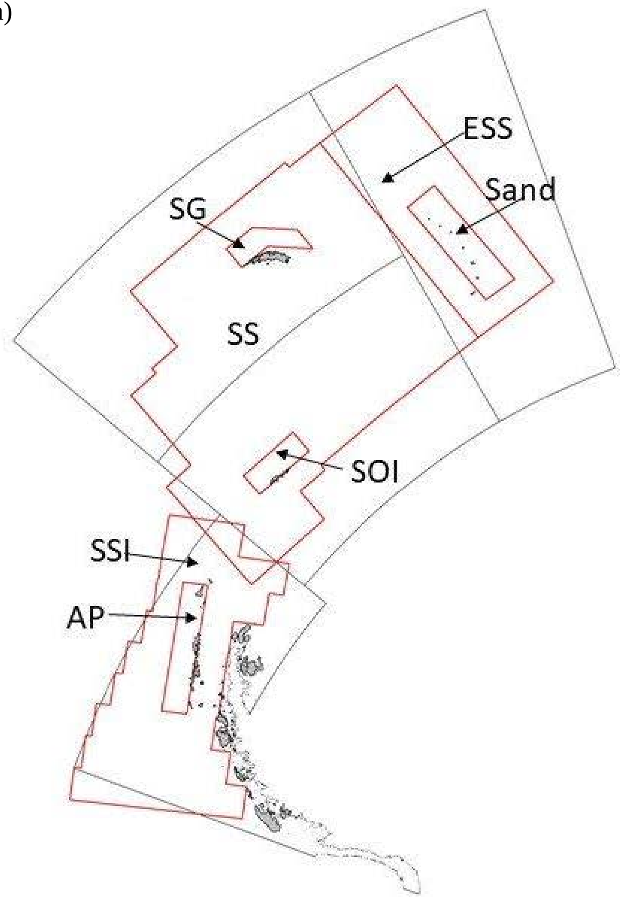
Table 1: Krill biomass estimates for survey strata conducted in Area 48 in 2019 (updating Table 5 of SG-ASAM-2019/08.) The nominal areas for each the strata are taken from SC-CAMLR-XIX, Annex 4, Appendix G, paragraph 2.3 and WG-EMM-11/26). * these survey strata do not have defined areas and hence only a density estimate. Biomass estimates are rounded to the nearest 1 000 tonnes.

Survey	Stratum	Nominal area (km^2)	Mean krill density ($g\ m^{-2}$)	Krill biomass (tonnes)	Variance component ($10^6\ t^2$)
2019 Area 48 Survey	Antarctic Peninsula	473 318	40.5	19 158 000	4 432 000
2019 Area 48 Survey	Scotia Sea	1 109 789	25.9	28 742 000	56 678 000
2019 Area 48 Survey	Eastern Scotia Sea	321 800	23.9	7 677 000	1 555 000
2019 Area 48 Survey	South Shetland Islands	48 654	67.7	3 295 000	621 000
2019 Area 48 Survey	South Orkney Islands	24 409	77.8	1 900 000	337 000
2019 Area 48 Survey	South Georgia	25 000	9.1	227 000	3 000
2019 Area 48 Survey	South Sandwich Islands	62 274	25.9	1 616 000	68 000
Subarea 48.1	Elephant Island	43 865	56.0	2 458 000	822 000
Subarea 48.1	West	38 524	9.9	381 000	5 000
Subarea 48.1	Bransfield Strait	24 479	102.4	2 507 000	210 000
Subarea 48.1	Joinville Island	18 151	83.9	1 507 000	238 000
Subarea 48.2	South Orkney Concentrated	*	170.6		
Subarea 48.2	South Orkney Fixed	*	59.0		
Subarea 48.3	Western Core Box	*	22.3		

Table 2: Krill biomass estimates for the 2019 Area 48 Survey.

Mean density ($g\ m^{-2}$)	Density variance ($g^2\ m^{-4}$)	Density CV (%)	Standing stock (tonnes)	Standing stock variance ($10^6\ t^2$)	Standing stock CV (%)
30.3	14.9	13	62 615 000	63 694 000	13

(a)



(b)

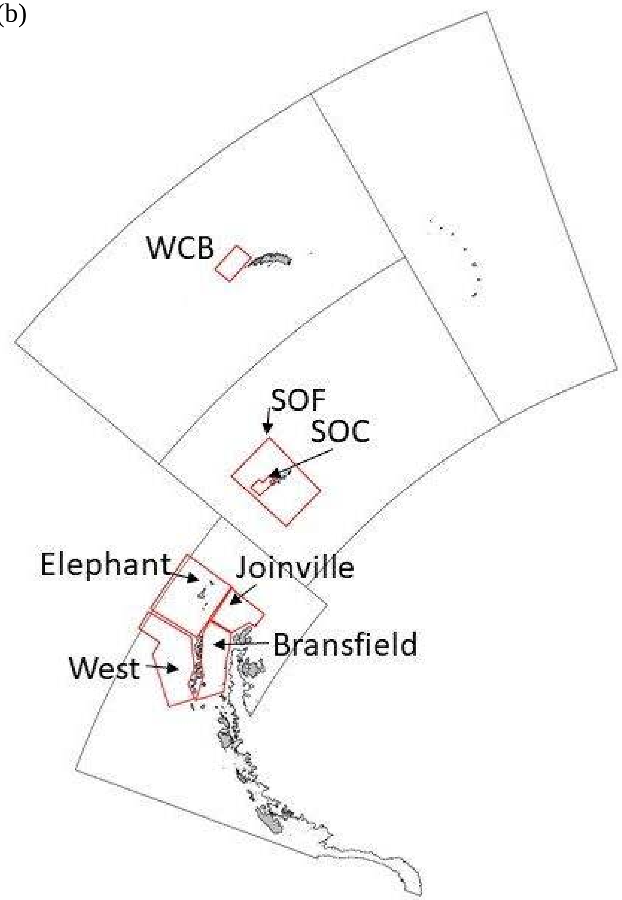


Figure 1: Strata referred to in paragraph 2.1.1 in: (a) 2019 Area 48 Survey and (b) subarea surveys. Data for strata boundaries from https://raw.github.com/ccamlr/2019Area48Survey/master/map_data/survey%20strata.geojson.

Appendix A

List of Participants

Subgroup on Acoustic Survey and Analysis Methods
(Bergen, Norway, 26 to 30 August 2019)

Convener	Dr Xianyong Zhao Yellow Sea Fisheries Research Institute, Chinese Academy of Fishery Science zhaoxy@ysfri.ac.cn
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CCAMLR Secretariat	Dr Keith Reid Science Manager keith.reid@ccamlr.org

Appendix B

Agenda

Subgroup on Acoustic Survey and Analysis Methods
(Bergen, Norway, 26 to 30 August 2019)

1. Opening of the meeting

2. Large-scale krill surveys conducted in 2019

   2.1 Area 48 multinational survey
      2.1.1 Cross-checking of survey results among different participants
      2.1.2 Comparison of results using the dB window and the swarm-based methods
      2.1.3 Revised/refined analysis, including taking into account any issues raised during WG-EMM

   2.2 Area 58 Japanese survey
      2.2.1 Review of preliminary survey results, including the use of broadband acoustic data

3. Review of collection and analysis of krill acoustic data from fishing vessels

   3.1 Progress in data collection and delivery of acoustic data from fishing vessels
   3.2 Procedures for the collection and analysis of krill acoustic data collected on designated transects

4. Other technical aspects relevant to the krill acoustic surveys and data analysis

5. Other business

6. Advice to the Scientific Committee

7. Adoption of the report and close of the meeting.

Appendix C

List of Documents

Subgroup on Acoustic Survey and Analysis Methods
(Bergen, Norway, 26 to 30 August 2019)

SG-ASAM-2019/01	Acoustic data collection by the krill fishing industry to improve the monitoring of krill abundance K. Reid and J. Arata
SG-ASAM-2019/02	Preliminary biomass estimation of Antarctic krill based on the swarm-based method for CCAMLR Division 58.4.1 in 2018/19 using data obtained by Japanese survey vessel *Kaiyo-maru* K. Abe, R. Matsukura, N. Yamamoto, K. Amakasu and H. Murase
SG-ASAM-2019/03 Rev. 1	Density estimation of Antarctic krill (*Euphausia superba*) around South Shetland Island and Elephant Island (Subarea 48.1) using two frequencies with 38 and 120 kHz S. Choi, S. Chung, I. Han, W. Oh, D. An and K. Lee
SG-ASAM-2019/04 Rev. 1	Time series of Antarctic krill estimates around the South Shetland Islands from 2013 to 2019 X. Yu, X. Wang, X. Zhao, J. Zhang, G. Fan, Y. Ying and J. Zhu
SG-ASAM-2019/05	Diel vertical distribution of Antarctic krill around the South Shetland Islands in February 2019 and its potential effect on biomass estimation X. Wang, X. Yu, J. Zhang and X. Zhao
SG-ASAM-2019/06	Comparison of krill density estimated with swarm-based and dB-difference method using acoustic data collected by Chinese fishing vessel participating in the 2019 Area 48 survey X. Yu, X. Wang, J. Zhang and X. Zhao
SG-ASAM-2019/07	Biomass estimates of Antarctic krill based on survey conducted by the Chinese fishing vessel FV *Fu Rong Hai* during the 2019 Area 48 survey X. Wang, X. Yu, X. Zhao, J. Zhang, G. Fan, J. Zhu and Y. Ying

SG-ASAM-2019/08 Rev. 1	Biomass results from the International Synoptic Krill Survey in Area 48, 2019 G. Macaulay, G. Skaret, T. Knutsen, O.A. Bergstad, B. Krafft, S. Fielding, S. Choi, S. Chung, K. Demianenko, V. Podhornyi, K. Vishnyakova, L. Pshenichnov, A. Chuklin, A. Shishman, X. Wang, X. Zhao and M. Cox
SG-ASAM-2019/09	Supervised and unsupervised (RapidKrill) estimates of krill density from DY098 A. Ariza, S. Fielding and R. Blackwell
SG-ASAM-2019/10	Methodological aspects of the International Synoptic Krill Survey in Area 48, 2019 G. Macaulay, G. Skaret, T. Knutsen and B. Krafft

Annex 7

Report of the Working Group on Fish Stock Assessment
(Hobart, Australia, 7 to 18 October 2019)

Contents

Report of the Working Group on Fish Stock Assessment

(Hobart, Australia, 7 to 18 October 2019)

Opening of the meeting

1.1 The meeting of WG-FSA was held in Hobart, Australia, from 7 to 18 October 2019. The Convener, Dr D. Welsford (Australia), opened the meeting and welcomed participants to Hobart (Appendix A). He encouraged all participants to engage in discussion in the Working Group and urged participants to ensure that the discussions were based on science and where there were alternative views that these should be reflected as testable scientific hypotheses.

1.2 Dr D. Agnew (Executive Secretary) welcomed all participants to the CCAMLR Secretariat. He looked forward to the seeing the outcomes of the meeting being presented to the Scientific Committee and the Commission and hoped that everyone would also have an opportunity to enjoy the spring weather in Hobart.

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

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

1.5 In this report, paragraphs dealing with advice to the Scientific Committee and other working groups have been highlighted. These paragraphs are listed under Item 9. In addition, the information used in developing assessments and other aspects of the Working Group's work is included in the Fishery Reports (www.ccamlr.org/node/75667).

1.6 The report was prepared by M. Belchier and C. Darby (UK), A. Dunn (New Zealand), T. Earl (UK), M. Eléaume (France), J. Fenaughty (New Zealand), I. Forster (Secretariat), N. Gasco (France), E. Grilly (Secretariat), P. Hollyman (UK), C. Jones (USA), D. Maschette (Australia), F. Massiot-Granier (France), T. Okuda (Japan), C. Péron (France), K. Reid (Secretariat), G. Robson (UK), M. Söffker (EU), S. Somhlaba (South Africa), S. Thanassekos (Secretariat), P. Tixier and P. Ziegler (Australia).

Review of data available

IUU fishing activity

2.1 CCAMLR-38/12 Rev. 1 presented a report on illegal, unreported and unregulated (IUU) fishing activity and trends in 2018/19. For the second consecutive year, no vessels included on the non-Contracting Party (NCP)-IUU Vessel List were reported as sighted by Members inside the Convention Area. The paper further presented a summary of reported instances of unidentified fishing gear in 2018/19.

2.2 The Working Group welcomed the lack of reported IUU fishing activity in the Convention Area in 2018/19, noting that without surveillance data it was difficult to provide effort-corrected trends of IUU activity.

2.3 The Working Group noted the importance of being able to identify the origins of abandoned, lost or otherwise discarded fishing gear (ALDFG) when recovered in the Convention Area and requested that the Secretariat review the current requirements for gear marking by CCAMLR vessels against the Food and Agriculture Organization (FAO) *Voluntary Guidelines on the Marking of Fishing Gear* (FAO, 2019) to advise on their consistency as well as the potential for clarifying and improving gear marking requirements in CCAMLR fisheries.

2.4 CCAMLR-38/BG/17 Rev. 1 presented draft technical guidelines to assist vessels which encounter unidentified fishing gear in the Convention Area. The work is summarised and the draft guidelines were published to the Unidentified fishing gear in the Convention Area e-group in 2019 (https://groups.ccamlr.org/group/60/stream). The Working Group welcomed this development and indicated that when the guidelines are finalised, they should be communicated to all Members that may encounter ALDFG.

Fishery notifications

2.5 CCAMLR-38/BG/07 Rev. 1 presented the exploratory fishery notifications for 2019/20. There was a total of 62 notifications across five exploratory toothfish fisheries submitted for 2019/20 and no new fishery notifications.

2.6 The Working Group welcomed the additional data on vessels and gear that are available via the hyperlinks included in CCAMLR-38/BG/07 Rev. 1 to the individual notifications on the CCAMLR website (https://www.ccamlr.org/fishery-notifications/notified). The Working Group requested that the details of gear type, including different configurations of different autoline gear, and a time-series of total notifications be included as a table in this background paper in the future. A summary of the gear type for vessels notified in 2019 is given in Table 1.

Reconciliation of CDS and monthly fine-scale catch and effort data

2.7 CCAMLR-38/BG/11 presented a data comparison between the Catch Documentation Scheme for *Dissostichus* spp. (CDS) and the fine-scale catch and effort data for the 2018 and 2019 fishing seasons. Overall, the comparison indicated that, in both seasons, the total toothfish catches reported from the Convention Area in the CDS and from catch data differed by less than 1%. Specific issues were identified in the accurate reporting of subarea and species in *Dissostichus* Catch Documents (DCDs) which the Secretariat are working with Members to resolve.

2.8 The Working Group welcomed this analysis and the overall high correlation between catch and effort data and verified landings data. The Working Group, however, highlighted the need to better understand discrepancies and their potential effects on assessments and the resulting advice. The Working Group further requested that the Secretariat extend this analysis to earlier fishing seasons.

2.9 The Working Group agreed that the process used by the Secretariat to identify where discrepancies arose between the CDS and fine-scale catch and effort data should continue to use a relative (10%) and an absolute (200 kg) threshold to trigger further investigation and correspondence with relevant Members to identify reasons for such a discrepancy.

2.10 The Working Group recognised the data quality improvements that have been achieved as part of the ongoing reconciliation of CDS and fine-scale catch and effort data, but advised the Scientific Committee that the current difference in the requirements to report landings from subareas or divisions in Conservation Measure (CM) 10-05, rather than the management areas specified in CM 41-09 (for Subarea 88.1 and small-scale research units (SSRUs) 882A–B), mean that it is currently not possible to use the CDS and fine-scale catch and effort data reconciliation process as a data quality input into the integrated assessment for toothfish in that area.

2.11 The Working Group recommended that the Secretariat provide any proposed changes, and links to the catch and effort (C2) forms and observer forms to WG-FSA at each of its annual meetings as a paper.

2.12 The Working Group recalled the discussion at WG-SAM (WG-SAM-2019 report, paragraphs 4.6 to 4.7) on the potential reasons for the underestimation of catches on Ukrainian vessels that had been highlighted by the C2/CDS reconciliation in 2018 (SC-CAMLR-XXXVII, paragraphs 12.3 and 12.4). The Working Group noted that while there was no paper submitted to WG-FSA on this matter, SC CIRC 19/93 was received during the meeting and included a description of the analyses undertaken by Ukraine to identify where underestimation of catch in the C2 data had occurred.

2.13 Based on the details provided in SC CIRC 19/93, and a clarification from Dr K. Demianenko (Ukraine) that the resubmission of data included all data from three Ukrainian vessels (*Calipso*, *Koreiz* and *Simeiz*) from 2015 to 2018, the Working Group noted that there were no discrepancies in the CDS and fine-scale catch and effort data reconciliation in 2019 and this reflected the changes in practices on vessels that had been implemented in 2018/19 by Ukraine.

2.14 The Working Group recommended that Ukraine provide details of the methods used to re-estimate the catches in the resubmitted C2 data and report on the evaluation of the implications of these changes on the provision of management advice to WG-SAM-2020.

2.15 The Working Group recommended that the all data collected on the *Calipso*, *Koreiz* and *Simeiz* from 2015 to 2018 be quarantined by the Secretariat, pending the outcomes of any evaluation by WG-SAM of the methods used to re-estimate the C2 data and the Working Group's advice on the implications of those revisions on the work of the Scientific Committee.

Report on catches in the Convention Area

2.16 SC-CAMLR-38/BG/01 Rev. 1 presented catches of target species from directed fishing on toothfish, icefish and krill in the Convention Area in 2017/18 and 2018/19, as well as catches taken during research activities listed in Table 1 of CM 24-05.

2.17 The Working Group welcomed the details provided in the paper and noted that in future this paper should include a clear reconciliation between the different sources of catch data, including the aggregated catch data used for fishery monitoring, the detailed (haul-by-haul) catch data and the Member-verified landings data (from the *CCAMLR Statistical Bulletin*).

Data management

2.18 WG-FSA-2019/14 presented an overview of the taxon data project currently being undertaken by the Secretariat. This project has compared the current CCAMLR taxon list with the most recent Aquatic Sciences and Fisheries Information System (ASFIS) List of Species for Fishery Statistics Purposes published by the FAO that is currently used as the definitive source by CCAMLR and the World Register of Marine Species (WoRMS) that provides a taxonomic reference for all marine species. The aims of the project are to:

(i) identify inconsistencies between the CCAMLR taxon list, the FAO ASFIS list and WoRMS

(ii) evaluate the value of using WoRMS as a taxonomic reference within the CCAMLR taxon list

(iii) propose a solution to deal with the taxonomic inconsistencies within the CCAMLR master data program.

2.19 The Working Group welcomed this proposal from the Secretariat outlined in WG-FSA-2019/14 and agreed to the use of WoRMS as a taxonomic reference within CCAMLR and its implementation in the CCAMLR data systems. The Working Group requested the Secretariat to provide regular updates on taxonomic code corrections to WG-EMM and WG-FSA and to ensure that any changes to taxonomic codes used, including from changes in species taxonomy in the CCAMLR database, are clearly documented and historical codes used by CCAMLR are retained. The Working Group recommended the Secretariat engage with WoRMS and ASFIS to obtain three-letter alpha codes and AphiaIDs for Antarctic taxa which are needed by CCAMLR and are missing from WoRMS and ASFIS.

Catch and effort data and biological observations from CCAMLR fisheries

2.20 WG-FSA-2019/01 reported on the Coalition of Legal Toothfish Operators (COLTO)–CCAMLR Toothfish Catch and Effort Data Workshop that was held in South Africa in July 2019 that followed the rationale and scope considered in 2018 (WG-FSA-2018 report, paragraphs 2.12 to 2.18 and SC-CAMLR-XXXVII, paragraphs 3.44 and 3.45) and refined in COMM CIRC 19/29. The paper contained a series of recommendations for the consideration of the Working Group and the Scientific Committee.

2.21 The Working Group welcomed the COLTO–CCAMLR Workshop and agreed that it had been a very efficient outreach process that had engaged a broad range of stakeholders, had achieved many useful outcomes and provided clear recommendations for consideration by WG-FSA.

2.22 The Working Group reviewed the recommendations from WG-FSA-2019/01, the outcome of which is presented in Table 2. The Working Group recommended:

(i) the Secretariat continue to develop the proposed new C2 form and fishery data manual intersessionally with Members, noting the endorsed recommendations by this working group on C2 form content and specific instructions (Table 2)

(ii) the Scientific Committee consider removal of the requirement to complete the B2 form where currently specified in the conservation measures

(iii) the Scientific Committee consider the addition of text specifying coordinated universal time (UTC) timing for fishery opening and closure dates in the appropriate conservation measures

(iv) the Scientific Committee consider the removal of the requirement for vessels to report aggregated vulnerable marine ecosystem (VME) data.

Fishery monitoring and closure procedures

2.23 CCAMLR-38/BG/12 described the Secretariat's application of procedures to monitor and forecast closures in CCAMLR fisheries in the 2018/19 season, including a description of the issues in applying the procedures and specific circumstances which can result in catch over-runs and under-runs.

2.24 The Working Group noted that WG-FSA-18/07 described the two-stage process for the forecasting and closure process for exploratory toothfish fisheries and that SC-CAMLR-XXXVII, Annex 11, focused on the first stage of this process.

2.25 The Working Group recommended that the Scientific Committee include the complete two-stage process as an annex to its report.

2.26 The Working Group agreed that any forecasting process depends, for its accuracy, on the extent to which vessels continue to fish in the forecast period in the same manner as they fished in the period prior to the forecast. In the case of the fishery in the special research zone (SRZ) in 2018/19, the Working Group noted the unpredictability in changes in fishing effort (including one vessel setting 66 000 hooks in one day, as well as a general tendency of other vessels to reduce the number of hooks they set as the closure date approaches), as well as the relatively high level of fishing capacity compared to the catch limit, increases the uncertainty of the forecast.

2.27 The Working Group discussed the proposal in CCAMLR-38/BG/12 for an experimental change to a 48-hour period (extended from the current 24-hour period) for the removal of gear from the SRZ to allow a more orderly closure of the fishery to improve the success of the closure forecasting algorithm. The Working Group recommended that the risk of a sudden increase in the number of hooks deployed immediately upon the announcement of the closure, which could lead to an overrun of catch limit, be taken into consideration when this proposal is considered.

2.28 The Working Group thanked the Secretariat for its work on the fishery closure algorithm (CCAMLR-38/BG/12) and noted that the closure algorithm resulted in the fishery closure at a lower catch than predicted at the time that the closure notice was issued (see Figure 1).

2.29 The Working Group recommended that the forecasting process currently used by the Secretariat and as detailed in WG-FSA-18/07 and SC-CAMLR-XXXVII, Annex 11, should be used in 2019/20, and that the Secretariat provide a summary of the operation of the algorithm in the 2019/20 season to WG-FSA-2020.

2.30 The Working Group recommended that the Secretariat review the forecasting algorithm for fishery closures after implementation in the 2019/20 season and consider alternative scenarios in a paper to WG-SAM in 2020.

Fishery Report updates

2.31 The Secretariat presented an update to the web-based set of documents following the discussion at WG-SAM (WG-SAM-2019 report, paragraphs 4.8 to 4.13), using a hierarchical structure for the Fishery Documents for Subarea 48.6, containing a Fishery Summary with links to a Species Description, Fishery Report and the Stock Assessment documents (Figure 2).

2.32 The Working Group welcomed the prototype demonstrated for Subarea 48.6 and encouraged the Secretariat to continue the approach for all Fishery Reports. The Working Group also noted that the same publication process as in previous years would be followed such that the draft reports will be made available for comment by Members prior to being published on the public part of the CCAMLR website.

2.33 The Working Group also recalled the request to those Members providing integrated toothfish assessments to develop the Stock Annexes (e.g. WG-FSA-2019/09) for those stocks (WG-SAM-2019 report, paragraph 4.11 and WG-FSA-2018 report, paragraphs 2.32 and 2.33). The Working Group recommended that Members continue development of a common format for our public domain documentation of these fisheries.

Review of updated stock assessments and provision of management advice (all fisheries)

Champsocephalus gunnari

C. gunnari in Subarea 48.3

3.1 The fishery for mackerel icefish (*Champsocephalus gunnari*) in Subarea 48.3 operated in accordance with CM 42-01 and associated measures. In 2018/19, the catch limit for *C. gunnari* was 3 269 tonnes. Details of this fishery and the stock assessment of *C. gunnari* are contained in the Fishery Report (www.ccamlr.org/node/75667).

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

3.3 In January/February 2019, as part of its regular monitoring program (WG-FSA-2019/20), the UK undertook a random stratified bottom trawl survey of the South Georgia and Shag Rocks shelves. A total catch of 6.3 tonnes of *C. gunnari* was reported from the research survey. Similar to the 2017 survey, stomach content analysis showed a high proportion of *Themisto* sp., rather than the krill seen in other years.

3.4 WG-FSA-2019/30 presented a preliminary assessment of *C. gunnari* in Subarea 48.3 based on the random stratified bottom trawl survey. A bootstrap procedure was applied to the survey data to estimate the demersal biomass of *C. gunnari* in this subarea. The bootstrap estimated the median demersal biomass at 53 124 tonnes, with a one-sided lower 95%

confidence interval of 32 399 tonnes. A catch limit of 3 225 tonnes for 2019/20 and 2 132 tonnes for 2020/21 would ensure at least 75% biomass escapement after a two-year projection period.

Management advice

3.5 The Working Group recommended that the catch limit for *C. gunnari* in Subarea 48.3 should be set at 3 225 tonnes for 2019/20 and 2 132 tonnes for 2020/21.

C. gunnari in Division 58.5.2

3.6 The fishery for *C. gunnari* in Division 58.5.2 operated in accordance with CM 42-02 and associated measures. In 2018/19, the catch limit for *C. gunnari* was 443 tonnes. Fishing was conducted by one vessel and the total reported catch up to 28 September 2019 was 443 tonnes. Details of this fishery and the stock assessment of *C. gunnari* are contained in the Fishery Report (www.ccamlr.org/node/75667).

3.7 The results of a random stratified trawl survey in Division 58.5.2 undertaken in April 2019 were summarised in WG-FSA-2019/03. Sampling protocols, such as the design and the duration of the hauls, were similar to recent surveys, but with a new set of randomly selected station points. As in previous years, toothfish and skates were also tagged during the survey. Within Gunnari Ridge only five of the 18 stations were completed, after two very large catches of icefish caused the catch limit for the division to be reached.

3.8 Based on data gathered during the survey, an assessment for *C. gunnari* using the generalised yield model (GYM) was presented in WG-FSA-2019/02. The presence of two very large catches in Gunnari Ridge caused the bootstrap distribution to be multi-modal. Consistent with the advice of WG-FSA (WG-FSA-2013 report, paragraphs 4.2 and 4.3) these hauls were removed, which resulted in a unimodal distribution. The one-sided bootstrap lower 95% confidence bound of total biomass of age 1+ to 3+ fish from the 2019 survey and fixed model parameters was estimated at 3 724 tonnes. Estimates of yield indicate that a catch limit of 527 tonnes of *C. gunnari* in 2019/20 and 406 tonnes in 2020/21 would satisfy the CCAMLR decision rules.

Management advice

3.9 The Working Group recommended that the catch limit for *C. gunnari* in Division 58.5.2 should be set at 527 tonnes for 2019/20 and 406 tonnes for 2020/21.

Dissostichus spp.

3.10 The Working Group noted that its advice was based on information from a combination of papers to this Working Group, papers to and corresponding responses by other CCAMLR working groups, advice from Scientific Committee and Commission meetings, peer-reviewed publications and work conducted during this meeting.

3.11 The Working Group recalled the results of the CCAMLR Independent Stock Assessment Review for Toothfish and the conclusions by the Scientific Committee that (SC-CAMLR-XXXVII, paragraphs 3.52 to 3.56):

(i) CCAMLR's approach, using a single modelling framework (CASAL) across stocks, based on surveys, catch and a comprehensive annual tagging program across fisheries is appropriate for the management of these stocks

(ii) in fisheries managed for low overall exploitation rate like toothfish, tagging data are essential because they provide an absolute index of abundance that is generally not provided by other types of data typically used to assess stock status

(iii) CCAMLR's approach with tagging studies makes it a leader in this area, and this knowledge is of interest to the broader stock assessment community

(iv) CCAMLR applies assumptions in the stock assessments in a precautionary manner, when there is uncertainty in parameters and assumptions, and the management of the fisheries is consistent with CCAMLR's precautionary approach and Article II

(v) appropriate practices are being followed and the assessments continue to adapt to new standards in most instances examined. Differences in standards, when they occurred, were within the scope of standards in the assessment field, but were also consistent with management strategies of CCAMLR

(vi) the many instances where the assessment scientists considered spatial structure in fishing and population dynamics indicated a high level of understanding of the importance of this component to the assessment of these fisheries in the future.

3.12 Based on the recommendation of the Scientific Committee (SC-CAMLR-XXXVII, paragraph 3.54) to continue to evaluate the recommendations by the expert group (SC-CAMLR-XXXVII, Table 3), the Working Group assessed how these recommendations had progressed and identified outstanding research issues (Table 3).

3.13 The Working Group recommended that a bridging analysis be used in all stock assessments to explore the effects of changes in the stock assessment due to updated data, revised parameter estimates and changes to model approaches since the last assessment model which has been used to provide catch advice.

CCAMLR decision rules

3.14 SC-CAMLR-38/15 discussed some of the strengths and weaknesses of the CCAMLR decision rules. The paper noted that the decision rule was highly precautionary, as was appropriate for the management of deep-water Antarctic species and shown to be robust to changes in the fishery–stock interactions. The robustness of CCAMLR's toothfish management protocol, based on the decision rule, was evaluated by considering hypothetical, future changes in the fishery–stock interactions and the stock productivity which could result from climate change. However, the robustness of the decision rule to potential climate change induced variation in productivity, highlighted a sensitivity that should be considered by the Scientific

Committee and its working groups. The development of the decision rule to include limit or target reference points, based on exploitation rate would ensure that management advice was also robust to change in productivity. The modification could also provide a basis for the provision of catch advice where historic IUU fishing has occurred and historic biomass is unknown.

3.15 The Working Group noted that the CCAMLR decision rules have a target of 50% of the virgin spawning stock biomass, B_0, and a limit of 20% of B_0 which are considerably higher than the targets and limit levels used in other fisheries around the world. In the management of many fisheries outside the Convention Area, the biomass which leads to maximum sustainable yield (B_{MSY}) is used as targets. Since B_{MSY} for toothfish is around 25% of B_0 (SC-CAMLR-38/15), the CCAMLR approach to setting catch limits in toothfish fisheries is far more precautionary.

3.16 The Working Group recalled that the CCAMLR decision rules rely on an estimate of B_0. However, there are situations where B_0 is unknown or difficult to estimate, such as when there have been unknown levels of IUU fishing in the past. There may also be undetected changes in the productivity of the fish stock which would lead to a change in the values of B_0.

3.17 The Working Group noted that maintaining historic B_0 values within the decision rule if there are undetected changes in productivity in the fish stock will lead to different results when productivity either decreases or increases:

(i) if there is an undetected decrease in productivity to a new lower B_{02}, applying the decision rule reduces the catch limits to the higher biomass target of the old state. Yield is forgone, but the stock is not overfished

(ii) if there is an undetected increase in productivity to a new higher B_{03}, applying the decision rule increases the catch limits to the lower biomass target of the old state. Yield is too high and the stock will be overfished.

3.18 The Working Group noted that the robustness of the current decision rules could be increased by the addition of harvest control rules under specific circumstances, such as when productivity changes are detected or when the level of historical IUU catches is unknown.

3.19 The Working Group noted a simulation of the long-term effects of applying the CCAMLR decision rules using constant exploitation rate instead of constant catch, which was conducted using the Ross Sea region assessment in WG-FSA-2019/08. Both strategies result in the CCAMLR decision rule criteria being met, however, the constant catch strategy (maximum constant yield) results in wider range of realised estimates of stock status than the constant exploitation rate strategy (Figure 3). With the constant catch strategy, spawning stock biomass fluctuated between 20% and 95% B_0, with 75% of the distribution between 40% and 60% B_0. With the constant exploitation rate strategy, spawning stock biomass fluctuated to a smaller extent between 30% and 80% B_0, with 75% of the distribution between 45% and 55% B_0.

3.20 The Working Group noted that any refinements of the CCAMLR decision rules require thorough testing with simulations through, for example, a management strategy evaluation to ensure that they remain consistent with achieving the objectives of Article II of the Convention.

3.21 The Working Group recommended that the Scientific Committee task WG-SAM with investigating potential refinements of the CCAMLR decision rules to increase their robustness in specific circumstances, such as using target and limit exploitation rates, through management strategy evaluations.

3.22 The Working Group compared catch-weighted mean length and the proportion of immature fish in Antarctic (*Dissostichus mawsoni*) and Patagonian (*D. eleginoides*) toothfish catches over the period in which CCAMLR data on toothfish fishing were available, with unstandardised data presented in CCAMLR Fishery Reports, as reported in WG-FSA-2019/40.

3.23 The catch-weighted mean length of fish in the catch varied across fisheries and between species (Figure 4).

3.24 For *D. mawsoni* caught in Subareas 48.6, 88.1 and 88.2 and Divisions 58.4.1 and 58.4.2 for the 1998–2019 seasons, the distributions of mean length ranged from about 100 to 150 cm. Mean length has fluctuated over time, as the fishing focused in research blocks and management areas that contain different components of the population. For instance, the time series for SSRUs 882C–H indicated variation through time as the proportion of the catch changed with the fishery moving from the north with larger fish to the south of the subarea with smaller fish.

3.25 Within the Ross Sea region (Subarea 88.1 and SSRUs 882A–B) there is a latitudinal gradient in mean length. The northern SSRUs, where fish are older than on the shelf and slopes, have a higher mean length in the catch. The closer to the shelf, the more frequent immature toothfish are encountered and the lower the mean length.

3.26 For *D. eleginoides* caught in Subareas 48.3, 48.6 and 58.7 and Divisions 58.4.4b and 58.5.2 for the 1996–2019 seasons, the catch-weighted mean length is comparable across all the fisheries, ranging from 70 to 110 cm throughout the time series. Although some variation over time can be observed, the majority of stocks have a stable time series. Mean lengths for fish caught in Subareas 48.3 and 58.7 have increased in recent years.

3.27 The proportions of fish in the catch that were immature varied also across fisheries and between species (Figure 5).

3.28 For *D. mawsoni*, the proportion of immature fish in the catch is higher for fisheries in higher latitudes, which is consistent with current stock hypotheses (Hanchet et al., 2015 and WG-SAM-18/33 Rev. 1). For example, the slope and shelf of the Ross Sea region comprise higher proportions of immature fish, 60% and 80% respectively.

3.29 For *D. eleginoides* there is considerable variation across CCAMLR fisheries, ranging from 20% to 80% proportion of immature fish which is due to different depths and spatial locations of the different *D. eleginoides* fisheries. As with mean length, the percentages have been relatively stable across time in Subareas 48.3 and 58.7 showing decreases in the proportion of immature fish in the catch in recent years, consistent with the increase of mean length in the catch.

3.30 For each of the integrated assessments in Subareas 48.3 and 58.6 and Divisions 58.5.1 and 58.5.2 and the Ross Sea region, the effect of fishing on the proportion of fish that are immature in the total population was estimated for the virgin biomass (i.e. B_0), the current total population, and the population at the target level point at the end of the future 35-year projection period (Figure 6). The estimated proportion (by number) of fish in the population that were immature in the virgin biomass, across areas and species, was relatively high at 70–85%, as expected in an unfished population. With fishing, the proportion of fish that are immature in the population is predicted to increase slightly as the mature biomass is gradually reduced towards its target level. For those stocks currently at or near the 50% of the B_0 target level (e.g. in Subarea 48.3 and Division 58.5.2), the change was small, indicating that fishing activities between now and when the population is at the target biomass will not further change the structure of the population.

3.31 The Working Group noted that, consistent with the CCAMLR decision rules, each of the assessed stocks is following the trajectory of biomass reduction of the mature fish, resulting in a slight increase of the proportion of immature fish in the population (Figure 6).

3.32 Given that there is a potential for bias in the interpretation of raw length distributions, the Working Group recommended that catch-weighted length distributions and the derived metrics, including mean length presented in Figures 4 to 6, be added to the Fishery Reports.

3.33 The Working Group noted that this analysis demonstrated that the CCAMLR decision rules result in similar trajectories for different fish stocks, independent of stock-specific characteristics such as different growth and maturity rates across two species, or different fishery characteristics such as area and depth-specific selection patterns.

3.34 The Working Group noted that:

(i) CCAMLR toothfish stocks have inherent variability in the ratio of mature and immature fish in the catch, resulting from a range of specific biological and fishery characteristics for each fishery

(ii) without data standardisation for fishing effort, depth, area, gear selection and historic recruitment events, trends in the structure of the catch data in isolation cannot be used to determine the characteristics of the underlying population

(iii) when standardised, the catch data do not exhibit trends over time that would indicate that the stocks are being overexploited or fished inconsistent with CCAMLR's precautionary approach

(iv) through the application of the CCAMLR decision rules with a long-term average target of 50% of B_0, all assessed stocks are managed using a process that is independent of changes in the interactions between the fishery and the stock.

3.35 The Working Group noted that the position of the authors of WG-FSA-2019/40 stating that the CCAMLR management process applied to its toothfish stocks is not precautionary and is inconsistent with Article II, was not consistent with this analysis, conducted during the meeting of WG-FSA-2019.

3.36 The Working Group noted that any fishery is expected to have an impact on the fished population. The CCAMLR precautionary approach defines what impact is acceptable and that changes need to be reversible over a time frame of two to three decades as defined in Article II of the Convention.

3.37 Dr S. Kasatkina (Russia) noted that in her opinion, the CCAMLR approach was not precautionary and could not provide rational use of the toothfish stock in Subarea 48.3.

3.38 All other participants of the Working Group agreed that the CCAMLR assessment and management decision rule protocols are:

(i) consistent in the application across all toothfish stocks, including the stock in Subarea 48.3

(ii) in accord with the precautionary approach and CCAMLR's objectives under Article II

(iii) appropriate for the robust management of CCAMLR's toothfish stocks, given the wide range of stock and fishery characteristics across the CAMLR Convention Area.

3.39 Given the lack of agreement by the Working Group that the CCAMLR management of all of its fish stocks is precautionary, the Working Group noted it had been unable to provide consensus catch advice for all assessed stocks and research proposals associated with them. However, for all assessed stocks, the Working Group provided advice based on the use of best available science in the assessments on what catch level would be consistent with the CCAMLR decision rules.

3.40 The Working Group requested that the Scientific Committee consider precautionary catch limits for all the assessed stocks and research proposals associated with them so that advice to the Commission can be provided on the basis of the best available science. The Working Group also requested that the Scientific Committee consider how WG-FSA can provide advice on precautionary catch limits in the future.

3.41 In response to the nature of some of the discussions during the meeting, the Working Group recalled some of the principles set out in Article IX of the CAMLR Convention, as well as Resolution 31/XXVIII, particularly:

(i) the function of the Commission shall be to give effect to the objective and principles set out in Article II of this Convention. To this end, it shall formulate, adopt and revise conservation measures on the basis of the best scientific evidence available

(ii) Members work together to ensure that scientific information is adequately collected, reviewed and applied in a transparent fashion in accordance with sound scientific principles

(iii) the role of the Scientific Committee and its working groups is to promote rigorous science-based discussions. In particular, to ensure the participation of scientists with suitable scientific qualifications or experience at meetings of the Scientific Committee and its working groups.

Verification of CASAL runs

3.42 The Secretariat routinely verifies that stock assessments submitted to WG-FSA using CASAL (Table 4) are reproducible by a verification process performed in three steps:

(i) CASAL version: all assessments are requested to use the same version of CASAL. For WG-FSA-2019 all assessments used CASAL v2.30-2012-03-21 rev.4648

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

(iii) MPD (maximum posterior density) estimate verification: the 'B_0' estimate produced by a given model run is compared to that reported in the accompanying meeting paper.

3.43 Verifications of the MPDs were performed for the CASAL assessments submitted to WG-FSA in 2019 and indicated that all verifications produced the same MPDs as supplied (Table 5).

Whale depredation

3.44 WG-FSA-2019/33 presented estimates of *D. eleginoides* catches removed by killer whales and sperm whales when depredating on longlines in four CCAMLR areas (Subareas 58.6 and 58.7 and Divisions 58.5.1 and 58.5.2) and two fisheries outside the CCAMLR area in Chile and the southwest Atlantic. Using generalised additive models (GAMs) fitted to the catch-per-unit-effort (CPUE) data, the results indicated that: (i) whales removed a total of 6 699 tonnes (3 839–9 559 tonnes) of toothfish, equivalent to around 10% of the total catches over the 2009–2016 period and (ii) these removals greatly varied between fisheries, with the largest reported for Subarea 58.6 with 30% and the lowest for Division 58.5.2 with only 0.2% of the total catch.

3.45 The Working Group noted that the findings in WG-FSA-2019/33 provided standardised metrics to assess the economic and ecological implications of depredation, both locally and globally across *D. eleginoides* fisheries. The Working Group noted that this study can provide estimates of catch removals from whale depredation where these have not been available previously and recommended that estimated toothfish removals by whales be included in stock assessments.

3.46 The Working Group noted that the whale depredation risk varies strongly across the Convention Area, and that risk area maps could be created, similar to seabird mortality risk area maps, to improve the understanding of the whale depredation dynamics. However, the Working Group also noted that there is large variation within an area which seems to be related to particular vessels being targeted more by whales than others.

3.47 The Working Group noted that using GAMs as opposed to generalised linear models (GLMs) for estimating whale depredation allows to incorporate non-linear relationships such as the interaction location, and that including the number of whales depredating can improve the accuracy of the catch removals due to the high whale per-capita impact.

3.48 The Working Group noted that toothfish are part of the natural diet of sperm whales and it is unclear whether and how catch removals would modify the natural predation pressures of whales on toothfish.

Dissostichus eleginoides in Subarea 48.3

3.49 The fishery for *D. eleginoides* in Subarea 48.3 operated in accordance with CM 41-02 and associated measures. In 2018/19, the catch limit for *D. eleginoides* was 2 600 tonnes and the total reported removal was 2 172 tonnes. Fishing in the current season finished on 30 September 2019 (www.ccamlr.org/node/75667).

3.50 Dr Kasatkina introduced WG-FSA-2019/40, submitted by Russia, which reviewed multi-year variability in biological parameters in catches from the beginning of the longline fishery (1985–1990) for *D. eleginoides* in Subarea 48.3. Based on analysis of available publications and CCAMLR documents, the paper noted a decrease in the length and weight of females and males at first maturity, and a reduced number of large spawning fish which indicated a change in the length structure of the spawning part of *D. eleginoides* population in Subarea 48.3. The paper noted that for the *D. eleginoides* population, which is characterised by a very long lifespan, the recruitment group is the most vulnerable component. Therefore, a change in the rate and terms of sexual maturity of males and females and their entry into the spawning process, and a change in the length composition of fish in the catches, can be considered as signs of fishing impact on the population. The paper also noted that currently in Subarea 48.3 an excessively large number of immature and maturing *D. eleginoides* (recruitment group), which are undergoing intensive weight increases, are being caught.

3.51 The paper also noted that according to the analysis, a reduction of the catch limit will, as before, be taken mainly from immature juveniles. Currently, the *D. eleginoides* population in Subarea 48.3, which has been fished for more than 40 years, including more than 30 years by longlines, requires protection via the imposition of restrictions on fishing and changes to conservation measures, because the use of *D. eleginoides* resource in the Convention Area does not ensure its rational use. The paper proposed to:

(i) define the catch limit for *D. eleginoides* in Subarea 48.3 for the 2019/20 season as 0 tonnes

(ii) close the fishery in Subarea 48.3 from 2020

(iii) revise the precautionary approach to the use of the *D. eleginoides* stock in the Convention Area (Subarea 48.3) because the current approach does not ensure the rational use of this living resource.

3.52 The Working Group noted that the data and analyses presented in this paper (WG-FSA-2019/40 and SC-CAMLR-XXXVII/BG/25) were identical to those in WG-FSA-18/02 and recalled the discussion at WG-FSA (WG-FSA-2018 report, paragraphs 3.16 to 3.20) and the

Scientific Committee in 2018 (SC-CAMLR-XXXVII, paragraphs 3.64 to 3.71). Specifically, the Working Group recalled the advice from the Scientific Committee that the exclusive use of raw catch length distribution data to make assumptions about the state of the stock, in isolation from other information, was not an appropriate approach for determining the general status of a stock.

3.53 Dr Kasatkina repeated that WG-FSA-2019/40 reviewed analyses of multi-year variability in biological parameters in catches from 1985 to 2017 using Fishery Reports and other CCAMLR papers, as well as publications in peer-reviewed journals. She noted that papers by UK scientists are widely represented in the list of references, which includes 104 titles (SC-CAMLR-XXXVII/BG/25).

3.54 Dr Darby noted that the paper by Brigden et al., 2017 on Subarea 48.3 has made the same mistake in basing its conclusions on raw data.

3.55 The Working Group recalled WG-SAM-2019/32 which had provided an analysis of the complete time series of CCAMLR data to evaluate changes in the biological productivity parameters in Subarea 48.3, particularly whether the proportion of females in the catch, maturity at length and age, length–weight relationships and growth rates have changed through time and vary over depth.

3.56 WG-SAM (WG-SAM-2019 report, paragraphs 3.12 to 3.19) had noted variation through time in the Subarea 48.3 sex ratio, maturity, growth and length–weight parameter estimates, but no systematic trends. When the effects of confounding factors, such as depth, were included in the analysis, WG-SAM-2019 had agreed that there was no indication of systematic change that would indicate potential impacts from external influences such as the fishery or climate change. WG-SAM-2019 therefore considered that the current stock assessment was robust to the variation in growth and maturity parameters.

3.57 The Working Group noted that WG-FSA-2019/40 did not take into account the findings from WG-SAM-2019/32 and the relevant discussion at WG-SAM (WG-SAM-2019 report, paragraphs 3.12 to 3.19). The Working Group conducted a review of the catch-weighted mean length and the proportion of immature fish in the catch and noted that there were no changes through time that would indicate stock depletion (paragraphs 3.22 to 3.31).

3.58 The Working Group recalled discussions at WG-FSA (WG-FSA-2016 report, paragraph 3.91) which highlighted the importance of the scientific process of developing and evaluating hypotheses. The Working Group noted that where new evidence is presented, this needs to be accounted for in subsequent research.

3.59 The Working Group noted that the revised Fishery Reports, including catch-weighted standardised length distributions, could provide a valuable source of information as to where changes in management practices had occurred which would impact how data are collected.

3.60 WG-FSA-2019/28 presented an updated assessment for *D. eleginoides* in Subarea 48.3. The assessment indicated that spawning biomass has been relatively constant in recent years and that the current status of the stock was at 50% of B_0. Projections indicate that a constant catch of 2 420 tonnes in the 2020/21 and 2021/22 seasons would be consistent with the CCAMLR decision rules.

3.61 The Working Group recommended further work on:

(i) understanding the declining trend in the MPD values of spawning stock biomass prior to fishing (SSB_0) from the time series of cohorts of tagged fish in the likelihood profiles

(ii) conducting model sensitivity analyses excluding data from the trawl survey to evaluate whether the survey provides useful information on stock abundance.

3.62 The Working Group, having not reached consensus on advice on the catch limit, noted that a catch of 2 420 tonnes in 2020/21 and 2021/22 based on the outcomes of this assessment was consistent with the precautionary yield estimated using the CCAMLR decision rules and the management procedure as applied in previous years.

3.63 Dr Kasatkina made the following statement:

*'There is the need to exclude the possibility of a misunderstanding of her position regarding the management of Patagonian toothfish (*Dissostichus eleginoides*) resources in Subarea 48.3. This position was stated in the paper WG-FSA-2019/40 and the correspondent presentation. Currently, the Patagonian toothfish population in the South Georgia area requires protection via the imposition of restrictions on fishing and changes to conservation measures. Any catch limit here will be taken mainly from immature juveniles. Therefore, it is proposed to close the fishery in Subarea 48.3 from 2020. The paper WG-FSA-2019/28 could not influence her position.*

Setting the catch limit for Subarea 48.3 could not be supported for the next fishing season (2019/20) as there is no consensus regarding the continuation of fishing in Subarea 48.3 for next season.'

3.64 Dr Kasatkina noted that the purpose of the CCAMLR Independent Stock Assessment Review for Toothfish was to provide advice to the Scientific Committee and its working groups on the adequacy of the modelling approaches and methods used in CCAMLR's integrated toothfish stock assessments relative to international best practices, and to suggest recommendation regarding: (i) improvements to modelling; (ii) improvements to data; and (iii) the utility of alternative models and structures that could be explored. Conclusions on the stock status and population characteristics of toothfish in Subarea 48.3 were not provided (SC-CAMLR-XXXVII/02 Rev. 1).

3.65 All other participants noted that the statement by Dr Kasatkina did not provide any scientific evidence why immature fish in catches constituted a reason to close a fishery, as almost all of the other toothfish fisheries across the Convention Area have similar proportions of immature fish in their catches. They also noted that this position was in contradiction of recommendations from the CCAMLR Independent Stock Assessment Review for Toothfish and SC-CAMLR-XXXVII (SC-CAMLR-XXXVII, paragraphs 3.52 to 3.56), that CCAMLR's stock assessment approach was appropriate for the management of its toothfish stocks and that CCAMLR applies assumptions in the stock assessments in a precautionary manner and consistent with Article II.

3.66 Dr Darby recalled that the Independent Review Panel review was presented with all input data, results and historic advice for the assessed stocks, to enable it to respond to its terms of reference, which included inferences on stock status (SC-CAMLR-XXXVII/02 Rev. 1, Appendix 3, term of reference 1ii). Therefore, stock status and population data were included within the Independent Review Panel's conclusion that the assessment approach for all of the CCAMLR stocks was consistent with Article II.

3.67 The Working Group noted that around 40% of fish in *D. eleginoides* catches in Subarea 48.3 were immature and that all toothfish fisheries in CCAMLR contain a substantial proportion of immature fish in their catches (paragraphs 3.22 to 3.31).

3.68 The Working Group also noted that statements and proposals needed to have scientific justification, and that scientific papers should be evaluated on the basis of their scientific merit and evidence.

Dissostichus spp. in Subarea 48.4

3.69 The fishery for *D. eleginoides* in Subarea 48.4 operated in accordance with CM 41-03 and associated measures. The catch limit for *D. eleginoides* in Subarea 48.4 in 2018/19 was 26 tonnes and 17 tonnes were taken (www.ccamlr.org/node/75667).

3.70 WG-FSA-2019/29 presented an updated CASAL assessment model for *D. eleginoides* in Subarea 48.4. The assessment data were updated with observations for the 2017/18 season and the data-weighting method revised to be consistent with those applied in other CCAMLR assessment models. The model estimated that the stock was at 67% of B_0 in 2018/19 and that a yield of 27 tonnes in 2019/20 and 2020/21 was consistent with the application of the CCAMLR decision rules.

3.71 The Working Group noted that the growth function, which was fitted within the stock assessment model, fitted poorly to young fish and recommended the evaluation of alternative growth models in future assessments for Subarea 48.4.

3.72 The Working Group recalled that the population of *D. eleginoides* in Subarea 48.4 was most likely connected to that in Subarea 48.3, with currently over 40 tagged fish released in Subarea 48.4 and recaptured in Subarea 48.3, and one tagged fish having moved in the opposite direction and recaptured in Subarea 48.4. The Working Group noted that further research into population connectivity was underway, including genetic and otolith microchemistry research and an evaluation of a spatial stock assessment model covering both subareas. The Working Group agreed that managing the stocks in the adjacent subareas as separate entities was precautionary while this research is progressing.

3.73 The Working Group noted that a catch limit of 27 tonnes for *D. eleginoides* in Subarea 48.4 for 2019/20 and 2020/21 is consistent with CCAMLR decision rules based on the results of this assessment. The Working Group noted it had been unable to provide consensus advice on catch limits (see paragraph 3.39), however, it had provided advice based on the use of best available science in the assessments on what catch level would be consistent with the CCAMLR decision rules.

3.74 The fishery for *D. mawsoni* in Subarea 48.4 operated in accordance with CM 41-03 and associated measures. The catch limit for *D. mawsoni* in Subarea 48.4 in 2018/19 was 37 tonnes of which 33 tonnes were taken in the fishery (www.ccamlr.org/node/75667).

3.75 WG-FSA-2019/27 presented a Chapman biomass estimate for *D. mawsoni* in Subarea 48.4 from tagging returns. Using estimates from all years since 2010, the average biomass was estimated at 1 109 tonnes, while for the last five years (2015–2019) the average biomass was 1 187 tonnes. Applying a harvest rate of $\gamma = 0.038$ and using the five-year average biomass estimate resulted in a yield of 45 tonnes.

3.76 The Working Group noted that, historically, *D. mawsoni* in Subarea 48.4 has been treated as a separate stock. Based on the biological characteristics of the catches in Subarea 48.4 and the surrounding regions, *D. mawsoni* around the southern South Sandwich Islands are now hypothesised to be part of a larger stock that extends south into Subareas 48.2, 48.6 and possibly 48.5. The Working Group considered that the current tag-based method of assessment provides a precautionary approach to estimating the local biomass.

3.77 The Working Group noted that using the average biomass estimate from the last five years, to smooth the individual year estimates was an appropriate approach to providing robust advice.

3.78 The Working Group noted that the results of this assessment indicated that a catch limit of 45 tonnes for *D. mawsoni* in Subarea 48.4 for 2019/20 would be consistent with CCAMLR's management approach for this fishery. The Working Group noted it had been unable to provide consensus advice on catch limits (see paragraph 3.39), however, it had provided advice based on the use of best available science in the assessments on what catch level would be consistent with the CCAMLR decision rules.

D. eleginoides in Division 58.5.1

3.79 The fishery for *D. eleginoides* in Division 58.5.1 is conducted in the French exclusive economic zone (EEZ). Details of the fishery and the stock assessment are contained in the Fishery Report (www.ccamlr.org/node/75667).

3.80 The Working Group noted the development of two integrated CASAL assessment models (WG-FSA-2019/58), including updated data (up to August 2019), growth parameters and year-class strength (YCS) priors and estimation period. The reference assessment model (M1) estimated virgin spawning stock biomass, B_0, at 206 200 tonnes (95% confidence interval (CI): 194 130–218 380 tonnes), with the biomass in 2019 at 124 940 tonnes (95% CI: 112 910–136 490 tonnes) for the model with revised growth and YCS fixed at 1 (constant recruitment). Estimated spawning stock biomass (SSB) status in 2019 was 61% (95% CI: 57–65%).

3.81 The Working Group noted that model 2 which estimates YCS trends (i.e. recruitment) was in development. It also noted that YCS was below average in recent years and encouraged the authors to investigate this trend. Further, the Working Group noted that the parameters for the maturity ogive assumed in the model should be investigated. The current maturity ogive assumed that fish began to mature at about age 1, with 50% maturity at age 8 and full maturity not occurring before age 17. The Working Group recommended considering the stage, location and timing of the spawning season be considered when estimating the maturity ogive.

3.82 The Working Group welcomed the intention by the authors to implement a project to increase the number of otolith readings and recommended to read the otoliths of five individuals per 1 cm bin for every year when data is available. It also noted the importance of the readings of historical otoliths to improve the understanding of the stock recruitment. The Working Group also welcomed the upcoming POKER survey scheduled for 2021 to track juvenile abundance and suggested that the possibility to locally track the juvenile abundance every year was to be considered. These would improve the YCS and recruitment estimations which are critical parameters in the model.

3.83 The Working Group agreed that the catch limit set by France of 5 200 tonnes for 2019/20 that accounts for depredation was consistent with the CCAMLR decision rules for the model runs presented.

Management advice

3.84 No new information was available on the state of fish stocks in Division 58.5.1 outside areas of national jurisdiction. The Working Group, therefore, recommended that the prohibition of directed fishing for *D. eleginoides*, described in CM 32-02, remain in force in 2019/20.

D. eleginoides in Division 58.5.2

3.85 The fishery for *D. eleginoides* in Division 58.5.2 operated in accordance with CM 41-08 and associated measures. Details of the fishery and the stock assessment are contained in the Fishery Report (www.ccamlr.org/node/75667).

3.86 The updated stock assessment was presented in WG-FSA-2019/32. The assessment included updated observation data, estimated mortality from lost longlines, updated growth parameters, length–weight estimates and maturity estimates, and a simplified longline selectivity shape. The updated assessment model estimated virgin spawning stock biomass, B_0, at 70 519 tonnes (95% CI: 65 635–76 626 tonnes), with the estimated SSB status in 2019 of 0.51 (95% CI: 0.49–0.53).

3.87 The Working Group noted that the stock trajectory for *D. eleginoides* in Division 58.5.2 was expected to decline below 50% B_0 as a result of weak year classes in recent years and the effect of the historical switch from trawl fishing on younger fish to longline fishing on the same cohorts when older in the area.

3.88 The Working Group noted that the assumption of average recruitment in the future would allow the stock to rebuild to 50% B_0 at the end of the 35-year projection period. However, the estimated YCS has been below average since 1998. Scenarios that assumed future recruitment patterns similar to the average YCS estimated for the period after 1990 would result in the stock failing to rebuild to 50% of B_0 over the 35-year projection period.

3.89 The Working Group noted that the estimated stock status at the time of the next assessment in 2021, irrespective of the assumption of future YCS, was expected to be about 46% of B_0. While the Working Group noted that fluctuations around the target of 50% B_0 would be expected for stocks near or at the target levels (paragraph 3.19), it expressed concern that the stock may continue to decline if below-average YCS continued and were not accounted for in future assessments.

3.90 The Working Group recommended an update on stock parameters, including recruitment indices from the trawl survey, and age-frequency data and tag-recapture data from the fishery be presented in 2020 to evaluate whether recruitment and the stock trajectory were consistent with those estimated by this assessment.

3.91 The Working Group requested that the Scientific Committee task WG-SAM with developing advice on alternative harvest strategies that may provide a more precautionary approach for stocks that fluctuate around, or are below, the target level, and for stocks where recent patterns of weak year classes were apparent in the fishery.

Management advice

3.92 The Working Group noted that a catch limit for *D. eleginoides* in Division 58.5.2, set at 3 030 tonnes for 2019/20 and 2020/21 based on the outcome of this assessment, would be consistent with the precautionary yield estimated using the CCAMLR decision rules and the process for setting catch limits used in previous years. The Working Group noted it had been unable to provide consensus advice on catch limits (see paragraph 3.39), however, it had provided advice based on the use of best available science in the assessments on what catch level would be consistent with the CCAMLR decision rules.

3.93 No new information was available on the state of fish stocks in Division 58.5.2 outside areas of national jurisdiction. The Working Group, therefore, recommended that the prohibition of directed fishing for *D. eleginoides*, described in CM 32-02, remain in force in 2019/20.

D. eleginoides in Subarea 58.6

3.94 The fishery for *D. eleginoides* at Crozet Islands is conducted within the French EEZ and includes parts of Subarea 58.6 and Area 51 outside the Convention Area. Details of this fishery and the stock assessment are contained in the Fishery Report (www.ccamlr.org/node/75667).

3.95 WG-FSA-2019/57 Rev. 1 presented an updated stock assessment of *D. eleginoides* at Crozet Islands (Subarea 58.6 inside the French EEZ). The assessment model included updated data (up to August 2019), revised growth curves and catches taken on the Del Cano Rise from outside the Convention Area from 2003 to 2019 (including depredation at the same level as in the Crozet EEZ, model M3).

3.96 The Working Group noted that B_0 was estimated at 54 610 tonnes (95% CI: 48 560–60 880 tonnes), with the stock status in 2019 at 63% (95% CI: 58.2–66.6%) when considering model M3.

3.97 The Working Group noted that the catch composition of the fishery in the model used length observations and recommended that the authors investigate the use of age composition data instead. The Working Group, therefore, suggested to increase the number of otolith readings to five individuals per 1 cm bin for every year when data is available and noted the importance of the readings of historical otoliths to improve the understanding of the YCS estimates.

3.98 The Working Group agreed that the catch limit set by France of 800 tonnes in 2019/20, which accounts for depredation, was consistent with the CCAMLR decision rules for the model runs presented.

Management advice

3.99 No new information was available on the state of fish stocks in Subarea 58.6 outside areas of national jurisdiction. The Working Group, therefore, recommended that the prohibition of directed fishing for *D. eleginoides*, described in CM 32-02, remain in force in 2019/20.

D. mawsoni in the Ross Sea region

3.100 The exploratory fishery for *Dissostichus* spp. in Subarea 88.1 operated in accordance with CM 41-09 and associated measures. In 2018/19, the catch limit for *Dissostichus* spp. was 3 157 tonnes, including 65 tonnes set aside for the Ross Sea shelf survey. Fishing was conducted by 19 longline vessels and the total reported catch was 2 988 tonnes. Details of this fishery and the stock assessment are contained in the Fishery Report (www.ccamlr.org/node/75667).

3.101 WG-FSA-2019/07 presented an updated characterisation of the Ross Sea region fishery, including data from the 2018/19 season. The Working Group noted that the establishment of the Ross Sea region marine protected area (RSRMPA) has led to some redistribution of fishing effort. In 2019, the fishing effort was concentrated on the slope south of 70°S and the tag-recapture rate was increased. The Working Group noted the previous work anticipating the impact of the establishment of the MPA on the assessment of the stock (WG-SAM-17/41) and encouraged further work to develop statistics to assess the spatial overlap of fishing effort between years for this and other fisheries.

3.102 An update of the biological parameters used as input to the CASAL model was presented in WG-FSA-2019/11. Re-estimated growth and length–weight parameters were similar to previous estimates. An alternative, non-parametric, growth function fitted the data slightly better. Model sensitivity runs showed that the revision of growth parameters or non-parametric estimates made very little difference to the overall assessment of the stock. The Working Group encouraged further development of the non-parametric growth model.

3.103 The Working Group noted that the redistribution of effort combined with the variability of growth within the Ross Sea region may lead to bias in the estimation of growth and length–weight parameters. The Working Group noted the large amount of data (18 000 otoliths and over 570 000 measurements) available in the Ross Sea region and recommended that further analysis to quantify any differences in growth between areas be carried out, and the implications of any differences for management advice be considered.

3.104 An updated assessment model for *D. mawsoni* in the Ross Sea region was presented in WG-FSA-2019/08, with diagnostics in WG-FSA-2019/10 and a draft Stock Annex in WG-FSA-2019/09. The assessment used catch, catch-at-age and tag-recapture data from 1998 to 2019 and included the results from the Ross Sea shelf survey from 2012 to 2019. The estimate of B_0 of 71 730 tonnes was within 2% of the estimate in 2017. The Working Group noted that the comparison with previous assessments shows a consistent trend and estimate of B_0, with uncertainty decreasing as additional data was added. The Working Group noted that the model estimates of uncertainty are likely to be an underestimate of the total uncertainty about the stock size.

3.105 The Working Group noted that data from Members catching toothfish within the South Pacific Regional Fisheries Management Organisation (SPRFMO) area adjacent to the Ross Sea region was reported to SPRFMO using the CCAMLR data reporting forms, and also voluntarily submitted to CCAMLR by those Members. The Working Group recommended that this data continue to be included in assessments where appropriate, as described in WG-SAM-17/41.

3.106 The Working Group noted that catch data from some Ukrainian vessels fishing in the Ross Sea region had discrepancies between the C2 and CDS data (CCAMLR-38/BG/11) in 2015–2018, which had led to the data being quarantined (paragraph 2.15). The Working Group noted that the catch was a relatively small proportion of the overall catch included in the model for those years and inferred that the impact on the assessment of the stock would be small. The Working Group recommended that the effect of excluding this data on the assessment be investigated by performing a sensitivity analysis, for consideration by a future meeting of WG-SAM.

3.107 The Working Group welcomed the progress made by those developing integrated assessments towards the recommendations of the Independent Stock Assessment review. The Working Group's assessment of the progress towards these recommendations is detailed in Table 3.

Management advice

3.108 The Working Group recommended that the catch limit be set at 45 tonnes for the 2019/20 survey and 65 tonnes for the 2020/21 survey.

3.109 The Working Group recommended that following the procedure outlined in CM 91-05, the catch limit for the Ross Sea region (Subarea 88.1 and SSRUs 882A–B) in the 2019/20 and 2020/21 seasons be 3 140 tonnes (see Table 6 for potential catch allocation methods between management areas). The Working Group noted it had been unable to provide consensus advice on catch limits (see paragraph 3.39), however, it had provided advice based on the use of best available science in the assessments on what catch level would be consistent with the CCAMLR decision rules.

Research to inform current or future assessments in data-limited fisheries notified under Conservation Measures 21-01, 21-02 and 24-01

Trend analysis and proposed catch limits

4.1 The Secretariat updated the estimates of local biomass with uncertainty for *D. mawsoni* and *D. eleginoides* in research blocks in Subareas 48.6, 58.4, 88.2 and 88.3 as agreed by the Scientific Committee (WG-SAM-2016 report, paragraph 2.28) and the decision rules process using the trend analysis (WG-FSA-2018 report, Figure 4). Data quarantined according to the recommendation in paragraph 2.15 were not included in the process.

4.2 Estimates of local biomass presented in Table 7 used the updated vulnerable biomass estimates from the 2019 assessments in Division 58.5.2 (WG-FSA-2019/32) of 32 917 tonnes (CV 0.0308) and the Ross Sea region (WG-FSA-2019/08) of 84 658 tonnes (CV 0.0612). The estimate of fishable seabed area in the area open to fishing in the Ross Sea region is now 90 968.0 km^2 following the changes introduced with the coming into force of the RSRMPA.

4.3 The Working Group noted it had been unable to provide consensus advice on catch limits (see paragraph 3.39), however, it had provided advice based on the use of best available science in the assessments on what catch level would be consistent with the CCAMLR decision rules. It further noted that the catch limits included in Table 7 were developed using the same procedure as used last year, which has in the past been considered to follow a consistent approach and provide precautionary catch limits.

Conversion factors

4.4 CCAMLR-38/02 provided recommendations for developing guidelines for conversion factors. It recommended that a focus topic be undertaken at WG-FSA in 2020 to develop guidelines for standardising the methodology for calculating conversion factors in new and exploratory toothfish fisheries, and that these guidelines serve as 'best practice' for the calculation of toothfish conversion factors in these toothfish fisheries. These guidelines can be progressed during the intersessional period in advance of WG-FSA.

4.5 The Working Group agreed that such a focus topic or workshop would be very beneficial and should also aim to evaluate uncertainty associated with conversion factors. It was also noted that input or participation from fishing industry representatives would be valuable. Further, it was noted that this topic could potentially be an agenda item during WG-SAM.

4.6 It was noted that there are a variety of ways conversion factors are developed and utilised, including where some Members are provided with a conversion factor prior to going fishing, whereas others develop theirs during fishing operations.

4.7 The Working Group requested that the Scientific Committee note that holding a conversion factor workshop, or focus topic, during the coming intersessional period would be of great benefit to the work of WG-FSA.

4.8 The Working Group requested that the Secretariat survey Members to understand how toothfish conversion factors provided in all C forms are calculated and applied and present this to the workshop or focus topic. This review should include how the value is estimated and how it is provided to CCAMLR for all toothfish fisheries.

Stock identification, population structure, and connectivity

4.9 WG-FSA-2019/59 described a morphological analysis of *D. mawsoni* sagittal otoliths using a Fourier analysis to explore the feasibility of using otolith morphology to discriminate between stocks from Subareas 48.1, 48.6 and 88.1. The paper concluded that this method did not detect significant differences between regions, and further noted that otolith shapes alone can vary substantially even within the same research block. The authors recommended evaluating other techniques, such as otolith elemental signature and genetics to investigate stock structure for this species.

4.10 The Working Group agreed that, although stock discrimination was not detected in this case, it was nonetheless a valuable and useful study and thanked the authors for their efforts. It was suggested that there may be other approaches with different underlying properties that may be valuable to explore, both in relation to the statistical algorithms for stock identification and morphological analysis of otoliths. It was also noted that otolith morphology may change with age and that this could be a factor in future analysis.

4.11 The Working Group agreed that these types of studies should be further explored, particularly in combination with other datasets drawn from, for example, otolith chemistry or genetic samples.

4.12 WG-FSA-2019/61 provided a report on international collaborative research on otolith microchemistry of *D. mawsoni* otoliths in the Southern Ocean. Results indicate heterogeneity in stock structure of *D. mawsoni* between Subareas 48.6 and 88.1. The authors encouraged additional collection of otoliths from Subareas 48.4, 48.5 and 88.3 and Divisions 58.4.1, 58.4.2 and 58.4.3 and the SPRFMO area toward future research with this collaborative project.

4.13 The Working Group agreed that this work was valuable, and encouraged that this work continue and that additional samples be collected from other regions where there is little material. It further encouraged that oceanographic and physical data be collected in conjunction with these samples for potential use in future analyses. The Working Group noted that, based on the previous collaboration (WG-FSA-2018 report, paragraph 4.80), this collaborative project was already extended to Japan, Ukraine and the USA, and will be further extended to Australia, Russia, Spain and the UK.

4.14 WG-FSA-2019/P01 presented the results of a study on genetic stock connectivity of *D. mawsoni*. Samples were collected from Subareas 48.2, 48.4, 48.6, 88.1, 88.2 and 88.3 and Divisions 58.4.1, 58.4.2 and 58.5.2, as well as the SPRFMO area north of Subarea 88.1. The authors noted that this is the largest *D. mawsoni* genetics study to date in terms of sample size, and single nucleotide polymorphism markers and sampling locations. The study indicates that there is no genetic stock structure between management areas, likely due to the distribution of eggs and larvae by the Antarctic Circumpolar Current (ACC). Despite this, the lack of genetic division of stocks does not preclude the presence of local biological stocks in the Southern Ocean. It was noted that the overall quantity of DNA was higher in extractions from fin clips than from muscle tissue.

4.15 The authors of WG-FSA-2019/P01 recommended that: (i) a framework similar to the CCAMLR decision rules should be considered by management bodies outside the CCAMLR area to ensure sustainability due to potential stock linkages, (ii) spawning models should be updated to account for all the new information obtained since 2012, (iii) the inability to define stock boundaries from genetics alone limits the ability for close-kin mark recapture, and (iv) genetics are not a silver bullet for *D. mawsoni* and likely will need to be combined with something like stable isotopes for assigning IUU catch back to location.

4.16 The Working Group noted that there are likely both retention and dispersion processes that influence stock connectivity and agreed that it would be useful to combine this genetic approach with other information from tagging, otolith microchemistry and oceanographic models.

4.17 WG-FSA-2019/36 provided a report on research activities to define population structure of *D. mawsoni*, using samples from 11 geographic localities from Areas 58 and 88, and based on mitochondrial and microsatellite DNA markers. Specific objectives included a genetic diversity assessment and stock identification, and an analysis of phylogenetic relationships. The results indicate low levels of Mitochondrial DNA (mtDNA) diversity; that there was significantly higher mtDNA diversity in Area 58 than Area 88; and higher levels of polymorphism in microsatellites than in mtDNA. It was also noted that the Area 88 region likely represents a 'single' genetic stock, that the highest migration rates were observed from other populations to research block 883_4, and that there were no distinct clades or lineages detected.

4.18 The Working Group noted that the results described in WG-FSA-2019/36 were largely consistent with WG-FSA-2019/P01, and it was noted that it was common in such studies to see a reduction in discrimination between stocks as sample sizes increased where there is genetic mixing.

4.19 It was also noted that evidence in relation to migrations and variations within Subarea 88.3 was supported by population hypotheses for *D. mawsoni* in Area 48 developed during the Workshop for the Development of a *Dissostichus mawsoni* Population Hypothesis for Area 48 (WS-DmPH-18) (WG-SAM-18/33).

4.20 The Working Group agreed that the research presented in WG-FSA-2019/36 was valuable and suggested that further studies should be undertaken including areas that had relatively low sample sizes, and would benefit from increased collaboration with similar research activities such as those described in WG-FSA-2019/P01.

Vessel tagging survey

4.21 WG-FSA-2019/15 Rev. 1 provided a report on the implementation of the Scheme of International Scientific Observation (SISO) during 2018/19 that includes a summary of a survey undertaken by the Secretariat on tagging procedures. The primary themes in relation to tagging were equipment and operation, landing and handling fish, and personnel and training.

4.22 The Working Group noted the variable nature of tagging operations across the fishing fleet, and that 12 of the 17 vessels who responded to the survey rely on observers for all tagging duties, with no crew trained in procedures. It was further noted that only 75% of the fleet considered tagging to be a Flag State responsibility.

4.23 The Working Group noted the relatively low rate of survey participation by vessels. It noted that it would be useful to review who replied to the survey in relation to tagging data quality, as this could provide more information as to which data series should get more weighting, which in turn would improve stock assessments.

4.24 The Working Group noted that there had been previous recommendations endorsed by WG-SAM, WG-FSA and the Scientific Committee to have a workshop focused on tagging protocols and procedures (WG-SAM-2018 report, paragraph 5.8; WG-FSA-2018 report, paragraph 7.4; SC-CAMLR-XXXVII, paragraphs 2.6 and 2.7). The Working Group requested that the Scientific Committee note the benefit of such a workshop being held in the 2019/20 intersessional period and take this into consideration in developing its work plans.

4.25 The Working Group requested that the Scientific Committee engage with COLTO to explore hosting such a workshop during the upcoming intersessional period. Such a workshop should include scientists, vessel operators, scientific observers and other stakeholders, and should work toward developing a series of best-practice protocols and guidelines for tagging toothfish that could be applied across the fishing fleets in the Convention Area.

Process for reviewing research proposals

Table for evaluating research proposals

4.26 WG-FSA-2019/55 provided a proposal for a revised summary table to be used for the assessment of new and ongoing research plans. The Working Group noted that during WG-SAM-2019, the Conveners of WG-SAM and WG-FSA were requested to simplify language and reduce ambiguity of this table.

4.27 The Working Group agreed that the revised table in WG-FSA-2019/55 was a substantial improvement over the previous version used by WG-SAM and WG-FSA. A number of additional suggestions were made to further refine the table, including elements pertaining to research objectives and capabilities. The final table design was endorsed and used to assess proposals for research notifications in accordance with CM 24-01 (Tables 8 to 10).

4.28 The Working Group noted the large amount of time spent at both WG-SAM and WG-FSA assessing research plans, limiting the ability to focus on other areas of research. The Working Group recommended that proponents provide a self-assessment of their research plan prior to the start of the meetings. This would involve answering the questions shown in Tables 8 to 10 with an additional column providing specific reference to the sections in the research plan which addresses the question being asked. The self-assessments would provide the working groups with a guide for assessing if the research plans are consistent with CCAMLR's objectives.

Fishery status and the regulatory framework

4.29 WG-FSA-2019/66 provided recommendations to reduce confusion and better align toothfish fishery status with the CCAMLR regulatory framework. The framework designates five different types of toothfish fisheries: new, exploratory, established, lapsed and closed. The current status of toothfish fisheries has become increasingly disconnected in some fisheries throughout the Convention Area. The paper proposed that a suite of characteristics be developed to better align toothfish fisheries with the regulatory framework, and that these characteristics be used as triggers for assigning or reassigning fishery status based on their stage of development.

4.30 The Working Group agreed that the current designation of toothfish fishery status causes confusion for WG-FSA. It noted that CCAMLR's regulatory framework as applied to fishery status designations is not explicitly documented in one location, but is instead referred to throughout various Scientific Committee and Commission reports and discussions across many years.

4.31 The Working Group noted the potential triggers set out in WG-FSA-2019/66, and that these triggers would be useful to further develop and refine, given the nature of the regulatory framework.

4.32 In light of these discussions, the Working Group recommended that the Scientific Committee consider:

(i) Subarea 88.1 and SSRUs 882A–B (Ross Sea region toothfish fishery): Remove the term 'exploratory' in CM 41-09, but retain all elements required by Members to participate in the fishery in the conservation measure.

(ii) Division 58.4.4: This toothfish fishery, currently closed in accordance with CM 32-02, be reclassified as an exploratory fishery in accordance with CM 21-02, with a new CM 41-XX established for this exploratory fishery.

(iii) Division 58.4.3b: Change the current status of the exploratory toothfish fishery as set out in CM 41-07 to a status of 'lapsed'.

(iv) In relation to (iii), it was recommended that the Scientific Committee consider any toothfish fisheries that have had no fishing or research activities for 3–5 years classified as a lapsed fishery.

4.33 The Working Group agreed that it would benefit from a clear strategy from the Commission as to how the regulatory framework can be interpreted in order to better define the status of a toothfish fishery at its current stage of development and requested the Scientific Committee consider how to progress this. Such a strategy would assist the Working Group in developing scientific advice for toothfish fisheries.

Map data

4.34 The Working Group recalled previous discussions on maps provided in research plans (WG-FSA-2017 report, paragraph 4.13), regarding the use of a standard map projection as specified within the CCAMLR GIS, or providing the projection used in the map. Additionally, the Working Group recommended that maps within papers provide references for data layers used (e.g. bathymetry). This would allow the re-creation and analysis of maps/research design within the Working Group, should that be required.

Management area research reviews and management advice

Dissostichus spp. in Area 48

Subarea 48.1

4.35 WG-FSA-2019/17 presented a summary of the results of the longline survey for *Dissostichus* spp. conducted under CM 24-01 by the Ukrainian vessel *Calipso* in Subarea 48.1 during the 2018/19 season, as well as a one-year research proposal for the continuation of this survey. The purpose of the research is to assess the local status and population structure of *Dissostichus* spp. in this area, as well as contribute to the evaluation of stock hypotheses for toothfish across Area 48 (WS-DmPH-18).

4.36 The Working Group noted that the research design presented in WG-FSA-2019/17 was updated from that shown in WG-FSA-18/20 Rev. 1 to account for sea-ice conditions (SC-CAMLR-XXXVII, paragraph 3.118). This new design included nine stations in research block 481_1 (northernmost) and 20 stations in research block 481_2 (central block). Research block 481_3 (southernmost block) was removed from the proposal. The authors indicated that this effort-limited research plan was intended to collect data for one more year, however, the research analysis and reporting would continue after the on-water activities were completed. They further clarified that the planned longline stations were distributed across three depth strata, as specified in WG-FSA-2019/17, Table 2, and that the location of the sets was based on the expectation to recapture tagged fish and to enable catch rate comparisons between the two seasons.

4.37 The Working Group noted that a more detailed presentation of the results from the 2018/19 survey was given in WG-SAM-2019/33. The survey had been restricted by sea-ice conditions and only deployed and successfully retrieved seven sets (of the planned 29) in research block 481_1, due to an inability to access research block 481_2; two additional lines, comprising 25% of the hooks deployed, had also been lost under ice and not retrieved.

4.38 The Working Group noted that the risk to the completion of research objectives remains even if the survey is conducted in February 2020 because sea-ice models run during WG-FSA-2018 predicted general low accessibility of research block 481_2 (WG-FSA-2018 report, paragraphs 4.48 to 4.52).

4.39 A power analysis was run during WG-FSA in order to test whether the number of stations was sufficient to detect potential changes in abundance index over time. The sampling rate proved to be adequate as the 29 planned stations resulted in 80% chance of detecting a 30% change in CPUE.

4.40 The Working Group considered a map showing the completed stations in the 2018/19 survey and the planned stations for the proposed survey in 2019/20 to assess whether the data collected in the first season were representative of the population and could be used to update the management advice regarding catch limits in the next season. Based on this consideration, the Working Group concluded that the CPUE data estimated from the seven completed stations could be used to update the management advice on catch limits. The Working Group agreed that a catch limit of 43 tonnes should apply in this effort-limited survey, based on multiplying the number of planned stations by the upper 75th percentile of the average CPUE from the seven completed sets in the 2018/19 season.

4.41 WG-SAM-2019 noted that the tag-overlap statistic for the 2018/19 survey presented in WG-SAM-2019/33 was lower than the 60% threshold specified by CM 41-01 (WG-SAM-2019 report, paragraph 6.38). The Secretariat informed the Working Group that the tag-overlap statistic had been recalculated using the catch-weighted length frequency and was found to be higher than 60%.

4.42 The Working Group requested more information to assess the likely impacts from the proposed research on dependent and related species, consistent with Article II, and particularly regarding fish by-catch composition and biomass. The proposal indicated that the proponents are using Spanish-type longlines with minimal impact on benthic organisms (WG-SAM-2019/23) and that they will use deep-sea cameras to help understand the interaction of the longline with the bottom. It provided more information on fish by-catch and showed that by-catch to catch ratio was 30% with *Macrourus* spp. being the dominant species. The Secretariat provided a map showing that the distribution of by-catch was relatively uniform across the sampling locations completed in 2019/20.

4.43 The Working Group noted that this proposal had not specified a conservation measure exemption (CM 24-05) under CM 24-01 and, as such, noted that a by-catch limit for *Macrourus* spp. should be 7 tonnes (16% of the target species catch limit), consistent with CM 33-03.

4.44 The Working Group noted that all recommendations by WG-FSA-2018 and WG-SAM-2019 were accounted for in the new proposal, except the increase in sampling effort for biological measurements on by-catch species (WG-FSA-2018 report, paragraph 4.47). The authors agreed to increase the biological sampling of by-catch species to a minimum of 30 individuals per species on each line as suggested by the Working Group.

4.45 The Working Group suggested prioritising the research in the southern research block (481_2) in order to provide key information about stock structure and stock hypothesis in Area 48, subject to the proposal being agreed.

4.46 The Working Group welcomed the high level of international collaborations in this proposal. Part of the otoliths and toothfish genetic samples were sent to scientists at the Alfred Wegener Institute for Polar and Marine Research (Bremerhaven, Germany). Some toothfish otoliths were transferred to scientists at the Shanghai Ocean University (China) for microchemical analysis and age reading cross-laboratory validation. Otoliths of grenadiers will also be read. The results of the analysis will be presented at working group meetings in 2020.

4.47 The Working Group reviewed the research proposal as an ongoing research proposal and summarised its advice in Table 8.

Subarea 48.2

4.48 WG-FSA-2019/51 presented the results of the final fifth year of the longline survey conducted by the Ukrainian vessel *Simeiz* in Subarea 48.2 in March–April 2019, as set out in WG-FSA-18/49. Significant reductions were noted in the CPUE of *D. mawsoni* in the survey area compared with 2018. Data on the CPUE time series by research blocks of the target and main by-catch species, biological characteristics of toothfish and by-catch and seabird and marine mammal observations were presented. The authors noted that there was no plan to continue fishing activities in 2019/20, but to instead focus on delivery of research objectives off the water. The authors clarified that they will continue working on CPUE time series once the catch will have been re-estimated (paragraphs 2.12 to 2.15).

4.49 The Working Group welcomed the high level of international collaborations in this proposal. Part of the otoliths and toothfish genetic samples were sent to fellow scientists at the Alfred Wegener Institute for Polar and Marine Research (Bremerhaven, Germany). Some toothfish otoliths were transferred to scientists of the Shanghai Ocean University (China) for microchemical analysis and age reading validation across laboratories. Otoliths of grenadiers are also planned to be read.

4.50 The Working Group noted that a member of the Ukrainian research team, Illia Slypko, is a CCAMLR scholarship recipient who spent one week at the Australian Antarctic Division (Kingston, Australia) with the team led by his mentor (Dr Welsford) prior to WG-FSA this year, working on ageing of *Dissostichus* spp. with Australian colleagues.

4.51 The Secretariat noted that there were no tag-release details for two of the fish recaptured in this subarea in 2019, despite these being CCAMLR tags issued by the Secretariat. The Working Group expressed its concern that toothfish tagging had taken place using CCAMLR-issued tags but the details had not been supplied to the Secretariat as this was crucial for the development of stock hypotheses and biomass estimation. It requested the Secretariat to continue its enquiries and work with the Member that was supplied with these tags to discover the original tagging details.

4.52 The Working Group encouraged all Members to ensure that details of all toothfish tagging activities are submitted in a timely manner. Where there are any concerns about tagging data that was not amenable to submission using the SISO observer form, Members were requested to correspond with the Secretariat to determine the most appropriate data submission mechanism.

4.53 The Working Group requested an analysis of fish by-catch from Subarea 48.2 over the five-year survey period and a power analysis to be run to assess whether the number of stations in their sampling design was adequate to achieve their research objectives.

4.54 The Working Group recalled the importance of using a standard ageing protocol for *D. mawsoni* across areas and encouraged the proponents to ask for assistance from their New Zealand and Korean colleagues who are conducting ageing programs in Subarea 88.3 as part of their joint research plan.

4.55 The Working Group welcomed the increasing numbers of ageing programs being undertaken by Members.

Subareas 48.2 and 48.4

4.56 WG-FSA-2019/25 presented preliminary results from the final data collection year of a five-year research survey investigating the stock connectivity of toothfish species in Subareas 48.2 and 48.4. The three years of data collection will now be followed by a two-year period of data analysis. Data from a long-distance tag recapture was presented from a fish which travelled from the south of Subarea 48.6 to Subarea 48.4 (released 2013, recaptured 2017). It was noted that this movement was congruent with the stock structure hypothesis for this region (WG-SAM-18/33 Rev. 1, WG-FSA-2019/05).

4.57 The Working Group welcomed the inclusion of a period of time dedicated to post-survey analysis and suggested that a synthesis of all data collected from recent research fishing for toothfish for the region would be of merit.

Subarea 48.6

4.58 WG-FSA-2019/22 reported on annual research fishing operations from a multi-Member longline survey targeting *D. mawsoni* in Subarea 48.6. At the time of WG-FSA-2019 the research fishing activities were not yet completed. Eleven other papers were presented at WG-SAM-2019 (five papers) and WG-FSA-2019 (six papers) to address research questions and Working Group requests. The Working Group congratulated Japan, South Africa and Spain for the effectiveness of their collaboration, and the progress that was being made in assessing the status of stocks in this subarea.

4.59 Preliminary results from a satellite tagging experiment (six pop-up satellite archival tags (PSATs) deployed) were presented and showed two tags that were released earlier than expected and suggest long range (>200 n miles) and unexpectedly fast (20 km/day) movement if the data are accurate. Argos locations are yet to be obtained from the tag manufacturer.

4.60 The Working Group asked for details on the offal reported from the stomach content analysis. As no offal is discarded south of 60°S, suggestions were made as to its origin, including that the offal may have been heavily digested prey items, or as a result of vessels using offal as bait. The Working Group agreed that an option to record offal as bait be added to the C2 form, also noting the discussions at the COLTO–CCAMLR Workshop (Table 2).

4.61 The Working Group suggested some modifications to the spotlights used on benthic monitoring cameras to improve the quality of the image. It also emphasised the utility of fishing vessels as platforms to collect environmental data using devices such as conductivity temperature depth probes (CTDs) and PSATs as demonstrated in this report.

4.62 The Working Group noted that there were large discrepancies between the age readings of Spain and Japan and suggested they partner with more experienced readers to attempt to reduce this variability. It also noted the recent publication of ICES *Handbook of fish age estimation protocols and validation methods*, and encouraged Members to compile similar documentation for ageing species found in the Convention Area.

4.63 The Working Group noted that there may be the possibility of matching opportunistic observations of baleen whales taken during the survey with a latitudinal array of acoustic recorder moorings present in the Weddell Sea (e.g. Thomisch et al., 2016). It was also noted that there were no sightings of toothed whales during the survey and there was no evidence of depredation.

4.64 WG-FSA-2019/21 presented a preliminary integrated stock assessment model for *D. mawsoni* in research block 486_2 using CASAL. The authors identified issues with the stock assessment as it stands but noted that it is a useful exercise to identify areas of development for future work; no future projections of the stock or sustainable yield calculations were attempted. It was noted that all iterations of the model predicted far higher estimates of biomass than the trend analysis used in previous years (WG-FSA-2018 report, Table 4).

4.65 The Working Group requested that a table of model parameters be included in future reports to help with interpretation. It noted that there was an issue with poor fits of modelled data to the age–length keys (ALK) and that this could be due to several reasons. Two CASAL models were presented, one with data aggregated over several years and one with ALKs separated by year. The proposed level of five samples from every 5 cm length bin was suggested to be too low for annual ALKs and the Working Group proposed an increased sampling effort and age readings. The Working Group also suggested to use simulations to test the effect of otolith sample number and length class binning on ALKs and calculated growth parameters.

4.66 The Working Group noted that research block 486_2 sits within a wider hypothesised stock. It noted the importance of the assessment area reflecting the stock for an integrated assessment and recommended further work to reflect this in future models.

4.67 The Working Group highlighted the utility of collating all available data when attempting a CASAL stock assessment to identify gaps and give an indication of where to target future work. It was also suggested that certain parameters could be considered global for a single species and may be used from other areas that have existing CASAL assessments.

4.68 WG-FSA-2019/05 presented tag-derived movement data for *D. mawsoni* which provided new insights on the stock structure hypotheses developed during WS-DmPH-18. Most of the long-distance tag movements highlight an east to west direction and no migrations were seen between the hypothesised spawning grounds in the northern seamounts and the feeding grounds of the southern shelf.

4.69 The Working Group suggested the use of the newly developed CCAMLR tag-linking algorithm to try and identify any further tag recaptures in this region. The Working Group noted the need to understand whether continuing data collection will reach the desired outcomes. In this case, it is likely that a significant number of extra tags might be needed to reach a conclusion about the stock hypotheses. It was also raised that the PSATs (presented in WG-FSA-2019/22) are a new development which may lead to a more successful resolution to this question than conventional tagging.

4.70 The Working Group noted that there is little evidence to support north–south migrations from current tagging data in Subarea 48.6 but that there is some evidence for this from ontogenetic size and age structure profiles in the north and south of Area 88. It noted that as larger datasets of age structure are developed, a similar analysis could be done for this region.

4.71 The Working Group highlighted that previous work on trace element finger printing of otoliths from these research blocks showed no significant differences which may indicate movement between them (WG-FSA-18/75). The Working Group also highlighted the importance of data collection at spawning grounds and that any extra oceanographic data collected in these key areas would be of merit.

4.72 Data from the CCAMLR database highlighted a tagged fish recaptured within research block 486_1 but there was no mention of this area otherwise during research presentations from this area. The Working Group noted that this research block has not been fished in this context for several years due to low catch rates, but when it was, mostly smaller *D. eleginoides* were found there. It noted that ageing any otoliths from these specimens would provide useful information on the linkages between the northern part of Subarea 48.6 and other *D. eleginoides* populations in Area 48.

4.73 The Working Group noted the success of the workshop format in the case of the stock structure hypothesis for *D. mawsoni* in Area 48 (WG-SAM-18/33 Rev. 1) in not only addressing a key issue, but also in guiding the direction of subsequent science in Area 48 through the development of successful research plans.

4.74 WG-FSA-2019/48 reported on correlations of sea-surface temperature (SST) anomalies with sea-ice concentration (SIC) between Subareas 48.6, 88.1 and 48.5/the Weddell Sea. There is some correlation of SIC between Subareas 48.6 and 88.1 with SST data from 2002 to 2019, as well as concurrent spikes in SST anomalies between these areas. This work was explored further in WG-FSA-2019/49 which explored the possibility of predicting SIC in research block 486_5 using SST in research block 486_2.

4.75 The Working Group noted that the SST anomaly spikes correspond well with accessibility in research block 486_5, and that last year only 38% of catch was taken in this research block because of this issue (WG-FSA-2019/22, Table 3). The Working Group noted that these sea-ice diagnostics should be further developed to help planning research design, particularly in regard to expected tag-recapture data. It also noted that the SST anomaly seemed to be declining over the last few years, which may result in limited access to research block 486_5 for the next several years.

4.76 A proposal for the continuation of a multi-Member longline survey of *D. mawsoni* in Subarea 48.6 was presented in WG-FSA-2019/23 by scientists from Japan, South Africa and Spain. The Working Group noted that the Members addressed most of the comments raised at WG-SAM-2019 within their proposal. During the meeting, a revision was made to this proposal to add the milestone table presented in WG-SAM-2019/13 Rev. 1.

4.77 The Working Group requested further clarification at WG-SAM-2020 regarding the suggested statistical approach for calculating the difference in catch efficiency and effective tag-survival and tag-detection rates. The authors noted that the *Tronio* had demonstrated good tagging performance in the Ross Sea region (WG-FSA-17/36) and tagging performance of the two other vessels (*Shinsei Maru* and *Koryo Maru*) proved to be good according to the analyses conducted during WG-FSA-2019 (Figure 7). The Working Group also noted that the tagging performances were relative to the fleet in a given area and requested future work to calculate these statistics for all vessels within Subarea 48.6 when data will be available. The Working Group noted that electronic monitoring, such as installed recently on the Spanish vessel *Tronio*, could also help understand vessel differences in tagging performance. To this end, the Working Group encouraged other vessels to implement electronic monitoring to allow between-vessel comparisons.

4.78 The Working Group noted that the biomass estimates had declined in some of the research blocks in Subarea 48.6 resulting in declining catch limits. It was noted that this was potentially due to an increase in tag returns affecting the output of the Chapman biomass estimate. Research block 486_2 displayed a clear decline in the Chapman estimate between 2018 and 2019 with a high number of tag recaptures following a period of relative stability. This raised concerns about the status of the stock in this area.

4.79 The Working Group reviewed the research proposal as an ongoing research proposal and summarised its advice in Table 8.

4.80 The Working Group noted it had been unable to provide consensus advice on catch limits (see paragraph 3.39), however, it had provided advice based on the use of best available science in the assessments on what catch level would be consistent with the CCAMLR decision rules. The Working Group agreed on catch limits to be calculated for Subarea 48.6 using the trend analysis rules (WG-FSA-2017 report, paragraph 4.33) as shown in Table 7.

Dissostichus spp. in Area 58

Divisions 58.4.1 and 58.4.2

Ageing data

4.81 WG-FSA-2019/47 described the progress in age determination of otoliths from *D. mawsoni* collected in Divisions 58.4.1 and 58.4.2. Spanish and Australian scientists are working on the age and growth estimates of *D. mawsoni* within Divisions 58.4.1 and 58.4.2 from 2015 and 2017. In joining this collaborative work, scientists from the Republic of Korea conducted a comparison of age estimation using microscope and photographic methods by the same reader. The authors noted that using two methodologies to determine age allows differences in interpretation to be isolated and monitored.

4.82 Although the authors noted that age determination using a microscope or magnifier appeared more accurate than those from photographs and the bake and embed method of preparing otoliths, age determination using photographs can be used to facilitate exchange between Members to interpret otolith ring patterns and facilitate routine inter-laboratory calibration.

4.83 The Working Group highlighted the importance and need for comparisons within and among ageing programs as a routine procedure to provide confidence in the comparability of ages used for management. The Working Group noted the need for a workshop on age determination of *Dissostichus* spp., similar to the last one that was held concurrently with the first week of WG-FSA-2012 (Workshop on Techniques and Procedures for Ageing of Otoliths from *D. eleginoides* and *D. mawsoni*).

4.84 The Working Group noted that scientists from Australia and New Zealand have developed digital collections of aged *D. mawsoni* otolith images prepared from thin sections. Acknowledging the potential for digital reference collections to support inter-laboratory calibration in multi-Member ageing programs, the Working Group encouraged the development of digital reference sets by all Members undertaking ageing.

4.85 The Working Group recommended that Members provide the appropriate material in order that the Secretariat can create a digital repository on the CCAMLR website containing otolith ageing and calibration instruction manuals (including WG-FSA-17/15), digital reference collections and a record of the locations of physical reference material. The Working Group further noted that a centralised database of ages would facilitate the increasing number or multi-Member ageing programs and recalled that this was discussed at WG-FSA (WG-FSA-2012 report, paragraphs 10.18 and 10.19).

4.86 The Working Group considered WG-FSA-2019/63 which described the results of a modelling study of egg and larval transport of *D. mawsoni* in the East Antarctic region. The Working Group welcomed and thanked the authors for this large body of work and noted that it could be a useful tool to assess different stock hypothesis and provide further context for genetic studies undertaken to understand *D. mawsoni* connectivity, such as WG-FSA-2019/P01.

4.87 The Working Group noted the importance of including egg buoyancy, sink rates and ocean dynamic systems (e.g. barotropic and baroclinic) to the model, especially considering the potential difference between coastal and open oceans regions and using high-resolution data in the coastal region. In addition to this, incorporating accurate information on the depth that eggs hatch would be required. The Working Group further noted that the results from current research conducted by New Zealand on the ecology of toothfish eggs could add further value in the refinement of this study.

4.88 The Working group welcomed the proposed collaboration with other scientists in this study. Prof. G. Zhu (China) would like to include data from west of the Kerguelen Plateau and expressed interest to combine the method with otolith microchemistry. Dr Péron expressed interest in using this method to advance the stock hypothesis of *D. eleginoides* in Area 58.

Research proposals

4.89 Two alternative research proposals were presented for Divisions 58.4.1 and 58.4.2; a proposal to continue a multi-Member research plan, and a new proposal by Russia.

4.90 WG-FSA-2019/44 provided a proposal for the continuation of a multi-Member research plan by Australia, France, Japan, Korea and Spain on the *D. mawsoni* exploratory fishery in Divisions 58.4.1 and 58.4.2 from 2018/19 to 2021/22. Changes to last year's research plan (WG-FSA-18/59) included an update of operational details and the addition of the larval and egg transport study in the milestones. Research blocks will again be allocated between Members to ensure overlap between fishing gear types and vessels to enable further assessment of gear and vessel effects.

4.91 The Working Group recalled that this and the preceding proposal had been thoroughly reviewed over the last three years by WG-SAM and WG-FSA and had achieved all research milestones as noted by the Scientific Committee in 2018 (SC-CAMLR-XXXVII, paragraph 3.138).

4.92 The Working Group recalled that only Division 58.4.2 was open for fishing in 2018/19. A vessel from Australia and one from France undertook research fishing in Division 58.4.2 during the 2018/19 season. The Working Group reiterated its concern that the loss of a season of data from Division 58.4.1 has resulted in a break in the time series of the data collected in the division. The Working Group highlighted that this had caused a delay to the further development of a stock assessment and the ability of the Scientific Committee to provide advice to the Commission for this area.

4.93 Based on a recommendation by WG-SAM-2019, intersessional discussions were held between the existing co-proponent Members and Russia, but no agreement was reached. The Members noted that, should Russia agree to become a co-proponent of this proposal, its research contributions could be integrated in an additional research objective (marked in tracked changes in WG-FSA-2019/44). One option would be to include an additional objective (Objective 5) aiming to evaluate the effect of standardised sampling design on estimates of toothfish biomass and biological parameters (WG-SAM-2019 report, paragraph 6.72).

4.94 WG-FSA-2019/52 set out a proposal for a multi-Member research program on *D. mawsoni* in the East Antarctic (Divisions 58.4.1 and 58.4.2) from 2019/20 to 2021/22. The paper noted that the methodical aspects of the multi-Member research on the *D. mawsoni* exploratory fishery in the East Antarctic implemented during the seasons 2011/12–2017/18, as outlined in WG-FSA-2019/44, do not provide scientific-based data for understanding abundance, population structure and productivity indices, distribution of toothfish and dependent species according to the objectives and goals of this research in Divisions 58.4.1 and 58.4.2.

4.95 Dr Kasatkina noted that, in her opinion, the methodical aspects of multi-vessel research in 2011/12–2017/18, in Divisions 58.4.1 and 58.4.2 had significant shortcomings, namely:

(i) lack of standardised design of longline surveys (concentration of longline settings in local areas between 1 000–1 500 m in research blocks, use of different gear types and number of sets by year and research blocks

(ii) impact of longline gear type on length and age composition, proportion of mature fish and results of tag-recapture (Kasatkina, 2017, 2016; WG-FSA-17/16; SC-CAMLR-XXXVII/BG/23; Yates et al., 2017)

(iii) data collection does not fully cover the available toothfish habitat in each research block that leads to uncertainty regarding the understanding of impact of spatial process on vital rates, fishing mortality, and parameter estimation being a critical element of stock assessment and the long-term precautionary management

(iv) low efficiency of tag program (40 tag recaptures and 6 567 tag releases 2011/12−2017/18 for six research blocks).

4.96 The authors of WG-FSA-2019/52 also noted that use of different gear types and non-standardised sampling design is the critical factor for efficiency of the multi-Member research on *D. mawsoni* exploratory fishery in the East Antarctic in previous seasons 2011/12–2017/18 (WG-SAM-2019/34).

4.97 Dr Kasatkina noted that WG-FSA-2019/52 proposed a multi-Member research program on *D. mawsoni* in Divisions 58.4.1 and 58.4.2 from 2019/20 to 2021/22 based on standardisation of sampling longline gear and survey design. The objectives and goals for multi-Member research in East Antarctica Divisions 58.4.1 and 58.4.2 for seasons 2019/20–2021/22 would correspond to those in WG-FSA-18/59. The research outlined in WG-FSA-2019/52 proposed that only vessels equipped with a standard autoline system will participate in multi-Member research in East Antarctica (Divisions 58.4.1 and 58.4.2) from 2019/20 to 2021/22. It was noted that haul locations are stratified by depth and distributed across a range of depth strata (550–1 000, 1 001–1 500, >1 500 m) where possible. Each vessel will deploy at least 10 longlines in each depth strata (where present and sea-ice permitting) in each research block. The haul positions have been created based on stratified-randomised design in depth layers for each research block. It was proposed to optimise longline surveys using ‘Neumann’ location in the second year.

4.98 Dr Kasatkina provided the following statement:

'Our position is based on international practice of conducting surveys with the participation of several vessels by using a standard fishing gear and a standardised design. The papers presented at WG-SAM and WG-FSA provide evidence that the longline fishing gear affects biological parameters used in the model for toothfish stock assessment. The CCAMLR Independent Stock Assessment Review for Toothfish indicated that understanding the impact of spatial process on vital rates, fishing mortality, and parameter estimation is a critical element of the long-term precautionary toothfish management. This recommendation is in line with our position on altering the survey design and to cover the available toothfish habitat in the research blocks with data collection. At present, no scientifically based evidence was presented to WG-SAM and WG-FSA that standardisation design and fishing gear should not be used for multi-vessels resource research and such standardisation should be solved by statistical methods. Lack of agreement on research proposals in the East Antarctic is provided by different positions revealed regarding the methodology of research in the East Antarctic. Our position on research in East Antarctica is a standardisation-based scientific program. Other position is to continue research on Dissostichus mawsoni *exploratory fishery in the East Antarctic without standardisation. It is needed to recall that Scientific Committee significantly increased catch limit for research in the East Antarctic to provide a sufficient number of tagged fish recaptures to obtain a stock estimate within a reasonable time (3–5 years) (SC-CAMLR-XXXII, Annex 4, paragraph 2.7). This recommendation is not yet achieved. In order to achieve consensus on the research methodology in East Antarctica and to submit proposals to WG-FSA and WG-SAM, we propose an intersessional discussion to submit an appropriate document to WG-SAM and WG-FSA.'*

4.99 The other participants noted that:

(i) the matter of standardised gears being used in other international surveys such as in the International Council for the Exploration of the Sea (ICES) was discussed at WG-SAM-2019, paragraph 6.5 and that ICES survey designs include substantial overlap in survey strata between vessels to allow statistical standardisation (i.e. GAMs, Berg et al., 2014) of the results prior to conclusions being drawn on stock abundance (Walker et al., 2017)

(ii) currently, no compelling scientifically based evidence has been presented to the working groups on why a single standardised gear should be used in an exploratory fishery multi-Member research plan

(iii) the Independent Review Panel recommended that understanding the impact of spatial processes on vital rates, fishing mortality, and parameter estimation is a critical element of the long-term precautionary toothfish management and suggested that the stocks could be statistically analysed in a manner that took account of those effects and did not necessarily require altering survey designs

(iv) there was a difference between standardised surveys to obtain reference biomass estimates and research fishing which may use a variety of analytical techniques to interpret the data.

4.100 The Working Group recalled the advice of WG-SAM (WG-SAM-2019 report, paragraphs 6.5 and 6.58 to 6.72) for the development of the original proposal in WG-SAM-2019/19.

4.101 The Working Group recalled its previous advice, as well as that of the Scientific Committee and the CCAMLR Performance Review, requiring proponents of new research to collaborate with Members who are currently participating in established research programs within the same area. The Working Group also recalled the WG-SAM-2019 report, paragraph 6.72, outlining the commitment to work intersessionally to develop a joint research proposal for Divisions 58.4.1 and 58.4.2 for consideration by WG-FSA-2019, but noted that no joint proposal had been submitted to WG-FSA.

4.102 The Working Group noted that there was no agreement between the two research proposal proponents to submit a joint research proposal.

4.103 Dr Kasatkina was asked to clarify as to why there is a need to adopt a different approach to research within Divisions 58.4.1 and 58.4.2 and requested for her to outline:

(i) the scientific basis for treating this exploratory fishery differently to other exploratory fisheries within the Convention Area

(ii) a clear scientific justification for the need for a standard gear, considering that the vessels proposed in WG-FSA-2019/52 used different gear configuration (different line weighting; Table 1) and considering statistical methods have been successfully applied for gear standardisation (e.g. WG-FSA-17/16), a subject on which WG-SAM-2019 has held a focus topic and discussed extensively (WG-SAM-2019 report).

4.104 All other participants noted that:

(i) A continuation of the break in the time series in Division 58.4.1 will delay the provision of management advice for this region.

(ii) Multi-Member research is successfully undertaken across the Convention Area by vessels using different fishing gears, and used to develop integrated stock assessments and set catch limits.

(iii) Five papers presented to WG-SAM-2019 have demonstrated the standardisation of catch rates in a multi-vessel and multi-gear fishery and concluded that different vessel and gear types can be accounted for statistically (WG-SAM-2019 report, paragraphs 6.6, 6.7 and 6.11 to 6.13 and Table 1). They considered that there is no clear justification for the deployment of a single gear type in exploratory fisheries.

(iv) Large variances in catches occur even when different vessels fish in the same area using the same gear type, as is the case in the Ross Sea region. The impact of gear type on length frequency of the catches is accounted for in assessment models through the selectivity function, and that the reason as outlined in WG-FSA-2019/52 does not provide a scientific justification.

4.105 They further noted that the estimations of productivity parameters and stock structure in this division are not dependent upon the same gear type being used, that ‘Standard gear’ does not exist in the CCAMLR context, and that the use of different gear types can be accounted for in subsequent statistical analyses (GAMs), as is demonstrated in WG-FSA-17/16 for these divisions. These statistical analyses were published in 2019 in the international peer-reviewed journal *Fisheries Research* (Yates et al., 2019).

4.106 The Working Group evaluated the research proposal against the standard criteria and format for research proposals as shown in the Area 58 research proposal assessment table (Table 9). This research plan cannot be completed without collaboration from other Members and the proponent has limited off-water research capacity (only one researcher is listed in the proposal section 5a). Moreover, tagging performance of the proposed vessels is poor or unknown; one vessel had very poor tagging performance (*Palmer*) and the other (*Volk Arktiki*) had a good tagging detection rate but unknown tag survival rate.

4.107 The Working Group was unable to reach agreement on how the use of multiple gear types should be reflected in the Area 58 research proposal assessment table. The source of disagreement relates to the gear type being proposed.

4.108 The Working Group noted that the extensive discussions between the proponents of the two research plans to achieve a collaborative research plan in Divisions 58.4.1 and 58.4.2 prior to, and during, WG-FSA-2019 had failed.

4.109 The Working Group noted that the main reason for the difficulty in achieving consensus in the discussions to achieve a collaborative research plan was the requirement by Dr Kasatkina to use standardised autoline gear and a standardised design. The Working Group noted that there was the intention from the proponents from both research plans to find a solution for the spatial design of haul locations.

4.110 The Working Group recalled that the research plan in Divisions 58.4.1 and 58.4.2 is for an exploratory fishery similar to Subarea 48.6, and not a survey under CM 24-01 in a closed area. The Working Group noted that there is no requirement for the exclusive use of one gear type in an exploratory fishery.

4.111 Dr Kasatkina noted that the practice to use standardised gear and standardised gear design for the toothfish research are known in CCAMLR. The research program in the northern part of the Ross Sea SSRUs 882A–B was provided by vessels from New Zealand, Norway, the UK and Russia by using the standard autoline gear and standardised design.

4.112 All other participants recalled that the survey in the northern part of the Ross Sea that was notified under CM 24-01 in a closed area, was designed to investigate the variation in gear types as well as providing information on the stock structure in the region (WG-FSA-15/32). The design used blocks that would be transferred between vessels with different autoline gear types in order to investigate vessel effects. The survey was conducted for only one year as a result of Russia blocking further research in the area.

4.113 The Working Group noted that currently 4 000 tagged fish are estimated to be available in Divisions 58.4.1 and 58.4.2. The Working Group expressed its concern that without a further year of fishing in Division 58.4.1, there would be no opportunity to recapture these fish which had required a substantial multi-year, multi-Member research effort to release.

4.114 The Working Group noted it had been unable to provide consensus advice on catch limits (see paragraph 3.39), however, it had provided advice based on the use of best available science in the assessments on what catch level would be consistent with the CCAMLR decision rules. The Working Group agreed on catch limits to be calculated for Divisions 58.4.1 and 58.4.2 using the trend analysis rules (WG-FSA-2017 report, paragraph 4.33) as shown in Table 7.

Division 58.4.4b

4.115 WG-FSA-2019/62 presented a CASAL model for research block 5844b_1 taking into account the suggestions given by WG-SAM (WG-SAM-2019 report, paragraph 6.76), including the impact of incorporating annual ALKs, standardised CPUE and different IUU scenarios into the CASAL model when estimating the current biomass.

4.116 The Working Group noted the robustness of the model in estimating both B_0 and the current biomass across all scenarios that were investigated. The Working Group also noted that the model estimated higher current biomass than the Chapman method. The Working Group further noted the possibility of setting the catch limits based on the result of the CASAL model in this area.

4.117 The Working Group noted that this work shows that forward projection of stocks in time can provide a fairly consistent yield with robust estimates to account for IUU fishing. The Working Group noted the application of this work and the potential to inform the harvest control rules once further refinements had been made.

4.118 WG-FSA-2019/65 presented the annual multi-Member (France and Japan) longline survey for *D. eleginoides* in Division 58.4.4b for the 2018/19 season. The Working Group noted that the on-water research started in 2016/17 and it will conclude in the 2020/21 season.

4.119 The Working Group noted that the research results were for the 2018/19 season only, but that the appendix contained data for all other seasons. The Working Group also noted that the scientific observer data was still in progress at the time of the WG-FSA meeting.

4.120 The Working Group noted that work had progressed on the CASAL model evaluation, but that the low tag-recapture rates across the research block will affect this.

4.121 The Working Group noted the high level of by-catch in this division, with 70% of the total catch weight being by-catch (including weight of individuals discarded and estimated weight of individuals released or lost at the surface). The Working Group noted that the use of cameras on longlines would provide more information on the presence of sea pen hotspots, particularly in the eastern part of research block 5844b_2 where these are known to occur.

4.122 The Working Group noted the importance of making oceanographic data publicly available using international depositories and suggested that these types of data be submitted to the Southern Ocean Observing System (SOOS).

4.123 WG-FSA-2019/53 investigated the distribution and composition of by-catch caught in research fishing for *D. eleginoides* conducted by France and Japan in Division 58.4.4b between 2008 and 2018. The Working Group welcomed the progress made in addressing the concerns raised about progress against milestones at WG-FSA-2018 and at SC-CAMLR-XXXVII (SC-CAMLR-XXXVII, paragraph 3.158), including conducting by-catch analyses (SC-CAMLR-XXXVII, paragraph 3.159) according to the revised milestones outlined in SC-CAMLR-XXXVII, Annex 12.

4.124 The authors highlighted that the survey design had been amended to avoid sea pen hotspots in the eastern part of research block 5844b_2 (WG-FSA-18/23 and SC-CAMLR-XXXVII, paragraph 3.159).

4.125 The Working Group noted that there were high levels of skate by-catch recorded in both C2 data and observer data. The highest levels occurred in the eastern part of research block 5844b_2, where sea pen hotspots occur.

4.126 The Working Group noted that most skates were released in good or average condition, but further work is needed to assess skate survivability. The Working Group also noted the large number of skates for which the condition was unknown.

4.127 The Working Group noted spatial and bathymetric effects on skate by-catch rate, and that the autoline gear appeared to be less selective than trotlines and Spanish lines when conducting research fishing in this area, although data was not standardised for fishing patterns. When accounting for skates released (cut-off), the by-catch biomass to target catch ratio was 15% for trotlines and up to 70% for autolines. The Working Group considered possible causes for the high level of skate by-catch observed in this area, and that this may be caused by by-catch reporting practice and bait type as opposed to being a direct gear effect.

4.128 The authors informed the Working Group that vessels from the research plan proponents using autoline gear would not be participating in future research fishing in research block 5844_b2 due to the high catches of skate and are investigating ways to reduce the by-catch. The authors also informed the Working Group that they were involved in the update of the International Union for the Conservation of Nature and Natural Resources – the World Conservation Union (IUCN) Red List assessment for *Amblyraja taaf*, whose status is currently data deficient.

4.129 WG-FSA-2019/64 presented the research proposal for *D. eleginoides* in Division 58.4.4b by France and Japan. The Working Group noted that the proposal had been substantially revised to address the concerns expressed at WG-FSA-2018 and SC-CAMLR-XXXVII (SC-CAMLR-XXXVII, paragraph 3.158).

4.130 The Working Group noted the improved research plan and redefined research objectives presented in SC-CAMLR-XXXVII, Annex 12. The Working Group noted that the survey design had been amended to avoid sea pen hotspots in the eastern part of research block 5844b_2 (WG-FSA-18/23), as well as the addition of a new French vessel to increase research survey capacity.

4.131 Considering the progress made in the stock assessment model, and that the level of the estimated yields achieving the CCAMLR decision rules would allow a yield substantially higher than the catch limit set using the Chapman estimate of biomass (Table 7), the Working Group recommended that a 20% increase from the existing catch limit in research block 5844b_1, to 23 tonnes, would be consistent with the trend analysis procedure. However, the Working Group noted it had been unable to provide consensus advice on catch limits (see paragraph 3.39), however, it had provided advice based on the use of best available science in the assessments on what catch level would be consistent with the CCAMLR decision rules. The Working Group agreed on catch limits to be calculated for research block 5844b_2 using the trend analysis rules (WG-FSA-2017 report, paragraph 4.33) as shown in Table 7.

4.132 The research plan achieved all of its milestones and incorporated the advice from WG-SAM (WG-SAM-2019/08) and its evaluation is given in Table 9.

D. mawsoni in Area 88

Capacity

4.133 WG-FSA-2019/06 Rev. 1 provided the update of capacity and capacity utilisation within Subareas 88.1 and 88.2. The updated capacity metrics in the paper showed the same pattern as in previous updates and did not indicate an excess of capacity in the fishery. Interpretations of data for 2018 and 2019 were made in the context of changes in the areas of operation and the application of fishery closures in the exploratory fishery in Subarea 88.1.

4.134 The Working Group noted that WG-FSA-2019/06 Rev. 1 concluded that there was no evidence of capacity issues at the overall scale of the fishery in Subareas 88.1 and 88.2, while CCAMLR-38/BG/12 considered capacity issues in this fishery at the spatial scale at which catch limits and fishery closures are implemented.

4.135 The Working Group recommended that in future the capacity update presented in WG-FSA-2019/06 Rev. 1:

(i) be applied at the same spatial scales as catch limits are set in order to better reflect operational capacity issues in the fishery

(ii) include a measure of hooks set and retrieved each day during the season, to investigate factors influencing gear loss rates.

Regional comparisons of *D. mawsoni* diet

4.136 WG-FSA-2019/37 reported on prey items of *D. mawsoni* collected from two research areas (Areas 58 and 88) from 2016 to 2018 using metabarcoding analysis of 1 329 stomach contents. A total of 71 haplotypes were identified by cytochrome c oxidase subunit I universal primers, which included 60 fish and 8 cephalopod species. Results indicated that the major prey items of *D. mawsoni* are fish species (98%), with Whitson's grenadier (*Macrourus whitsoni*) and *Chionobathyscus dewitti* being the most important prey items.

4.137 The Working Group welcomed the progress of this research and noted the potential of such approaches to improve our understanding of the toothfish ecology and ecosystem interactions.

4.138 While recognising the challenge in comparing qualitative and quantitative approaches, the Working Group suggested that these results should be compared to other stomach analyses.

Prof. H.-W. Kim (Korea) noted his intention to conduct a quantitative per capita recruitment (PCR) analysis using individual stomach samples, which would allow quantitative comparison with the previous morphological analyses (WG-FSA-18/24).

Age determination

4.139 WG-FSA-2019/35 presented a comparison of age readings performed by two otolith readers from age reading programs in Korea and New Zealand, as well as an estimation of the early growth of *D. mawsoni* (less than age 10) in Subarea 88.3.

4.140 The Working Group recognised the homogeneity of the readings from the two readers and welcomed the use of the standardised plots recommended by the 2012 Ageing Workshop (WG-FSA-2012). The Working Group suggested that this work could be part of a larger study on growth estimation that is going to be developed for WG-SAM-2020. It also noted that the von Bertalanffy growth curves may not be well adapted to the small range of size and age data of this study. The Working Group further noted the importance of ageing tagged fish in improving the growth curve accuracy and the understanding of the inter-individual variability of growth and understanding migration strategy effects.

MPA catch allocation

4.141 SC-CAMLR-38/12 provided comments on resource support for conducting scientific programs in the RSRMPA. The authors noted that although the RSRMPA has existed for three years, it is still unclear how research catch limits in the MPA should be allocated. The operation of the RSRMPA will require significant resource potential directed towards catching *Dissostichus* spp. for the implementation of the research and monitoring plan (RMP). The authors noted that allocation of the overall Ross Sea region catch limit inside and outside the MPA should not limit the Olympic exploratory longline fishery outside the MPA which is a main data source for assessment models of toothfish in the Ross Sea region.

4.142 The authors also claimed that the transfer of catch from the overall catch limit to inside the MPA will have an additional impact on toothfish and the ecosystem in the MPA and will limit the exploratory longline fishery outside the MPA, which is a data source for assessment models of toothfish in the Ross Sea region. The authors further considered that the catch limit for any research in the RSRMPA should not be deducted from catch limits for exploratory fishing outside the MPA.

4.143 The Working Group noted that the transfer of catch from the overall catch limit to inside the MPA is not likely to impact the stock assessment since the catch of the survey represents 1.4% of the total catch limit for the Ross Sea region.

4.144 The Working Group noted that the catch limit in the Ross Sea is provided by the CASAL assessment of the entire Ross Sea stock including areas inside and outside the MPA.

4.145 The Working Group recalled that CM 24-01, paragraph 1(b), specifies how the catch allocations are to be performed.

4.146 Dr Kasatkina highlighted the importance of the shelf survey for the management of the Ross Sea region toothfish fishery noting it had started before the MPA was put in place. However, CM 91-05 did not clearly specify how the allocation of catch should be made for research within the RSRMPA and that in her opinion the catch should be allocated from within the RSRMPA SRZ, rather than allocated from outside the MPA.

4.147 The Working Group agreed on the importance of the shelf survey in this area and noted that before the MPA existed the catch was allocated from the overall catch limit.

4.148 The Working Group discussed the possible options for allocating catch within the MPA from the various areas of the Ross Sea region noting there are three likely allocation options for the shelf survey:

(i) allocation as applied in 2018/19, where the shelf survey catch is removed from the entire Ross Sea region limit before the allocation of catch to the three management areas (north of 70°S, south of 70°S and the SRZ)

(ii) allocation as suggested by Dr Kasatkina, where the shelf survey catch limit is allocated from the SRZ catch limit

(iii) as the MPA is closest to the south of 70°S region, allocate the shelf survey catch limit from the region south of 70°S catch limit.

4.149 The Working Group noted each of these options contains differing levels of risk. It recalled the discussion in CCAMLR-38/BG/12 regarding the difficulty in projecting catch in the SRZ in the presence of large numbers of vessels fishing, and the large number of hooks being set both collectively and by some individual vessels. Lowering the catch limit in the SRZ by allocating the catch limit of the shelf survey from this area, in addition to the potential of 140 tonnes allocated to an SRZ survey (paragraphs 4.156 to 4.169), would potentially exacerbate this issue. A breakdown of catch limits, using the three methods of allocation above, is outlined in Table 6.

4.150 The Working Group also noted that one of the objectives of the SRZ was to provide an area within the MPA that is fished at approximately half the exploitation rate of the fishery to allow comparison between areas of normal fishing, limited fishing and no fishing. Allocating catch from the SRZ for research in other areas of the MPA may impact on the ability to achieve this objective.

Research plans in the MPA

4.151 The Working Group recalled the advice in WG-SAM-2019 report, paragraph 6.16, that any research fishing proposed in MPA zones should ensure it maximises scientific outputs and that robust scientific conclusions can be drawn from those outputs. The Working Group formulated a table (Table 11) which it used to evaluate research plans within the MPAs against the suggested questions from WG-SAM-2019, noting the proponents of these research plans had not seen the table prior to the meeting.

Shelf survey

4.152 WG-SAM-2019/03 described the results from the 2019 Ross Sea shelf survey and the notification for the survey in 2020. The objectives of the survey are to: (i) continue monitoring the abundance and age structure of sub-adult toothfish in the south of SSRUs 881J and 881L in the southern Ross Sea using standardised gear in a standardised approach, (ii) continue monitoring trends of large sub-adult and adult toothfish in two areas situated in SSRU 881M which are of importance to mammalian toothfish predators, and (iii) to collect and analyse a wide range of data and samples from these areas (e.g. demersal fish, benthic invertebrates, stomach and tissue samples, acoustic data, etc.), which will contribute to the RMP for the RSRMPA.

4.153 The Working Group recalled the importance of this time series of surveys for the Ross Sea region stock assessment in delivering a long-term time series of recruitment, as highlighted by the Independent Review (WG-FSA-2018 report, paragraph 4.148). The Working Group welcomed the invitation of a CCAMLR scholarship recipient (Illia Slypko) to participate in the 2019/20 survey and highlighted again the value of the CCAMLR scholarship program in exchanging experience and knowledge between CCAMLR Members.

4.154 The Working Group recalled that the survey is effort limited with a core strata sampled every year and strata sampled in alternate years (i.e. McMurdo and Terra Nova; WG-FSA-2017 report, paragraph 3.83). The McMurdo strata will be sampled in the 2019/20 season.

4.155 The Working Group reviewed the research proposal against the criteria outlined in WG-FSA-2019/55 in Table 10 and the new proposed MPA research evaluation in Table 11. The Working Group recommended a catch limit of 45 tonnes for the 2019/20 season.

Special research zone

4.156 WG-FSA-2019/42 presented a proposal for a research program from 2019 to 2027 to investigate the life cycle, distribution and movement, biological parameters and stock structure of *Dissostichus* spp. in the eastern part of the Ross Sea over the shelf and continental slope in the SRZ.

4.157 During the course of the meeting, the proponents provided a revision (WG-FSA-2019/42 Rev. 1) to clarify the research plan was designed for 2019/20–2021/22 at the request of the Working Group. The revision also added details on the deployment of CTDs as part of the research plan, however, these were not considered in the Working Group’s assessment of the research plan.

4.158 The Working Group noted that the proposal (WG-FSA-2019/42) had been updated to address most of the comments expressed during WG-SAM-2019 and recognised the significant progress made by the proponents compared to WG-SAM-2019/17 and WG-FSA-18/33 Rev. 1. Changes included: (i) a corrected catch limit, (ii) survey stratification, (iii) updated locations of stations and overlapping sampling effort by vessels that would allow effects such as vessel effect, gear effect (the integrated weight of autoline of each vessel differs), effective tagging survival and tag-detection rate to be accounted for, and (iv) a vessel that uses autoline with weights while the other two vessels use integrated weighted lines (IWLs) was removed of the research plan.

4.159 WG-SAM (WG-SAM-2019 report, paragraph 6.85) expressed concerns that were partially or not addressed in the proposal:

(i) Tagging performance of the proposed vessels

Two vessels were notified for this research plan. The *Palmer* has poor tagging detection and a tagging survival of zero, the *Volk Arktiki* has a good tagging detection rate but unknown tag survival as the vessel has only completed one season in the Ross Sea region. The Working Group noted that there was still uncertainty as to the cause of poor tagging performance of the *Palmer*. The Working Group therefore recommended that electronic monitoring should be undertaken on the *Palmer* to assess potential causes for its consistently low performance in tagging survival and detection. The Working Group noted that the survey could be conducted with only one vessel, excluding the one with poor historical tagging performance. The Working Group requested the Scientific Committee take this into account in its consideration of this research plan.

(ii) The use of geographic reference data for the SRZ from the CCAMLR geographic information system (GIS) to present station localisation in a consistent projection.

The Working Group reviewed the coordinates of the block boundaries of the research plan, depth strata polygons and the projection used for the map shown in the research plan. The Working Group recommended that the proposal includes reserve stations, should sea-ice prevent operating in some regular stations of the research plan. The Working Group noted that a number of stations were shallower than the 550–1 000 m depth strata specified in the research plan. Additionally, a number of stations were less than 5 n miles apart, while the research plan specified a minimum distance of 5 n miles between hauls.

The Working Group recommended that the sampling locations be updated to account for the points mentioned above.

(iii) The proponents should undertake a power analysis, as requested for every effort-limited research proposal, to determine the required number of survey stations given the research objectives (see WG-SAM-18/06).

A power analysis to estimate the optimal number of stations, requested by WG-SAM (WG-SAM-2019, paragraph 6.18), was conducted for the original four research blocks by the Working Group during the meeting, using the mean catch per set of 1.32 and the standard deviation of 0.41 (WG-FSA-2019/42 Rev. 1). Based on these values, the power analysis estimated the number of stations needed for estimating abundance using the code in WG-SAM-2019/06. The research plan was estimated to have an 80% probability to be able to detect a change of 30% in relative biomass in the core survey strata between two years based on a sample size of 14 sets per year, per vessel and per research block with $\alpha = 0.05$ (3 000 iterations were used). When considering two vessels sampling in four research blocks with overlapping in two research blocks, the overall number of stations calculated with this method was 84.

However, the Working Group noted that these estimates were based on data from 2010–2012, while data from the most recent two seasons were not included. It further noted that in the 2010–2012 survey, trotline was used while autoline was proposed in the research plan, and that the differences in gear types could influence the results of the power analysis.

The Working Group recommended that Members further develop guidelines for power analysis for consideration by WG-SAM-2020.

4.160 The Working Group recommended that the research plan shall consist of two research blocks, with overlapping distributions of haul stations for the two vessels in each research block. The Working Group recommended that the two vessels participating in the survey should operate in such a way as to maximise the overlap in sampling stations actually fished within each research block. The Working Group also recommended priority be given to research block one, as it contained the greatest ice accessibility.

4.161 The Working Group did not have the time to allocate the number of stations calculated with the power analysis that would comply with the requirement of the research plan (i.e. 5 n miles apart, not shallower than 550 m, 84 stations, overlapping). It therefore recommended that the sampled stations shall be a selection of the stations in the proposal that were not shallower than 550 m. This selection represented 81 stations (Figure 8).

4.162 Dr Kasatkina noted that the SRZ provides a unique opportunity to conduct research directed towards a standardisation of toothfish resource research, combining data from the exploratory Olympic fishery and structured scientific research plans conducted under CM 24-01. Dr Kasatkina noted that proposals for a research survey include research considered a priority within the RMP for the RSRMPA.

4.163 The Working Group calculated the catch limit by multiplying the number of stations (81) by the mean CPUE plus the standard deviation of the seasons 2010–2012, which resulted in a maximum catch limit of 140 tonnes for the effort-limited survey. It also noted data from the most recent two seasons are now available and should be accounted for in future calculations.

4.164 The Working Group noted that objective 1 contained a stock assessment, and that toothfish within the SRZ are already assessed as part of the Ross Sea region stock assessment (WG-FSA-2019/08). The Working Group further noted that the development of time series of local trends in abundance and CPUE would be desirable for this area in order to compare them to trends outside the RSRMPA and within the RSRMPA general protection zone (GPZ).

4.165 The Working Group noted that insufficient details were provided in the proposal about the methods that were going to be used in the analysis of the research plan, and that it was unclear who was going to conduct the off-water analyses.

4.166 The Working Group recalled advice to other research plans that the proposed sampling rate of 10 fish per species, per line, was insufficient to collect enough data for the analysis planned.

4.167 The Working Group noted that Russia had not completed research programs from previous surveys in this region.

4.168 The Working Group emphasised the role of collaboration between Members, for example for calibration of otolith readings and otolith microchemistry. Dr Kasatkina indicated that she would be happy to engage in collaborative work.

4.169 The Working Group reviewed the research proposal against the criteria outlined in WG-FSA-2019/55 in Table 10 and the new proposed MPA research evaluation in Table 11.

4.170 Due to lack of consensus on catch advice for the Ross Sea region toothfish fishery (paragraph 3.39), the Working Group was unable to provide advice on a catch limit for the SRZ survey, which potentially represents a large proportion of the SRZ total catch limit.

D. mawsoni in Subarea 88.2

4.171 WG-FSA-2019/12 provided an update on the Amundsen Sea region toothfish fishery that has been operating since 2003. The biological characterisation of the fishery showed a truncation of the right-hand limb of the age distribution between 2004 and 2014. Few age data are currently available after 2014. The authors recommended that further ageing of toothfish in the Amundsen Sea region be made a priority to develop annual ALKs and age frequencies.

4.172 The Working Group recalled the discussion at WG-FSA-2017 relating to ageing toothfish in this region, specifically WG-FSA-2017 report, Table 1, which outlined priority otoliths for this region to be aged by specific Members.

4.173 Dr Ziegler and Dr Darby noted that ageing has been undertaken for this area by Australia and the UK. Both noted that their research teams had been delayed by the need to train new staff in ageing techniques in order to provide robust age estimates.

4.174 The Working Group once again requested the Members that have otoliths from this region (WG-FSA-2017 report, Table 1) to provide age data to assist in the development of a stock assessment in this region.

4.175 The Working Group highlighted that the fishery in Subarea 88.2 (SSRUs C–H) used to contain an integrated assessment of toothfish biomass and now only has sufficient tag-recapture data to perform a Chapman estimate in one research block (Table 7). The Working Group also noted the low overlap of effort between years within research blocks 882_1 to 882_4 and SSRU H that limited the number of tagged fish likely to be recaptured.

4.176 The Working Group again recommended, recalling WG-FSA-2018 (WG-FSA-2018 report, paragraph 4.174) that a requirement for research plans with milestones as part of the notification for conducting fishing in the area would encourage vessel coordination, and the submission of data for the assessment process and submission of advice to the Scientific Committee. The Working Group noted that currently CM 21-02, paragraph 6(iii) (notifications for participation in exploratory fisheries for *Dissostichus* spp.) included the data-limited exploratory fisheries and recommended the areas covered by SSRUs 882C–H be included here for future notifications.

4.177 The Working Group noted it had been unable to provide consensus advice on catch limits (see paragraph 3.39), however, it had provided advice based on the use of best available science in the assessments on what catch level would be consistent with the CCAMLR decision rules. The Working Group agreed on catch limits to be calculated for Subarea 88.2 using the trend analysis rules (WG-FSA-2017 report, paragraph 4.33) as shown in Table 7.

D. mawsoni in Subarea 88.3

4.178 WG-SAM-2019/02 presented a research plan for Subarea 88.3 in its final year with the aim to be fully reviewed at WG-FSA-2020. The main objective of this proposal is to determine the abundance and distribution of *D. mawsoni* in Subarea 88.3. Secondary objectives are to improve understanding of stock structure of toothfish in Area 88, to carry out calibration trials among the vessels, to collect data on the spatial and depth distributions of by-catch species, and to trial scientific electronic monitoring technologies.

4.179 The Working Group noted that sea-ice has been an issue in previous years. It further noted that the ice map that was used to design the survey has proven to not reflect the real ice conditions of the area, limiting vessel accessibility. Ice maps based on remote-sensing data may not give the full story when describing conditions on the water. The Working Group noted that no stations are in the immediate area of Pine Island Glacier (CCAMLR-38/20 and WG-SAM-2019 report, paragraph 6.95).

4.180 The Working Group also noted that all vessels are equipped with on-board electronic monitoring.

4.181 The Working Group reviewed the research proposal against the criteria outlined in WG-FSA-2019/55 in Table 10.

4.182 The Working Group noted it had been unable to provide consensus advice on catch limits (see paragraph 3.39), however, it had provided advice based on the use of best available science in the assessments on what catch level would be consistent with the CCAMLR decision rules. The Working Group agreed on catch limits to be calculated for Subarea 88.3 using the trend analysis rules (WG-FSA-2017 report, paragraph 4.33) as shown in Table 7.

Other fisheries research including crabs

4.183 WG-FSA-2019/38 presented results of preliminary analyses of oceanographic data collected by the four Ukrainian vessels operating in Subareas 48.1, 48.2, 88.1 and 88.2 during 2018/19. Temperature profile data from logging devices deployed on longlines were collected from 37 deployment locations.

4.184 The Working Group noted that information on bottom temperatures, particularly how they may change over the period of deployment, may provide useful information on environmental drivers of toothfish distribution and encouraged the authors to investigate toothfish catch rates and size distribution in relation to bottom temperature.

4.185 The Working Group welcomed the presentation of these results and noted that the data may be of interest to researchers studying the wider ecosystem and that they should be made available to WG-EMM. In particular, the data may be useful in regions such as the Antarctic Peninsula where the local oceanography is known to be complex.

4.186 The Working Group noted that the data would be made available to anyone interested upon request to the authors and that additional information on cetacean sightings from these fishing vessel activities was also available.

4.187 The Working Group noted that for some oceanographic applications there is a need for a high level of instrument precision and that calibration of instruments is important. It was noted that the loggers used in this study were either new or had been recalibrated before use by the manufacturers. It was noted that calibration of instruments on board fishing vessels is difficult but information on bottom temperatures would be useful for ecological studies.

4.188 WG-FSA-2019/39 summarised the zooplankton sampling activities carried out on Ukrainian fishing vessels in the Convention Area in 2018/19. Preserved zooplankton samples obtained from 53 vertical lift-net deployments to depths of 100 m have been sent to the University of British Columbia for identification and analysis.

4.189 The Working Group considered the results of the first season of research on crabs undertaken by the Russian vessel *Volk Arktiki* in Subareas 88.2 and 88.3 in March 2019 presented in WG-FSA-2019/41. The Working Group recalled that there had been considerable discussion of the results of this research at WG-SAM (WG-SAM-2019 report, paragraphs 6.101 to 6.106) and noted that the research had been severely constrained by ice conditions. The Working Group noted that the continental shelf region had been inaccessible in Subarea 88.2 and research effort was restricted to a region of offshore seamounts.

4.190 The Working Group thanked the authors for the report of the research and noted that 2 040 pots had been set during the research and catches of two species of lithodid crab were low, totalling 569 kg (1 696 individuals). Total weight of toothfish by-catch was 434 kg (17 individuals).

4.191 The research report presented length–weight relationships, length distributions, sex ratios and reproductive state, and samples were collected for histological, genetic, isotope and parasite studies. By-catch of *D. mawsoni*, *M. whitsoni* and *C. dewitti* was reported, for which length and weight were taken. Otoliths were sampled from 12 of the 17 by-caught toothfish, and two toothfish were tagged and released. The Working Group noted that analyses of size at sexual maturity are ongoing and requested that additional information on crab distribution with depth, CPUE and effects of soak time on catch rate be investigated and presented in the future.

4.192 The Working Group noted that approximately 45 pots were lost during operations as well as a further 30 damaged, and there was some concern about the potential to impact seabed communities in this area. Dr Kasatkina confirmed that the pots were fitted with biodegradable ‘escape panels’. The Working Group also noted that deep-water cameras were not deployed on pots during the research, and that this was a specific requirement set out by the Scientific Committee (SC-CAMLR-XXXVII, paragraph 4.3iv) and the Commission (CCAMLR-XXXVII, paragraph 5.73) for this research to proceed. There is no additional information of the impacts of pot fishing on benthic habitats.

4.193 The Working Group noted that on-water research would not continue in 2019/20 but further research was planned for the future.

4.194 Dr Kasatkina noted that an analysis of all aspects of further research was carried out taking into account the results from the 2018/19 season and financial side. The pilot project was approved by CCAMLR only for one season 2018/19 without clarity about the further plans for these studies (SC-CAMLR-XXXVII, paragraph 4.3). Therefore, a balanced decision was made to not proceed with the pilot project in the next season (2019/20). However, Russia does not exclude the possibility of continuing crab study in the future. The continuation of the research fishery for craboids in Subareas 88.2 and 88.3 may be conducted in the framework of the new fishery in accordance with CM 21-01.

4.195 The Working Group noted that ice conditions had severely limited the spatial extent of the proposed crab research and no data were available for the continental shelf region of Subarea 88.2 as planned.

4.196 The Working Group requested that the Scientific Committee consider whether future research should be conducted under CM 24-01 or considered as new fishery under CM 21-01 given the limited results and low spatial coverage of the research conducted to date.

Scheme of International Scientific Observation

5.1 WG-FSA-2019/15 presented information on developments in SISO, including the implementation of new observer manuals for finfish and krill fisheries and additional instructions and form alterations to accommodate a focused tagging program in Subarea 88.1 and SSRUs 882A–B, as endorsed by the Scientific Committee last year (SC-CAMLR-XXXVII, paragraph 6.36).

5.2 The Working Group thanked SISO observers and the Secretariat for their hard work during the 2018/19 season and noted the utility of the new observer manuals. The Working Group encouraged alignment between the observer manuals and data collection forms, and instructions and data fields presented as part of the proposed C2 form redevelopment (paragraph 2.22) to ensure consistency in data provided by both observers and vessels.

5.3 The Working Group noted that the development of the new observer manuals would require minor changes to the following conservation measures to ensure the correct manual is referenced:

(i) CM 22-06
(ii) CM 41-01
(iii) CM 51-04
(iv) CM 51-06
(v) Text of SISO.

5.4 The Working Group noted the contributions of SISO observers completing the vessel tagging survey (paragraphs 4.21 to 4.25) and from observers attending the COLTO–CCAMLR Workshop on vessel data reporting (paragraphs 2.20 and 2.21). The Working Group highlighted that this survey was helpful in understanding some of the issues observers may face that are not immediately obvious, such as obstacles present between the hauling bay and tagging station on some vessels, or that in most of the responses, observers manually transport toothfish (which can be of substantial weight) to the tagging station. The Working Group noted that this type of data could usefully inform future recommendations around work health and safety for observers.

5.5 The Working Group reinforced the desirability of SISO observers receiving training in tagging procedures as the majority of vessels in exploratory fisheries rely on observers for all tagging procedures (paragraphs 4.21 to 4.25).

5.6 The Working Group noted that the identification of observer names in papers presented to the Working Group may result in personal data confidentiality issues. The Working Group reflected that some observers may wish to be identified for recognition of working in CCAMLR fisheries and suggested that permission for identifying the observer could be specified in the bilateral arrangement between Designating and Receiving Members and communicated to the Secretariat when submitting the observer deployment notification.

Non-target catch and ecosystem impacts of fishing

6.1 WG-FSA-2019/19 noted that species identification is a major challenge in skate studies due to convergent morphology within and between genera. In order to address this question, the authors applied molecular tools to identify specimens of softnose skates (*Bathyraja* spp.) caught as by-catch from the longline fishery around South Georgia, similar to the methods already applied to resolve taxonomic uncertainty of *Amblyraja* (WG-FSA-18/73). Both mtDNA control region sequence analyses and the analysis with GenBank data highlighted that all *Bathyraja* specimens from South Georgia would be darkbelly skate (*B. meridionalis*), and noted that the genetic information of *B. meridionalis* and McCain's skate (*B. maccaini*) registered in GenBank may need some revision. Genetic diversity of these *B. meridionalis* was low and indicated a single population around South Georgia.

6.2 The authors noted that microsatellite markers are being developed to confirm species identity and conduct further population structure work. The authors also have contacted the owners of the original DNA sequences registered on GenBank to resolve this discrepancy among genetic studies for *Bathyraja*.

6.3 The Working Group noted that additional observer training about skate identification could improve species identification, rather than changing identification guides for skates.

6.4 As part of the objectives of the research plan for Division 58.4.3a detailed in WG-FSA-18/61, WG-FSA-2019/56 evaluated the by-catch composition, distribution and biological characteristics during completed fishing activities of this research plan between 2008 and 2018. Skates (mostly *A. taaf*) was by far the dominant by-catch species on longlines, followed by *Macrourus* spp. and blue antimora (*Antimora rostrata*). Bathymetry and location seemed to be a key factor determining by-catch of *A. taaf*, with higher CPUE in shallower waters above 1 000 m, with CPUE at times reaching 270 kg per 1 000 hooks (when skates released (cut-off) were included in the calculation). While 133 *A. taaf* have been tagged and released since 2009, none have been recaptured to date. The sex ratio between male and female skates was approximately similar, but there was a distinct bimodal distribution in total length for female *A. taaf*. The authors noted that *A. taaf* were caught more frequently and in higher numbers on lines set by a vessel using integrated weight autolines as opposed to trotlines, concluding that autoline may pose a greater risk to *A. taaf*.

6.5 The Working Group noted that the observed differences in size and quantity of skates could be attributed to vessel effects, gear effects, or geographical attributes such as depth. It noted that while a vessel effect was apparent in plots of catch and effort, further analyses to evaluate these factors would assist with understanding the extent to which skate by-catch is attributable to gear type. It also recalled that in other mixed-gear fisheries such as in Subarea 88.1, analyses indicated that vessel effects seem to be a more significant factor explaining by-catch levels than gear type. It further noted that CPUE standardisation models were in development for Division 58.4.3a, but due to limited overlap between vessels and gears this may need to be conducted on a subset of the data presented in WG-FSA-2019/56.

6.6 The Working Group noted that information of post-release survivorship was important to understanding the likely impact of by-catch of skates. It recalled that a survival study had been conducted by the French-flagged autoline vessel *Saint André* (WG-FSA-14/05), and had concluded that post-release skate survival was high, however, as it related to different species of skate to those by-caught in Division 58.4.3a, it was uncertain how applicable these results were in this instance.

6.7 The Working Group noted that the length–weight relationships for by-caught skates appeared different for the two vessels that had operated in Division 58.4.3a. It encouraged further analysis of this data to determine if this was due to an error in measurement or identification.

6.8 The Working Group noted that under the current move-on rule of 1 tonne per line, the move-on rule for skates has only been triggered once despite concerns raised around the by-catch patterns observed and requested the Scientific Committee to review the methods of mitigating skate by-catch in Division 58.4.3a, including the move-on rule.

6.9 The Working Group noted that for the purposes of the focused skate tagging program to be conducted in 2019/20 and 2020/21 in the Ross Sea region, all live skates up to a maximum of 15 per line should be tagged following the protocols in CM 41-01, Annex 41-01/C. As part of the maximum of 15 tagged skates per line, vessels may tag skates alive but with a low probability of survival if the condition of the skate is recorded along with the tag number during 2019/20 and 2020/21 in the Ross Sea region.

6.10 The Working Group clarified that for the purpose of the focused skate tagging program to be conducted in 2019/20 and 2020/21 in the Ross Sea region, the selection of skates for tagging would not be restricted to those in good condition and that for each skate tagged the species, disc width and injury category should be recorded along with tag numbers (WG-FSA-2018 report, paragraph 6.36).

Incidental mortality of seabirds and marine mammals

6.11 The Secretariat provided an update on incidental mortality of seabirds and marine mammals in CCAMLR fisheries during 2018/19 (WG-FSA-2019/16). The paper summarised incidental mortality associated with fishing activities collected in scientific observer and vessel data during 2018/19 as received by the Secretariat up to 8 October 2019, and included a short report, as requested by the Scientific Committee (SC-CAMLR-XXXVII, paragraph 5.22), providing details on multiple Antarctic fur seal (*Arctocephalus gazella*) mortalities that occurred during the 2017/18 season.

6.12 There were two seal mortalities reported in 2018/19 CCAMLR longline fisheries. The Working Group noted that the extrapolated total of 103 seabirds killed in the 2018/19 season was the third-lowest mortality figure on record.

6.13 In CCAMLR trawl fisheries, the Working Group noted that there had been three seabirds and three seals killed through interactions with fishing gear. The Working Group thanked the Secretariat for the report on the 19 Antarctic fur seal mortalities in the krill fishery in 2017/18. The report stated that an ineffectively attached marine mammal exclusion device (MMED) may have contributed to the issue.

6.14 Noting that MMEDs have been highly effective in reducing marine mammal mortalities, the Working Group encouraged trawl vessels to inspect their MMED in the event of any marine mammal mortality to ensure that it is in structurally good order and correctly attached.

6.15 WG-FSA-2019/60 presented results collected from surface and underwater video observations during the 2018/19 season designed to monitor the behaviour of *A. gazella* interacting with krill trawling operations in Subarea 48.3. No seals were observed inside the trawl net from the underwater video operations. The paper noted that when krill swarms were distributed deeper, this usually resulted in more aggressive behaviour as seals chased a krill-filled trawl. The Working Group noted that this study is still in progress, that analyses presented here are preliminary, and that additional detail will available on completion of the work.

6.16 The Working Group appreciated the initiation of this work and encouraged similar research to increase understanding of marine mammal interactions with trawl gear and how such interactions could be managed. However, the Working Group also noted that currently the deployment of underwater cameras is difficult and that these operations impact the fishing process negatively.

6.17 The Working Group recalled advice to the Scientific Committee that there are currently no by-catch limits for marine mammals specified for the krill fishery (WG-FSA-2018 report, paragraph 6.57).

6.18 WG-FSA-2019/31 presented a final report on fishing effort and seabird interactions during three season extension trials (1–14 April, 1–14 November and 15–30 November) in the longline fishery for *D. eleginoides* in Division 58.5.2. Due to the application of effective seabird by-catch mitigation by participating fishing vessels, the overall risk of seabird mortality in this fishery was low with 20 mortalities in total reported between 2003 and 2018. The rate of seabird mortality in the core fishing season and the existing post-season extension from 15 September to 31 October was less than 0.0001 birds per 1 000 hooks (or less than 0.1 birds per million hooks). The rates of seabird mortality for the pre-season and two post-season extension trials were comparable to that during the existing pre-season extension from 15 to 30 April.

6.19 The Working Group noted that in the last three years all seabird mortalities occurred during the season extensions while seabird mortalities had occurred prior to that during the core season. It was unclear whether there was a temporal trend or pattern in seabird mortalities during the core season due to the rare nature of these mortality events.

6.20 The Working Group noted the conclusion of the three season extension trials, with seabird mortality risk in the trial periods being highly uncertain but similar to one of the existing season extension periods. Therefore, the Working Group recommended that the specifications of the longline fishing season in CM 41-08 (CM 41-08, paragraph 3) remain unchanged.

6.21 The paper also recommended the requirement for any vessel to demonstrate full compliance with CM 25-02 in the previous season be removed from CM 41-08 (CM 41-08, paragraph 3) since there is already effective seabird by-catch mitigation by fishing vessels in this fishery both in the specification and application of seabird mortality mitigation measures. The Working Group requested that the Scientific Committee review this requirement.

6.22 WG-FSA-2019/34 presented a study investigating the effects of climate change, fisheries interactions and terrestrial invasive species on the demography of four albatross species (black-browed *Thalassarche melanophris*, grey-headed *T. chrysostoma*, light-mantled *Phoebetria palpebrata* and wandering *Diomedea exulans*) using a 20-year monitoring dataset (1995–2014) at Macquarie Island.

6.23 The paper reported that positive Southern Annular Mode indices and La Niña events correlate with increased albatross survival. Increased survival in black-browed albatross was also linked to reduced fishing effort, concurrent gear changes, and improved mitigation methods in the southwest Atlantic and Chilean fisheries. A positive effect was detected on the survival of black-browed albatrosses from the squid trawl fishery of New Zealand, suggesting a possible influence of food provisioning from discards on this population as well. There were no discernible trends associated with the success and survivorship of albatrosses breeding on Macquarie Island from CCAMLR fisheries. The paper also indicated that terrestrial habitat degradation due to rabbit grazing had a negative impact both on the survival and the probability of breeding success on albatross populations for the study species. The authors observe, however, that there were limited options to mitigate climate effects on seabird survival and breeding success.

6.24 The Working Group welcomed this integrated approach as an example for formulating management responses to various influences and effects to enhance breeding success of seabirds.

Invertebrate by-catch and vulnerable marine ecosystems (VMEs)

6.25 The Working Group recalled that a dedicated VME Workshop was held in 2009 (WS-VME-09) (SC-CAMLR-XXVIII/10) and that conclusions of this Workshop were set out in SC-CAMLR-XXIX, paragraph 9.37, and reflected in CMs 22-06 and 22-07, as well as in the SISO observer manual. The Working Group also recalled that SC-CAMLR-XXXVII, and the WG-EMM-2019 report, paragraphs 6.39 and 6.40, recommended further work on VMEs and VME indicator taxa. The Working Group also noted that CM 22-06, paragraph 15, stated that the Scientific Committee would review that conservation measure every two years and that CM 22-07, paragraph 9, indicated that the conservation measure should be reviewed in 2012. Considering the varying degrees of progress on these items, the Working Group recognised that the development of a work plan to review bottom fishing impacts on VMEs in the Convention Area was overdue.

6.26 The Working Group noted that since WS-VME-09, new technologies and methods have emerged and are becoming more accessible. These technologies, such as benthic cameras and electronic monitoring have the potential to rapidly progress questions around VMEs relevant to CCAMLR (paragraphs 6.34 to 6.38).

6.27 The Working Group noted that there is a need to review VME data collected to date within the Convention Area and provide a synthesis of results. Such an assessment would serve as a starting point in the development of a VME workplan. The Working Group identified a range of topics that should be considered as part of a review on CCAMLR VME protocols and bottom fishing impacts and these are set out in Table 12 and recommended that the table were considered as a basis for a VME work plan for the Scientific Committee.

6.28 The Working Group requested the Scientific Committee to identify the best mechanism to go forward with a review and workplan (e-group, virtual meetings, workshop or any other means), noting that the diverse range of expertise needed (including benthic taxonomists, fisheries experts, ecologists and modellers) may not be present at a typical meeting of the Working Group.

6.29 The Working Group noted that CCAMLR had been at the forefront of developing VME encounter protocols and that many regional fisheries management organisations (RFMOs) had now also developed procedures for reporting on VME encounters, and that a review of methods conducted outside CCAMLR could provide useful information to a review of the CCAMLR process.

6.30 The Working Group noted that summary information is provided via the CCAMLR website but requested that the Secretariat routinely provide more detailed information in spatial and temporal trends in VME triggers to WG-FSA. Noting the issues regarding the collection of by-catch information highlighted by the Scientific Committee in 2018 (SC-CAMLR-XXXVII, paragraph 5.17), the Working Group requested that the Secretariat undertake an analysis of VME data collection practice on board vessels across the Convention Area, comparing encounter rates between vessels and regions in a manner inspired by the assessment of by-catch reporting (WG-SAM-15/23 and WG-FSA-18/67).

6.31 The Working Group recommended that CCAMLR VME taxa identification materials be reviewed and evaluated, including an assessment of whether the current VME taxa list is comprehensive and appropriate. The Working Group noted that the CCAMLR VME indicator taxa guide would need to be revised in light of the work carried out as part of the CCAMLR taxon data project (WG-FSA-2019/14).

Determining fishing footprint

6.32 An updated method for calculating the CCAMLR fishing footprint was presented (WG-FSA-2019/67). The method used a data-derived estimate of the uncertainty around the locations of longlines to define a buffer around these lines. Within a georeferenced framework, buffered lines are then matched to a 10 km grid. The proportion of the area of each grid cell that is covered by buffered lines is then used as a footprint index. Accuracy of line position on the seabed was an issue that may affect the footprint estimates.

6.33 The Working Group recommended that the new method for assessing fishing footprint presented in WG-FSA-2019/67 be reviewed and compared with existing methods such as presented in WG-SAM-10/20 and WG-FSA-18/43 and be presented at WG-SAM-2020.

Determining fishing impact on seabed and use of electronic monitoring

6.34 The Working Group noted that a comparison between electronic monitoring results and benthic camera observation could provide a good assessment of the accuracy of VME reporting by vessels and provide an estimate of organisms lost during hauling.

6.35 The Working Group noted that electronic monitoring (e.g. WG-FSA-2019/13; CCAMLR-38/BG/40) should be encouraged and could be used for assessing VME taxa. The Working Group encouraged Members to provide analyses of data on the detection of VME indicator species during hauling comparing observer-derived observations with electronic monitoring.

6.36 The Working Group noted that gear interactions with the seabed have been addressed in the past (e.g. WG-SAM-10/20), however, new methods have been developed and new technology is now available that can be used to assess impacts of gears more directly. WG-FSA-2019/24 reported on benthic cameras and movement sensors deployed on longlines (autolines). Results showed that horizontal line movement was very limited (10's of centimetres rather than 10's of metres) and occurred mostly during hauling. Habitats observed in footage were mostly unconsolidated or gravel substratum with low levels of density of epibenthic organisms. Benthic organisms that were observed were mostly restricted to dropstones and rarely encountered. The data collected on line movement will be used to model the behaviour of autolines on the seabed.

6.37 The Working Group noted that VME taxa observed at the surface may only be a portion of those impacted. Benthic cameras are becoming cheaper and widely available and can be used to provide direct observations of gear interactions with the seabed (e.g. WG-SAM-2019/03). Systematic camera deployments on lines would help to develop a greater understanding of benthic habitats, VME indicator taxa distribution and could be used to inform on the development of VME management strategies in the future.

6.38 A further advantage of in situ benthic cameras would be data collected to help understand differences in VME reporting from vessels using autolines and vessels using Spanish lines or trotlines and whether these differences are linked to gear type. The Working Group encouraged Members to use benthic cameras more widely.

Thresholds, risk areas and move-on rules

6.39 An example of taxon-specific thresholds to trigger risk areas was presented at WG-EMM (WG-EMM-2019/52) and an R code provided in WG-FSA-2019/46. These papers use sea pen data collected in research block 5844b_2 and show that despite the high number of individual organisms collected, no threshold was reached. The issues that were identified were a result of the low weight and small volume of sea pens. The probability of reaching a 5-VME-unit threshold was shown to be null whereas the probability of reaching a 2.5-VME-unit threshold would be much higher and more appropriate for the sea pen assemblage. The Working Group noted that light or heavy weight organisms have different probabilities to trigger thresholds and this should be more systematically investigated. The R code provided in WG-FSA-2019/46 may provide a starting point to evaluate differential thresholds as a function of mass.

6.40 The Working Group recommended, as suggested in WG-FSA-18/51, that since multiple taxa may be encountered, the use of measures of diversity (taxonomic or functional) of taxa should be further investigated as part of the trigger threshold in CM 22-07.

6.41 The Working Group noted that additional camera deployments following VME encounters could provide more comprehensive information on the composition, distribution and extent of VMEs and to better characterise risk areas. The Working Group noted that VME encounter protocols could be revised in order to obtain this additional information on VME distribution and that a suitable sampling strategy would need to be developed as part of this.

6.42 The Working Group recommended that analysis methods for incorporating new (electronic monitoring and camera) data streams and external data streams (e.g. from research voyages), including distribution modelling, should be considered. The Working Group noted that accurate VME taxa reporting is necessary to provide presence data for single or multi-species modelling. Benthic cameras could be used to provide an extensive set of environmental and taxonomic data (substratum type, organisms 3D structure and coverage, diversity). The Working Group recalled that modelling techniques for data-deficient areas should be investigated to produce suitable habitat maps that have been identified as useful to put by-catch observation in a broader context (WG-EMM-2019 report, paragraph 6.38).

Marine debris

6.43 The Secretariat presented WG-FSA-2019/18 on gear loss as reported by longline vessels for the 2017/18 and 2018/19 fishing seasons, including differences in the rate of loss by gear type. There was no difference in the relative rates of reporting of lost hooks by gear type, however, there was a significant difference found in the frequency of complete line loss, with trotline gear having higher rates of complete line loss than Spanish or autoline gear.

6.44 The Working Group noted the importance of accurate reporting of gear loss by vessels to understand environmental impacts, particularly given that longline gear often contains polymer materials that degrade slowly, and that gear loss is cumulative over time. The Working Group recommended that a 'length of line lost' data field be included in the C2 data form and that instructions on completing fields on gear loss be clarified in a fishery data manual.

6.45 The Working Group further considered the need to identify and understand causes of gear loss, noting that there are numerous circumstances that may lead to gear loss events. The Working Group recommended that a description of the circumstances that led to a line being lost should be provided along with the C2 data when they are submitted to the Secretariat in order to evaluate the information requirements for a text field to be included in the future C2 form to enable routine reporting of causes of gear loss to be specified.

6.46 Further research and monitoring of gear loss causes and trends were encouraged in order to progress understanding and subsequent advice to support reduction and mitigation of ALDFG, noting that increased application of environmental monitoring may assist in accurate reporting of gear loss.

6.47 The Working Group recommended that the Secretariat continue to report on gear loss in the Convention Area annually and suggested that future updates consider temporal trends throughout the season as well as relation of gear loss to capacity.

6.48 The Working Group considered WG-FSA-2019/04 that detailed the use of pop-up buoys for short-term deployment of scientific instruments on the sea floor and recommended that the Working Group consider the use of techniques such as the acoustic pop-up buoy recovery systems in longline fisheries to reduce potential gear loss, particularly in areas with high sea-ice cover.

6.49 The Working Group agreed that this was an important topic to consider and communicate back to the fishing industry, noting that trial and implementation of available technology would be important to assess impacts on frequency of gear loss. It was also noted that use of this type of gear would need to be in accordance with appropriate gear marking requirements as detailed in CM 10-01.

6.50 The Working Group considered SC-CAMLR-38/09 which reviewed the CCAMLR Marine Debris Program, current methodology and data submission procedures, and emerging issues and current knowledge of marine debris levels in the Southern Ocean. The paper highlighted the difficulty in quantifying and monitoring marine debris levels, trends and associated impacts across the Convention Area due to the spatial scale at which data is currently collected and considered ways in which the program could be modernised.

6.51 The Working Group agreed that the review was timely and that further work would be required to identify how to best use current marine debris data holdings, as well as identifying potential sources for currently collected marine debris data, noting that monitoring of microplastics should be incorporated into the program.

6.52 The Working Group supported the recommendation in SC-CAMLR-38/09 that the Scientific Committee establish an Intersessional Correspondence Group on Marine Debris (ICG-MD) to review and develop the CCAMLR Marine Debris Program, which could include defining its objectives, developing program materials and methodology and developing an analytical approach that would allow for quantification of marine debris levels across the Convention Area.

Future work

By-catch and ecosystem considerations

7.1 The Working Group recalled that it had previously been tasked with several wider ecosystem considerations of fishery impacts, including by-catch limits in the krill fishery, regional risk assessments for non-target species, VME protection and management, and incidental mortalities of seabirds and marine mammals, as well as consistent by-catch reporting and reporting requirements by vessels on shark by-catch.

7.2 Recalling discussion at WG-FSA (WG-FSA-2018 report, paragraphs 6.11 to 6.14), the Working Group noted that alternative methods for setting fish by-catch limits might need to be developed further and evaluated. In 2018, the Working Group recommended that the Scientific Committee consider the development of a by-catch work plan that could include the development of standardised reporting metrics and risk assessment methods. The Working Group recommended that a focus topic on the assessment of status of fish by-catch could be scheduled for WG-FSA-2020 to advance this work further.

Cooperation with other organisations

7.3 The Working Group noted that the 10th International Fisheries and Monitoring Conference was planned to be held in Hobart, Australia, from 1 to 5 March 2021 and that this conference would provide opportunities for Members to engage in operational and data collection issues in scientific observer programs outside of CCAMLR.

7.4 The Working Group noted the Scientific Committee on Antarctic Research (SCAR) Open Science Conference to be held in Hobart, Australia, from 31 July to 11 August 2020 and in particular its session on the role of fish in the Antarctic ecosystem. The Working Group agreed on the importance of the cooperation between CCAMLR, SCAR and other organisations or individuals to ensure the use of the latest science advancements in CCAMLR's management approaches.

Spatial planning in Domains 4, 5 and 6

7.5 The Working Group noted the intersessional Expert Workshop on Pelagic Spatial Planning for the eastern sub-Antarctic region (Domains 4, 5, and 6) held in Cape Town, South Africa, from 26 to 30 August 2019 (SC-CAMLR-38/29), noting, in particular, the related results of the genetic work and stock connectivity for *D. mawsoni* presented to the Working Group (WG-FSA-2019/P01).

Notifications of other scientific research

7.6 WG-FSA-2019/58 indicated the intent to continue the quadrennial POKER Survey (multi-species survey focusing on shallow areas), which is scheduled for 2021 and aims to track juvenile abundances of *D. eleginoides* in Division 58.5.1.

7.7 WG-FSA-2019/32 indicated the intent to continue a comprehensive monitoring program which includes an annual random stratified trawl survey to consolidate and estimate recent trends in YCS in *D. eleginoides* in Division 58.5.2.

7.8 The Working Group noted the start of a PhD thesis that focused on skates in French EEZs and the request of the proponents for feedback and collaboration on the subject. It further noted that presentation of this work would be useful to include at WG-FSA-2020 if a focus topic on by-catch was agreed as a priority.

7.9 The Working Group noted Australian projects led by the Institute for Marine and Antarctic Studies, including a project aiming to map the distribution of benthic fauna and assemblages on the Antarctic continental shelf and a project which will focus on the impacts of recent environmental variability on *D. eleginoides* catch at Heard Island and McDonald Islands, and looked forward to results from this work being presented at future Working Group meetings.

7.10 The Working Group noted the large number of potential areas for other future work throughout its report and encouraged Members to contribute work to address these.

Other business

Circular from Russia

8.1 The Working Group discussed a letter from Russia regarding the current meeting of WG-FSA that was issued on 14 October 2019 as COMM CIRC 19/104–SC CIRC 19/94.

8.2 The Working Group agreed that this was an unprecedented situation with a Commission circular from a Member providing direction on the content of the report of the Working Group prior to the conclusion of the scientific discussions and the preparation of the draft report. The Working Group expressed its concern that an unprecedented intervention such as this was not consistent with the normal conduct of scientific discussions in the Working Group.

8.3 The Convener reiterated his comments made at the opening of the meeting that, where consensus could not be reached, alternative scientific hypotheses would be reflected in the report following the normal practice of the Working Group and consistent with the Rules of Procedure of the Scientific Committee.

8.4 The Working Group expressed its strong support for the Convener in his conduct of this and previous meetings of the Working Group and his approach to achieving consensus on science-based management advice.

8.5 The Working Group requested that the Scientific Committee and the Commission consider the content of COMM CIRC 19/104–SC-CIRC 19/94 and provide guidance on the provision of science-based advice from the Working Group.

Electronic monitoring on fishing vessels

8.6 WG-FSA-2019/13 presented examples demonstrating the use of electronic monitoring in the Ross Sea longline toothfish fishery and indicated that such an approach would support research by automating tasks that do not require human effort (e.g. by recording the deployment and operation of a tori line during line setting and other line observations) hence enabling observers to allocate more effort to other – arguably more important – tasks.

8.7 Dr S.-G. Choi (Korea) informed the Working Group that the Korean vessel *Greenstar* is going to use similar electronic monitoring equipment as described in WG-FSA-2019/13 during its research fishing in Subarea 88.3 in 2019/20 and that the data collected during this period would be analysed as part of the multi-Member collaboration in that research fishing.

8.8 CCAMLR-38/BG/40 presented an introduction to electronic monitoring on longline fishing vessels that included information from, inter alia, video cameras, warp sensors and global positioning systems (GPS) and outlined the potential application of this monitoring to assist data collection on vessels. The electronic monitoring system described in CCAMLR-38/BG/40 is installed and secured by a third-party provider and provides an independent means for evaluation of compliance-related events.

8.9 The Working Group welcomed the development of electronic monitoring and agreed that these approaches would help improve the accuracy of data collection in the Convention Area (Table 2). The Working Group noted that electronic monitoring data should not be viewed as a replacement for SISO observers but provides improved efficiency of vessel operations, including improved approaches to the provision of catch reporting data required by CCAMLR. Information to improve understanding of vessel operations and practices that allow more comprehensive analyses enhanced interpretation of conventional data collection.

8.10 The Working Group recommended that the Scientific Committee consider the requirement for electronic monitoring on fishing vessels undertaking research under CM 24-01, paragraph 3.

Trophic biomarkers

8.11 WG-FSA-2019/26 presented a combined fatty acids and stable isotopes approach to investigate the feeding ecology of marbled rockcod (*N. rossii*) and black rockcod (*N. coriiceps*) in the western Antarctic Peninsula. The trophic biomarkers used in the study did not elucidate which was the main prey item as lipid source for *N. rossii* and *N. coriiceps*, suggesting the need for further investigations.

8.12 The Working Group welcomed this study and encouraged the authors to analyse different trophic biomarkers to improve our understanding of the feeding ecology of these species and also to extend the spatial and temporal scale of the study as this is likely to further elucidate differences between species compared to sampling in a single location in one year.

Cetacean interactions with fishing vessels

8.13 WG-FSA-2019/50 presented an easy-to-implement approach to photographing cetaceans using a relatively inexpensive camera system to increase the information available for whale photo identification from fishing vessels and to encourage more Members to engage in the collection of photographic data.

8.14 The Working Group welcomed the detailed technical description provided in WG-FSA-2019/50 and encouraged the collection of photographs of cetaceans on all vessels operating in the CCAMLR area noting the great potential for this data in quantifying and monitoring the effects of depredation on fish stocks as well as understanding cetacean interactions with krill vessels (WG-EMM-2019 report, paragraphs 4.49 and 4.50).

Information from the SIOFA area

8.15 WG-FSA-2019/45 presented an analysis of *D. eleginoides* data collected from observers on board vessels which operated between 2017 and May 2019 in waters managed by the Southern Indian Ocean Fisheries Agreement (SIOFA) (within FAO Subareas 51.7 and 57.4), adjacent to the Convention Area. The analysis included fish weight, length, sex and tagging data from these areas.

8.16 The Working Group noted that this analysis confirmed existing stock hypotheses for this region in respect of the connectivity between toothfish population in the SIOFA area with those around Crozet, Kerguelen and Heard Islands. The Working Group also noted the occurrence of very long soak times, in some case over 100 hours, and the potential importance of these in the analysis of any trends in CPUE that might indicate local depletion.

8.17 The Working Group also noted that the Spanish vessels fishing for toothfish in the SIOFA area collected observer data according to the SISO protocol. The Working Group suggested that CCAMLR Members that undertook fishing on toothfish populations that are included in existing assessments considered by CCAMLR voluntarily provide relevant catch and observer data to CCAMLR until a data-sharing scheme between CCAMLR and SIOFA is agreed.

8.18 WG-FSA-2019/54 presented an analysis of photo-identification data of killer whales and sperm whales in the southern Indian Ocean using French observer data from the Crozet Islands and Spanish observer data on del Cano Rise in the SIOFA area. Of the 37 individual killer whales identified from the del Cano Rise fishery, 26 of these have also been observed interacting with longline vessels in the Crozet and/or Kerguelen Islands. Based on the available data from the period 2009–2019, depredation rates on longlines targeting *D. eleginoides* in the del Cano Rise in the SIOFA area were estimated to be 7.5%.

8.19 The Working Group welcomed the collection of cetacean interaction data in the SIOFA area that enhances the understanding of the ecology of cetacean species, the connectivity of populations and, more importantly, the impacts and patterns of interactions with fisheries. The Working Group asked the Commission to bring this document and the importance of these depredation rates in estimates of removals and management of toothfish to the attention of SIOFA.

Bathymetry data

8.20 The Working Group noted that a 2019 update of bathymetry data had been released by GEBCO and requested that this data be incorporated into the CCAMLR GIS and made available for downloading by Members. The Working Group also requested that the Secretariat provide an analysis of any changes in the estimates of fishable areas used in the estimates of local biomass in exploratory fisheries.

Survey update

8.21 Dr J. Devine (New Zealand) provided an update on the Ross Sea winter survey that was taking place at the time of the meeting, the Working Group looked forward to receiving the results from the survey in due course. Dr Devine also provided an update on the benthic camera to be deployed on New Zealand fishing vessels in the coming season.

Advice to Scientific Committee

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

(i) Reconciliation of CDS and monthly fine-scale catch and effort data –

  (a) all data collected on the *Calipso*, *Koreiz* and *Simeiz* from 2015 to 2018 be quarantined by the Secretariat (paragraph 2.15).

(ii) Catch and effort data and biological observations from CCAMLR fisheries –

    (a) development of the proposed new C2 form and fishery data manual (paragraph 2.22)

    (b) removal of the requirement to complete the B2 form where currently specified in the conservation measures (paragraph 2.22)

    (c) for vessels to report aggregated VME data (paragraph 2.22).

(iii) Fishery monitoring and closure procedures –

    (a) include the complete two-stage process for the forecasting and closure process for exploratory toothfish fisheries as an annex to the Scientific Committee report (paragraph 2.25).

(iv) Catch limits for *C. gunnari* in Subarea 48.3 and Division 58.5.2 (paragraphs 3.5 and 3.9).

(v) CCAMLR decision rules –

    (a) investigating potential refinements of the CCAMLR decision rules (paragraph 3.21)

    (b) provision of advice on precautionary catch limits for all the assessed stocks and research proposals on the basis of the best available science (paragraph 3.40).

(vi) Management advice for *Dissostichus* spp. –

    (a) lack of agreement that the CCAMLR management of all of its fish stocks is precautionary (paragraph 3.39)

    (b) advice based on the use of best available science in the assessments on what catch level would be consistent with the CCAMLR decision rules (paragraph 3.39).

(vii) *D. eleginoides* in Division 58.5.1 and 58.6 –

    (a) prohibition of directed fishing for *D. eleginoides*, described in CM 32-02, remain in force in 2019/20 (paragraphs 3.84 and 3.99).

(viii) *D. eleginoides* in Division 58.5.2 –

    (a) advice on alternative harvest strategies for stocks where recent patterns of weak year classes were apparent in the fishery (paragraph 3.91)

    (b) prohibition of directed fishing for *D. eleginoides*, described in CM 32-02, remain in force in 2019/20 (paragraph 3.93).

(ix) Conversion factors –

    (a) conversion factor workshop, or focus topic, would be of great benefit to the work of WG-FSA (paragraph 4.7).

(x) Vessel tagging survey –

(a) benefit of a workshop on tagging protocols and procedures be included in future work plans (paragraph 4.24).

(xi) Fishery status and the regulatory framework –

(a) clarification of the status of toothfish fisheries in Subarea 88.1 and SSRUs 882A–B, Division 58.4.4 and Division 58.4.3b (paragraph 4.32)

(b) benefit of a clear strategy from the Commission as to how the regulatory framework can be interpreted to assist the development of scientific advice for toothfish fisheries (paragraph 4.33).

(xii) Subarea 48.1 –

(a) catch limit for effort-limited survey in Subarea 48.1 (paragraph 4.40).

(xiii) Special research zone –

(a) request to take poor historical tagging performance into account in its consideration of research plan (paragraph 4.159).

(xiv) Subarea 88.2 –

(a) notifications for fishing in SSRUs 882C–H be included in CM 21-02, paragraph 6(iii) (notifications for participation in exploratory fisheries for *Dissostichus* spp.) for data-limited exploratory fisheries (paragraph 4.176).

(xv) Crab fishing –

(a) future research should be conducted under CM 24-01 or considered as new fishery under CM 21-01 (paragraph 4.196).

(xvi) Incidental mortality of seabirds and marine mammals –

(a) requirement for any vessel to demonstrate full compliance with CM 25-02 in the previous season be removed from CM 41-08, paragraph 3 (paragraph 6.21).

(xvii) Invertebrate by-catch and VMEs –

(a) development of a VME work plan (paragraphs 6.27 and 6.28).

(xviii) Marine debris –

(a) description of the circumstances that led to a line being lost provided along with C2 data (paragraph 6.45)

(b) support for the establishment an Intersessional Correspondence Group on Marine Debris (paragraph 6.52).

(xix) Future work –

(a) assessment of status of fish by-catch and methods for setting fish by-catch limits (paragraphs 6.8 and 7.2).

(xx) Provision of science-based advice –

(a) request for guidance on the provision of science-based advice from the Working Group given the content of COMM CIRC 19/104–SC CIRC 19/94 (paragraph 8.5).

(xxi) Information from the SIOFA area –

(a) depredation rates in estimates of removals and management of toothfish brought to the attention of SIOFA (paragraph 8.19).

Adoption of the report and close of the meeting

10.1 The report of the meeting was adopted.

10.2 At the close of the meeting, Dr Welsford thanked all participants for their patience and dedicated work that had allowed the Working Group to make significant progress in addressing the priorities of the Scientific Committee. Dr Welsford also highlighted the positivity and collaboration between many Members, and thanked the rapporteurs and the Secretariat for their efficiency and support throughout the meeting.

10.3 On behalf of the Working Group, Mr Maschette and Mr Somhlaba thanked Dr Welsford for his even-handedness and good humour when guiding the Working Group through a large, and at times challenging, work program and thanked him for the leadership he had provided over four years of serving as WG-FSA Convener.

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Table 1: Gear details for vessels that have notified to fish in exploratory toothfish fisheries in 2019/20 (source www.ccamlr.org/compliance/licensed-vessels).

Vessel	Flag	Statistical Area(s)	Gear type	Integrated weight line	Integrated weighting	Longline weights	Minimum mass longline weights	Maximum spacing between weights	Number of hooks per cluster	Spacing between hook clusters	Spacing between droplines	Number of clusters per dropline	Hook spacing	Snood length
Altamar	Uruguay	88.1, 88.2	Autoline	Y	50								1.4	0.48
Antarctic Discovery	Australia	58.4.1, 88.1, 88.2	Autoline	Y	50								1.4	0.45
Antarctic Chieftain	Australia	58.4.1, 58.4.2	Autoline	Y	50								1.4	0.45
Argos Froyanes	United Kingdom	88.1, 88.2	Autoline	Y	50								1.6	0.4
Argos Georgia	United Kingdom	88.1, 88.2	Autoline	Y	50								1.4	0.4
Calipso	Ukraine	88.1, 88.2	Spanish			Y	9	70					1.5	0.7
Calipso	Ukraine	88.1, 88.2	Trotline			Y	8	28	5	0.5	28	2		
Cap Kersaint	France	58.4.1	Autoline	Y	50	Y		9.6					1.2	0.35
Globalpesca I	Chile	88.1, 88.2	Trotline			Y	6	17	7	5	20	1		
Greenstar	Korea, Republic of	88.2	Trotline			Y	5	35	5	0.5	35	5		
Hong Jin No. 707	Korea, Republic of	58.4.1, 88.1, 88.2	Trotline			Y	5	32	5	0.5	32	3		
Janas	New Zealand	88.1, 88.2	Autoline	Y	50		5						1.4	0.4
Janas	New Zealand	88.1, 88.2	Autoline	Y	50		5						1.4	0.59
Kingstar	Korea, Republic of	58.4.1, 88.1	Trotline			Y	5	35	5	0.5	35	5		
Koreiz	Ukraine	88.1, 88.2	Spanish			Y	9	70					1.5	0.7
Koryo Maru No. 11	Japan	58.4.1, 58.4.2, 88.1, 88.2, 48.6	Spanish			Y	10.62	40					1.5	1

(continued)

Table 1 (continued)

Vessel	Flag	Statistical Area(s)	Gear type	Integrated weight line	Integrated weighting	Longline weights	Minimum mass longline weights	Maximum spacing between weights	Number of hooks per cluster	Spacing between hook clusters	Spacing between droplines	Number of clusters per dropline	Hook spacing	Snood length
Koryo Maru No. 11	Japan	58.4.1, 58.4.2, 88.1, 88.2, 48.6	Trotline			Y	10.62	50	5	0.5	80	9		
Kostar	Korea, Republic of	88.1, 88.2	Trotline			Y	5	23	5	0.5	23	4		
Marigolds	Ukraine	88.1, 88.2	Trotline			Y	8	15	5	0	20	1		
Marigolds	Ukraine	88.1, 88.2	Trotline			Y	8	25	5	0.5	25	3		
Nordic Prince	United Kingdom	88.1, 88.2	Autoline	Y	50								1.4	0.4
Palmer	Russian Federation	58.4.1, 88.1, 88.2	Autoline	Y	50								1.4	0.4
Polus I	Ukraine	88.1, 88.2	Spanish			Y	9	70					1.5	0.7
Polus I	Ukraine	88.1, 88.2	Trotline			Y	8	20	8	0	20	1		
Polus I	Ukraine	88.1, 88.2	Trotline			Y	8	25	4	0.5	25	3		
Polus I	Ukraine	88.1, 88.2	Trotline			Y	8	30	4	0.5	30	2		
Saint André	France	58.4.1, 58.4.2	Autoline		50		5	20					1.4	0.47
San Aotea II	New Zealand	88.1, 88.2	Autoline	Y	50	Y	5	1.4					2.2	1.4
San Aotea II	New Zealand	88.1, 88.2	Autoline	Y	50	Y	5	1.4					1.4	0.5
Shinsei Maru No. 3	Japan	58.4.1, 58.4.2, 88.1, 88.2, 48.6	Trotline			Y	10	45	5	0.5	45	5		
Simeiz	Ukraine	88.1, 88.2	Spanish			Y	9	70					1.5	0.7
Simeiz	Ukraine	88.1, 88.2	Trotline			Y	8	28	5	0	28	1		

(continued)

Table 1 (continued)

Vessel	Flag	Statistical Area(s)	Gear type	Integrated weight line	Integrated weighting	Longline weights	Minimum mass longline weights	Maximum spacing between weights	Number of hooks per cluster	Spacing between hook clusters	Spacing between droplines	Number of clusters per dropline	Hook spacing	Snood length
Sparta	Russian Federation	58.4.1, 88.1, 88.2	Autoline			Y	5	50					1.2	0.4
Sparta	Russian Federation	58.4.1, 88.1, 88.2	Spanish				10.5	80					1.2	0.4
Sunstar	Korea, Republic of	88.1, 88.2	Trotline			Y	5	35	5	0.5	35	5		
Tronio	Spain	58.4.1, 88.1, 48.6	Spanish			Y								
Volk Arktiki	Russian Federation	58.4.1, 88.1, 88.2	Autoline	Y	200								1.4	0.4

Table 2: Outcome of the review of the recommendations of the COLTO–CCAMLR Workshop (WG-FSA-2019/01).

COLTO–CCAMLR Workshop recommendations	WG-FSA-2019	Outcome
There needed to be a better facility for recording multiple bait types and the proportion of bait type used per line.	Endorsed recommendation	Proposed new C2 form contains additional bait type and proportion fields
A detailed description of how baiting percentage was estimated by Members was necessary.	Endorsed recommendation	Clarify method of calculation in C2 form instructions
Hook size should be recorded once per voyage as vessels did not change this over the course of a trip. The addition of measurement fields to categorise hook types would be useful.	Endorsed recommendation	Measurement fields added to proposed new C2 form
The hook code field did not provide useful information given the increasing number of manufacturers and potential differences in hooks. It was recommended that the fishing industry should approach gear manufacturers to receive hook specification sheets that may further inform how this data should best be captured. It was recommended that this information, including photographs of hooks, snoods and swivels would be useful to capture for lost gear identification purposes and for WG-FSA to consider how best to collect and store that data.	Endorsed recommendation	Consider submitting photographs as part of vessel gear notifications
Removal of the ‘number of other hooks lost’ field as the vast majority of hooks that are lost are those attached to lost sections of line.	Recommendation not supported	Retain hooks lost not attached to sections of line field and addition of a field on length of line lost to proposed new C2 form. Clear instructions on how to complete these fields to be specified in C2 form instructions
The number of droplines per line be included for trotline gear, which was recommended at WG-SAM (WG-SAM-2019 report, paragraph 6.9).	Endorsed recommendation	Proposed new C2 form contains droplines field
Clarity is required in conservation measures regarding UTC being the default for season and small-scale research units (SSRU) openings and closures.	Endorsed recommendation	Addition of UTC timing text to appropriate conservation measures
The Workshop reinforced that all setting/hauling positions/times should be based on anchor deployment/retrievals at the surface and recommended that this should be clear in the instructions.	Endorsed recommendation	To be clearly specified in C2 form instructions
Hauling positions should also be recorded in the C2 form as per the observer data form.	Endorsed recommendation	Proposed new C2 form contains hauling position fields
A haul interruption field be added for the benefit of data users.	Endorsed recommendation	Proposed new C2 form contains hauling interruption field

(continued)

Table 2 (continued)

COLTO–CCAMLR Workshop recommendations	WG-FSA-2019	Outcome
It was noted that bottom-to-line distances may be altered during fishing in double-line systems with an aim to reduce by-catch rates. The Workshop suggested that an analysis be performed and provided to WG-FSA to see if this effect was observed in the data.	Endorsed recommendation	
Removal of the 'setting direction (bearing)' field, as the assumption of setting in a straight line is generally not correct.	Endorsed recommendation	Bearing field removed in proposed new C2 form
Clarity on instructions for vessel requirements to mark gear and report unit segments for vulnerable marine ecosystem (VME) data was required.	Endorsed recommendation	Secretariat consult with Members on methods of marking gear and to specify instructions in fishery data manual
As different product grades could necessitate differing conversion factors, being able to utilise more than three conversion factors in a single line would be useful, and utilising a format similar to the observer longline logbook could achieve this. This could also help with reconciliation of C2 data and Catch Documentation Scheme for *Dissostichus* spp. (CDS) data if the ability to record the same product type multiple times was available on a *Dissostichus* catch document (DCD).	Endorsed recommendation noting that it would be necessary to record product weights for each conversion factor used on each haul for CDS reconciliation purposes	Product weight field introduced on the conversion factor worksheet of the proposed new C2 form
The VME requirements in the C2 form are aggregated from the VME fine-scale reports, and it was recommended that the aggregated VME requirements therefore be removed from the C2 forms.	Endorsed recommendation	Aggregated VME fields removed in proposed new C2 form
Consolidation of CE forms and C2 forms would reduce the workload on vessel operators in some fisheries. Support was expressed for form consolidation in fisheries with 5-day and 10-day CE reporting requirements, however, feasibility concerns were expressed in fisheries where daily CE reporting is required, due to the 0600h deadline for daily reports.	Endorsed recommendation	Move to consolidated reporting once new C2 form is introduced. New C2 form would be submitted at the current CE form frequency, with consequent conservation measure changes required.
As tagging data is a vessel responsibility, vessels should report tagging data. Operationally, observers can still assist with collection of data and completion of forms.	WG-FSA noted that non-reporting of tag data by vessels is a compliance issue, and encouraged vessels to work with observers to ensure tagging data was consistent between observer and vessel submissions	
At the end of the reporting period, vessels should only report completed hauls rather than partially completed hauls. Any data resubmission should include the full form.	Endorsed recommendation	To be clearly specified in C2 form instructions

(continued)

Table 2 (continued)

COLTO–CCAMLR Workshop recommendations	WG-FSA-2019	Outcome
Feedback at the individual vessel level may be a valuable tool to improve vessel data quality, and information on tag-overlap statistic and tagging recapture information relative to the overall fleet operating in that fishery would be greatly appreciated by the fishing industry.	WG-FSA noted the feedback reports supplied by the Secretariat for observer data submissions and agreed that vessel feedback reports would be valuable	Secretariat will work with Members intersessionally to develop feedback reports for vessel C2 submissions
As the requirement to submit fine-scale biological data was now covered under the Scheme of International Scientific Observation (SISO), references to the requirement for vessels to submit B2 data should be removed from the relevant conservation measures.	Endorsed recommendation	Will require removal of B2 references in appropriate conservations measures
Requirements on observer and vessel reporting forms should be consistent where relevant, particularly for set/haul positions and tagging data.	Endorsed recommendation	Proposed new C2 form format has been aligned with observer longline logbook where possible
A fishery data manual be developed to provide clear instructions on how to complete data fields on the C2 forms.	Endorsed recommendation	Secretariat to develop fishery data manual with assistance from Members via e-group intersessionally
The specification of the role of fishery data coordinators should be undertaken by Members.	Endorsed recommendation	Secretariat to coordinate role and detail responsibilities
Electronic monitoring could assist in managing observer workloads and improve task prioritisation.	Noted	Refer paragraphs 8.6 to 8.9
Electronic monitoring can be used to resolve potential disputes or uncertainties that can arise during deliberations at the Standing Committee on Implementation and Compliance (SCIC).	Noted	CCAMLR-38/BG/40 will be presented to SCIC
A presentation to SCIC on electronic monitoring would be useful, which could include proposals on minimum monitoring standards.	Noted	CCAMLR-38/BG/40 will be presented to SCIC

Table 3: Recommendations from the Stock Assessment Review for Toothfish extracted verbatim from the report (SC-CAMLR-XXXVII, Annex 5, where further description of these points can be found) and progress to date. RP – review panel, SC – Scientific Committee, SA – stock assessments, VB – von Bertalanffy.

RP comments	Description of work	Cross-reference	Status
Documentation			
1. It is recommended that a standardised format be developed by CCAMLR for the presentation of details of assessments to facilitate understanding of the assumptions, data preparation and inputs, parameter estimation and results across the assessments performed by CCAMLR, and that a public summary document with these details be developed and updated at a fixed period (e.g. five years).	Stock Annex template being developed	WG-FSA-2019/08, WG-SAM-2019/35	In progress
Stock hypotheses			
2. A number of assessments described the proposed stock hypotheses and described ideas for future work. The RP suggests that appropriate experts be consulted, and a review be planned if these assessments or CCAMLR require evaluation of the hypotheses.	Description of stock hypothesis. Genetics, otolith shape, otolith microchemistry	WG-FSA-2019/32, WG-FSA-2019/36, WG-FSA-2019/59, WG-FSA-2019/61, WG-FSA-2019/P01	Ongoing
Surveys			
3. Where possible, such surveys should be continued and optimised to ensure recruitment variability can be detected.	Survey reports from Subarea 88.1 and SSRUs 882A–B, Division 58.5.2 and Subarea 48.3	WG-SAM-2019/03, WG-FSA-2019/03, WG-FSA-2019/20	Ongoing
4. Subareas 88.1/88.2 – Consideration should be given to restricting the data from the survey to be more representative of recruitment.		WG-FSA-2019/08	Complete
5. Subareas 88.1/88.2 – Consideration should be given to designing the [Ross Sea shelf] survey to take this into consideration or increasing the catch limit, so that the unused catch limit can be released after the survey, or by releasing excess fish, etc.	The survey catch limit has only been reached once in the timeseries		Low priority
6. Division 58.5.2 – a more appropriate approach to fitting the survey might be to fit the index-at-age data using a multivariate likelihood function and the empirical variance-covariance matrix.	Sensitivity – method yet to be developed		Future work

(continued)

Table 3 (continued)

Review panel comments	Description of work	Cross-reference	Status
Ageing			
7. In some cases just a single experienced reader has been used. The RP suggests that, where possible, increasing the number of readers to a minimum of two experienced readers, within laboratories, would be beneficial.	All otoliths are double-read in Division 58.5.2 and Subareas 48.3 and 48.4. All use reference libraries and reader validation. Age reading workshops are being planned.	WG-FSA-2019/32, WG-FSA-2019/28, WG-FSA-2019/29	Ongoing
8. It would be interesting to investigate how smoothing the age–length key (ALK) matrix (by applying a kernel or using some sort of spline function) would affect the SA.	Sensitivity		Future work
Growth			
9. The RP suggests that all SAs implement methods to account for these potential biases in fitting VB growth curves.	The growth model accounts for potential biases by length-bin sampling and selectivity for Division 58.5.2. In Subareas 48.3 and 48.4, random sampling reduces the effect.	WG-FSA-2019/32	Ongoing
10. Additionally, investigation of the impact of errors in ageing on the VB by the SA scientists have shown that the fit is robust to this error. The RP suggests that this be investigated occasionally to ensure that no biases occur.	Sensitivity		Future work
11. Because changing the VB can affect the calculated virgin biomass, and thus the depletion estimates, the RP suggests that the SA scientists explore whether the fitted VB in these cases is sufficiently precautionary.	Bridging analysis in Division 58.5.2 and Subarea 88.1 and SSRUs 882A–B. For Subarea 48.3 and Subarea 88.1 and SSRUs 882A–B analysis used to show robustness to the change over time.	WG-FSA-2019/32, WG-FSA-2019/11, WG-FSA-2019/08, WG-SAM-2019/32	Ongoing
12. The RP also suggests that the SA scientists investigate the use of other growth curves that may exhibit better properties in regard to the data. A more flexible curve might produce a more realistic fit.	Mean length at age maximum likelihood estimation used in Subarea 88.1 and SSRUs 882A–B.	WG-FSA-2019/11, WG-SAM-2019/32	Ongoing

(continued)

Table 3 (continued)

Review panel comments	Description of work	Cross-reference	Status
13. The RP recommends that sensitivity analyses be used to assess the impact of the different choices of the growth model on stock assessment results and on biological reference points.	Sensitivity for Subareas 88.1 and 88.2 and 48.3	WG-FSA-2019/11, WG-FSA-2019/08, WG-SAM-2019/32	Ongoing
14. Potential changes in growth rates and fishery selectivity will influence tag-recapture rates, particularly due to the dome-shaped selectivity of these fisheries. The RP also recommends that more flexible growth curves be investigated.	Sensitivity. Estimated selectivity in Subareas 48.3 and 48.4 not domed	WG-FSA-2019/08	Future work
15. The RP recommends that the use of ALKs be investigated to estimate the age composition of tagged fish released as an input to the assessment models for all the toothfish stocks, instead of the current approach.	Sensitivity		Future work
Data weighting			
16. The RP recommends that data weighting methods for tagging data should be further investigated. For example, consideration should be given to using data weighting methods based on the average time at liberty.	Method yet to be developed	WG-FSA-2019/08	Ongoing
Tag loss			
17. The RP suggests that it is timely to update this analysis for Subareas 48.3 and 48.4 and Subarea 88.1 and SSRUs 882A–B stocks based on more recent information that may include fish with a longer time at liberty. Changes in tag-loss rates should be investigated. Information on the uncertainty involved in the estimation should be provided.	Tagging loss rates for Subarea 48.3 reviewed.	WG-SAM-14/35	Future work
Initial tagging mortality			
18. The RP encourages future research on the estimation of initial tagging mortality rates, and factors that may cause this to vary.	Experimental, sensitivity		Future work
Tag detection			
19. The review panel encourages future research on the estimation of tag-detection rates, and factors that may cause this to vary.	Experimental, sensitivity	WG-FSA-13/29, WG-FSA-2019/07	Future work
20. The RP recommends that implementation of good tagging protocols (release and recapture) be encouraged for all vessels involved in these fisheries.	Regular training of observers and review of tagging procedures, proposed workshop with COLTO. Survey of vessel behaviour. Update of observer manuals.	WG-FSA-13/29, WG-FSA-2019/15, SC-CAMLR-38/01	Ongoing

(continued)

Table 3 (continued)

Review panel comments	Description of work	Cross-reference	Status
Time at liberty truncation			
21. Tagging data was limited to recapture years-at-liberty less than four for Division 58.5.2 (although data exist for up to six years at liberty) and Subarea 48.3 and Subarea 48.4 assessments, but six years at liberty for Subarea 88.1 and SSRUs 882A–882B assessments. The RP recommends further investigation of this issue.	Time at liberty of six years are used in the Division 58.5.2 assessment. Sensitivity reviewed in 2017 for Subareas 48.3 and 48.4	WG-FSA-2019/32, WG-SAM-17/35	Completed
Selectivity			
22. The spatial distribution of the fleets has changed over time, particularly in the early years of the fisheries and in Subarea 88.1 and SSRUs 882A–882B and temporal changes in selectivity should be considered.		WG-FSA-2019/08	Ongoing
Natural mortality			
23. The RP recommends that consideration should be given to estimating age-specific natural mortality rates using a functional form with few parameters and sex-specific natural mortality rates. Simulation analysis should be conducted to determine in what circumstances natural mortality rates can be reliably estimated.	Sensitivity analysis	WG-FSA-2019/32, WG-SAM-2019/04	Ongoing
Recruitment standard deviation			
24. The RP recommends that consideration should be given to adjusting the penalty for years in which there is incomplete information about year-class strength.	Sensitivity		Future work
Sex structure			
25. The RP suggests that a more thorough evaluation is needed on the necessity of sex. If it is concluded that a sex-structured model is appropriate, all the data collection programs need to be modified to collect the appropriate sex information.	Sensitivity Subarea 88.1 and SSRUs 882A–B sex structured		Future work
Diagnostics			
26. A standard set of diagnostic plots across the assessments covering important and sensitive parameters is encouraged to be included in each stock assessment.	Diagnostic plots used as per WG-SAM-15/26	WG-FSA-2019/32, WG-FSA-2019/10, WG-FSA-2019/28, WG-FSA-2019/29	Completed
Ecosystem drivers in assessment models			
27. This was beyond the scope of the terms of reference. However, CCAMLR may wish to consider an external review whose goal is to consider this question specifically.			

Table 4: Initial CASAL assessments reported to WG-FSA-2019. All authors and the Secretariat used the same version of CASAL: v2.30-2012-03-21 rev.4648.

CASAL assessment		WG-FSA document number
Species	Area	
D. eleginoides	Subarea 48.3	2019/28
	Division 58.5.1	2019/58
	Division 58.5.2	2019/32
	Subarea 58.6	2019/57 Rev.1
D. mawsoni	Subarea 48.4	2019/29
	Ross Sea	2019/08

Table 5: B_0 estimates reported to WG-FSA and comparison with Secretariat estimates.

Model run	Reported B_0 (tonnes)	Secretariat B_0 (tonnes)	Difference (%)
D. eleginoides			
Subarea 48.3	82 451	82 451	0
Division 58.5.1			
M1	206 842	206 842	0
M2	232 153	232 153	0
Division 58.5.2	71 210	71 210	0
Subarea 58.6			
M1	54 398	54 398	0
M2	54 426	54 426	0
M3	54 442	54 442	0
D. mawsoni			
Subarea 48.4	1 004	1 004	0
Ross Sea	72 314	72 314	0

Table 6: Potential catch allocation methods for the Ross Sea shelf survey. Method 1 uses the method used 2012–2018 of allocating catch from the overall Ross Sea region toothfish fishery. Method 2 allocates the shelf survey catch limit from the special research zone (SRZ) catch limit and method 3 allocated it from the south of 70°S catch limit.

Area	Percent	No Survey	Method 1	Method 2	Method 3
North of 70°S	19	597	588	597	597
South of 70°S	66	2 072	2 043	2 072	2 027
SRZ	15	471	464	426	471
Shelf survey	-	-	45	45	45
Total	100	3 140	3 140	3 140	3 140

Table 7: Research block biomass estimates and catch limits estimated using the trend analysis and Chapman methods for Subareas 48.1, 48.6, 58.4, 88.2 and 88.3. ISU – increasing, stable or unclear; D – declining.

Subarea/ division	Research block	Species	Catch limit 2018/19 (tonnes)	Trend decision	Adequate recaptures	CPUE trend decline	*B* (tonnes)	0.04×B	0.8×CL	1.2×CL	Recommended catch limit 2019/20 (tonnes)
48.1	48.1_1	*D. mawsoni*	40					0	32	48	43*
48.6	486_2	*D. mawsoni*	175	ISU	Y	N	1 602	64	140	210	140
48.6	486_3	*D. mawsoni*	32	ISU	Y	Y	3 276	131	26	38	38
48.6	486_4	*D. mawsoni*	144	ISU	N	N	4 075	163	115	173	163
48.6	486_5	*D. mawsoni*	274	ISU	Y	N	24 636	985	219	329	329
58.4.1	5841_1	*D. mawsoni*	115	ISU	N	N	7 663	307	92	138	138
58.4.1	5841_2	*D. mawsoni*	116	ISU	N	N	5 285	211	93	139	139
58.4.1	5841_3	*D. mawsoni*	149	ISU	N	Y	4 275	-	119	179	119
58.4.1	5841_4	*D. mawsoni*	19	ISU	N	N	693	28	15	23	23
58.4.1	5841_5	*D. mawsoni*	50	ISU	N	N	4 705	188	40	60	60
58.4.1	5841_6	*D. mawsoni*	130	ISU	N	Y	4 590	-	104	156	104
58.4.2	5842_1	*D. mawsoni*	50	ISU	N	N	5 243	210	40	60	60
58.4.3a	5843a_1	*D. eleginoides*	30	D	N	Y	1 196	-	24	36	24
58.4.4b	5844b_1	*D. eleginoides*	19	ISU	Y	N	180	7	15	23	23**
58.4.4b	5844b_2	*D. eleginoides*	22	D	N	Y	238	-	18	26	18
88.2	882_1	*D. mawsoni*	240	D	N	Y	4 574	-	192	288	192
88.2	882_2	*D. mawsoni*	240	ISU	Y	Y	5 790	232	192	288	232
88.2	882_3	*D. mawsoni*	160	ISU	N	N	4 540	182	128	192	182
88.2	882_4	*D. mawsoni*	160	ISU	N	Y	5 930	-	128	192	128
88.2	882_H	*D. mawsoni*	200	ISU	N	N	3 758	150	160	240	160
88.3	883_1	*D. mawsoni*	20	D	N	Y	1 433	-	16	24	16
88.3	883_2	*D. mawsoni*	25	D	N	Y	2 881	-	20	30	20
88.3	883_3	*D. mawsoni*	50	ISU	N	N	5 736	229	40	60	60
88.3	883_4	*D. mawsoni*	50	ISU	N	N	2 485	99	40	60	60
88.3	883_5	*D. mawsoni*	10	D	N	Y	124	-	8	12	8
88.3	883_6	*D. mawsoni*	30					0	24	36	30
88.3	883_7	*D. mawsoni*	30					0	24	36	30
88.3	883_8	*D. mawsoni*	10					0	8	12	10
88.3	883_9	*D. mawsoni*	10					0	8	12	10
88.3	883_10	*D. mawsoni*	10					0	8	12	10

* see paragraph 4.40

** see paragraph 4.131

Table 8: Summary of the assessment of the new and underway research proposals in Area 48. Summary of the rationale behind footnotes should be taken in the context of the details in paragraphs 4.35 to 4.38 and 4.58 to 4.80. Two research plans had completed their last year of on-water activities in Area 48 in 2018/19 and were not assessed against these criteria (see WG-FSA-2019/51 and WG-FSA-2019/25). Data analyses are underway and results will be presented until the completion of the research objectives. ESP – Spain, JAP – Japan, UKR – Ukraine, ZAF – South Africa, TOA – *Dissostichus mawsoni*; n/a – not applicable.

Subarea/division:	48.1	48.6
Proposal:	WG-FSA-2019/17	WG-FSA-2019/23 Rev. 1
Members:	UKR	JAP, ZAF, ESP
Conservation measure under which the proposal is submitted:	24-01	21-02
Time period:	2019/20	2018/19–2020/21
Main species of interest:	TOA	TOA
Main purpose of the research (e.g. abundance, population structure, movement, …)	Structure	Abundance
Is the purpose of the research linked to Commission or Scientific Committee priorities?	Y	Y
1. Quality of the proposal		
1.1 Is there enough information to evaluate the likelihood of success of the research objectives?	Y	Y
2. Research design		
2.1 Is the proposed catch limit in accordance with research objectives?	Y	Y
2.2 Is the sampling design appropriate to achieve research objectives?	Y	?[6]
2.3 Have the environmental conditions been thoroughly accounted for?	N[1]	Y
3. Research capacity		
3.1 Have the research platforms demonstrated experience in:		
3.1.1 Conducting research/exploratory fishing following a research plan?	Y	Y
3.1.2 Collecting scientific data?	Y	Y
3.2 Do the research platforms have acceptable tag detection and survival rates?	Y	Y
3.3 Have the research teams sufficient resources and capacity for:		
3.3.1 Sample processing?	Y	Y
3.3.2 Data analyses?	Y	Y
4. Data analyses to address the research questions		
4.1 Are the proposed methods appropriate?	N[2]	Y
5. Impact on ecosystem and harvest species		
5.1 Is the catch limit proposed consistent with Article II[a] of the Convention?	?[6]	?[6]
5.2 Are the impacts on dependent and related species accounted for and consistent with Article II[b] of the Convention?	Y	N[3]

(continued)

Table 8 (continued)

Subarea/division:	48.1	48.6
Proposal:	WG-FSA-2019/17	WG-FSA-2019/23 Rev. 1
Members:	UKR	JAP, ZAF, ESP
Conservation measure under which the proposal is submitted:	24-01	21-02
Time period:	2019/20	2018/19–2020/21
Main species of interest:	TOA	TOA
6. Progress towards objectives for ongoing proposals		
6.1 Have the past and current milestones been completed?	n/a	Y
6.2 Has previous advice from the Scientific Committee and its working groups been addressed?	Y	Y
6.3 Are all the objectives likely to be completed by the end of the research plan?	N[1,4]	Y
6.4 Are there any other concerns?	Y[5]	N

[a] Prevention of decrease in the size of any harvested population to levels below those which ensure its stable recruitment.

[b] Maintenance of the ecological relationships between harvested, dependent and related populations of Antarctic marine living resources and the restoration of depleted populations. Prevention of changes or minimisation of the risk of changes in the marine ecosystem which are not potentially reversible over two or three decades.

[1] There are concerns about the accessibility of the fishing grounds due to sea-ice (WG-FSA-2018 report, Figure 5).

[2] Requires higher sampling of by-catch species.

[3] Requires more analysis on by-catch populations, see WG-SAM-2019/09.

[4] The on-water activities will be completed by the end of the research plan but the off-water analyses will continue in future years.

[5] C2 and CDS catch data reconciliation outcomes (see paragraphs 2.11 to 2.14).

[6] See paragraph 4.80.

Table 9: Summary of the assessment of the new and underway research proposals in Area 58. Summary of the rationale behind footnotes should be taken in the context of the details in paragraphs 4.89 to 4.132. AUS – Australia, ESP – Spain, FRA – France, JPN – Japan, KOR – Korea, RUS – Russia, TOP – *Dissostichus eleginoides*; TOA – *Dissostichus mawsoni*, n/a – not applicable.

Subarea/division:	58.4.1/2	58.4.1/2	58.4.4b
Proposal:	WG-FSA-2019/44	WG-FSA-2019/52	WG-FSA-2019/64
Members:	AUS, ESP, FRA, JPN, KOR	RUS	JPN, FRA
Conservation measure under which the proposal is submitted:	21-02	21-02	24-01
Time period:	2018/19–2021/22	2019/20–2021/22	2016/17–2020/21
Main species of interest:	TOA	TOA	TOP
Main purpose of the research (e.g. abundance, population structure, movement, …)	Abundance	Abundance	Abundance
Is the purpose of the research linked to Commission or Scientific Committee priorities?	Y	Y	Y
1. Quality of the proposal			
1.1 Is there enough information to evaluate the likelihood of success of the research objectives?	Y	Y	Y
2. Research design			
2.1 Is the proposed catch limit in accordance with research objectives?	Y	Y	Y
2.2 Is the sampling design appropriate to achieve research objectives?	?[1]	?[1]	?[1]
2.3 Have the environmental conditions been thoroughly accounted for?	Y	Y	Y
3. Research capacity			
3.1 Have the research platforms demonstrated experience in:			
3.1.1 Conducting research/exploratory fishing following a research plan?	N[2]	Y	N[3]
3.1.2 Collecting scientific data?	Y	Y	Y
3.2 Do the research platforms have acceptable tag detection and survival rates?	N[4]	N[5]	N[6]
3.3 Have the research teams sufficient resources and capacity for:			
3.3.1 Sample processing?	Y	N[7]	Y
3.3.2 Data analyses?	Y	N[7,8]	Y
4. Data analyses to address the research questions			
4.1 Are the proposed methods appropriate?	Y	N[8]	Y
5. Impact on ecosystem and harvest species			
5.1 Is the catch limit proposed consistent with Article II[a] of the Convention?	?[13]	?[13]	?[13]
5.2 Are the impacts on dependent and related species accounted for and consistent with Article II[b] of the Convention?	Y	N[9]	Y

(continued)

Table 9 (continued)

Subarea/division:	58.4.1/2	58.4.1/2	58.4.4b
Proposal:	WG-FSA-2019/44	WG-FSA-2019/52 Rev. 1	WG-FSA-2019/64
Members:	AUS, ESP, FRA, JPN, KOR	RUS	JPN, FRA
Conservation measure under which the proposal is submitted:	21-02	21-02	24-01
Time period:	2018/19–2021/22	2019/20–2021/22	2016/17–2020/21
Main species of interest:	TOA	TOA	TOP
6. Progress towards objectives for ongoing proposals			
6.1 Have the past and current milestones been completed?	Y	n/a	Y
6.2 Has previous advice from the Scientific Committee and its working groups been addressed?	Y	Y	Y
6.3 Are all the objectives likely to be completed by the end of the research plan?	N[10]	N[7]	Y
6.4 Are there any other concerns?	Y[11]	Y[12]	N

[a] Prevention of decrease in the size of any harvested population to levels below those which ensure its stable recruitment.

[b] Maintenance of the ecological relationships between harvested, dependent and related populations of Antarctic marine living resources and the restoration of depleted populations. Prevention of changes or minimisation of the risk of changes in the marine ecosystem which are not potentially reversible over two or three decades.

[1] Dr S. Kasatkina (Russia) reiterated that the use of different types of longline gears compromise the achievement of research plan objectives (paragraph 4.95).

[2] One vessel out of eight (*Cap Kersaint*) has not yet fished in a fishery under CM 21-02, however, it has fished within Subarea 58.6 and Division 58.5.1.

[3] One vessel out of four (*Cap Kersaint*) has not yet fished in a fishery under CM 24-01, however, it has fished within Subarea 58.6 and Division 58.5.1.

[4] All vessels have good tagging performance (WG-FSA-17/36), except the *Kingstar* (Republic of Korea) and the vessels proposed by France which do not have their tagging performances calculated but have had tag recaptures before in this area (Divisions 58.4.1 or 58.4.2).

[5] One vessel has very poor tagging performance (*Palmer*) and the other (*Volk Arktiki*) has good tagging detection rate but unknown tag-survival rate due to fishing only one year in 2018/19.

[6] Tagging performance has not been calculated in this region but vessels have had tag recaptures before.

[7] Dr Kasatkina recognised that this research plan cannot be completed without collaboration from other Members and the proponent has limited off-water research capacity (only one researcher is listed in the proposal section 5a).

[8] There is not enough information in the proposal.

[9] The proposed design present risks of high fish by-catch in the shallow and deep strata as it was demonstrated in research block 5841_6 (SC-CAMLR-XXXVI, paragraph 3.148).

[10] Completion of research objectives is conditional on the continuation of the exploratory fishing activities.

[11] Despite extensive discussions between the co-proponents, the different parties were not able to find a common ground to incorporate Russian vessels in the existing multi-Member research plan.

[12] Any new proposals should be integrated within existing research in the area (WG-SAM-2019 report, paragraph 6.70).

[13] See paragraphs 4.114 and 4.131.

Table 10: Summary of the assessment of the new and underway research proposals in Area 88. Summary of the rationale behind footnotes should be taken in the context of the details in paragraphs 4.151 to 4.181. KOR – Korea, NZ – New Zealand, RUS – Russia, UKR – Ukraine, TOA – *Dissostichus mawsoni*, MPA – marine protected area.

Subarea/division:	88.2[a]	88.1[a]	88.3
Proposal:	WG-FSA-2019/42 Rev. 1	WG-SAM-2019/03	WG-SAM-2019/02
Members:	RUS	NZ	NZ, KOR, UKR
Conservation measure under which the proposal is submitted:	24-01	24-01	24-01
Time period:	2019/20–2021/22	2017/18–2021/22	2017/18–2019/20
Main species of interest:	TOA	TOA	TOA
Main purpose of the research (e.g. abundance, structure, movement, …)	Structure	Structure	Structure
Is the purpose of the research linked to Commission or Scientific Committee priorities?	Y	Y	Y
1. Quality of the proposal			
1.1 Is there enough information to evaluate the likelihood of success of the research objectives?	N	Y	Y
2. Research design			
2.1 Is the proposed catch limit in accordance with research objectives?	Y	Y	Y
2.2 Is the sampling design appropriate to achieve research objectives?	?[1,2]	Y	?[2]
2.3 Have the environmental conditions been thoroughly accounted for?	Y	Y	N[3]
3. Research capacity			
3.1 Have the research platforms demonstrated experience in:			
3.1.1 Conducting research/exploratory fishing following a research plan?	Y	Y	Y
3.1.2 Collecting scientific data?	Y	Y	Y
3.2 Do the research platforms have acceptable tag detection and survival rates?	N[4]	Y	Y
3.3 Have the research teams sufficient resources and capacity for:			
3.3.1 Sample processing?	N[5]	Y	Y
3.3.2 Data analyses?	N[5]	Y	Y
4. Data analyses to address the research questions			
4.1 Are the proposed methods appropriate?	N[5,6]	Y	Y
5. Impact on ecosystem and harvest species			
5.1 Is the catch limit proposed consistent with Article II[b] of the Convention?	?[9]	Y	?[10]
5.2 Are the impacts on dependent and related species accounted for and consistent with Article II[c] of the Convention?	N[6]	Y	Y

(continued)

Table 10 (continued)

Subarea/division:	88.2[a]	88.1[a]	88.3
Proposal:	WG-FSA-2019/42 Rev. 1	WG-SAM-2019/03	WG-SAM-2019/02
Members:	RUS	NZ	NZ, KOR, UKR
Conservation measure under which the proposal is submitted:	24-01	24-01	24-01
Time period:	2019/20–2021/22	2017/18–2021/22	2017/18–2019/20
Main species of interest:	TOA	TOA	TOA
6. Progress towards objectives for ongoing proposals			
6.1 Have the past and current milestones been completed?	n/a	Y	Y
6.2 Has previous advice from the Scientific Committee and its working groups been addressed?	N[7]	Y	Y
6.3 Are all the objectives likely to be completed by the end of the research plan?	N[5]	Y	Y
6.4 Are there any other concerns?	Y[8]	N	N

a See Table 11 applying to research conducted within MPA.
b Prevention of decrease in the size of any harvested population to levels below those which ensure its stable recruitment.
c Maintenance of the ecological relationships between harvested, dependent and related populations of Antarctic marine living resources and the restoration of depleted populations. Prevention of changes or minimisation of the risk of changes in the marine ecosystem which are not potentially reversible over two or three decades.

1 There was not enough information in the proposal but the sampling design was revised during the WG-FSA-2019 with the assistance of the Secretariat and other Members (paragraph 4.161).
2 Dr S. Kasatkina (Russia) reiterated that the use of different types of longline gears compromises the achievement of research plan objectives (paragraph 4.95).
3 High variability in environmental conditions (sea-ice) had impacted this research in the past.
4 One vessel has very poor tagging performance (*Palmer*) and the other (*Volk Arktiki*) has good tagging detection rate but unknown tag-survival rate due to fishing only one year in 2018/19.
5 There is not enough information in the proposal.
6 Requires higher sampling of fish by-catch species.
7 Advice on electronic monitoring, power analysis and tag performance updates were not presented in WG-FSA-2019/42 and had to be calculated during the WG-FSA-2019.
8 Analyses from previous research by this Member in this region are still pending (WG-FSA-2018 report, paragraph 4.167).
9 See paragraph 4.170.
10 See paragraph 4.182.

Table 11: Summary of the assessment of research plans carried out within marine protected areas (MPAs). NZ – New Zealand, RUS – Russia, TOA – *Dissostichus mawsoni*.

Subarea/division:	88.2	88.1
Proposal:	WG-FSA-2019/42 Rev. 1	WG-SAM-2019/03
Members:	RUS	NZ
Conservation measure under which the proposal is submitted:	24-01	24-01
Time period:	2019–2022	2018–2022
Main species of interest:	TOA	TOA
Does the proposal:		
1. Explain which priority research elements are addressed to inform the MPA evaluation process?	Y	Y
2. Explain why the proposed research or data collection cannot be conducted during the exploratory fishery?	Y	Y
3. Explicitly integrate replication and randomisation in their research design?	N[1]	Y
4. Provide a detailed rationale for the choice of comparable reference areas?	N[1]	Y
5. Describe the mechanism by which research fishing is coordinated with other research fishing and with any Olympic fishery?	Y	Y
6. Provide an assessment of how the research may impact the objectives of the MPA?	N[1]	N[1]

[1] There was not enough information in the proposal.

Table 12: Vulnerable marine ecosystem (VME) work plan summary.

Topics	Workflow
1	Collate relevant conservation measures and associated documents (guides, etc.) to review current practice and summarise reporting trends.
2	Review VME impact mitigation procedures in regional fisheries management organisations (RFMOs) that may inform CCAMLR.
3	Review reporting of VME by vessels – assess trends by year, location, gear, flag etc.
4	Review line section marking/recording and develop standard protocol.
5	Provide data on efficacy of current sampling methods by comparing observer-derived observations with electronic monitoring at hauling.
6	Assess efficacy of surface sampling to describe seafloor habitat with the use of benthic camera data.
7	Review new methods for assessing fishing footprint and compare with existing methods.
8	Evaluate VME taxa identification materials.
9	Assess whether current VME taxa list is comprehensive and appropriate.
10	Consideration of actions following VME encounters (e.g. additional sampling with cameras).
11	Consideration of analysis methods/modelling for incorporating new (electronic monitoring and camera) data streams and external data streams (e.g. research voyages), including distribution modelling.
12	Integrating above results to develop recommendations (e.g. review VME thresholds, data collection, and reporting protocols and recommend changes to conservation measures as appropriate).

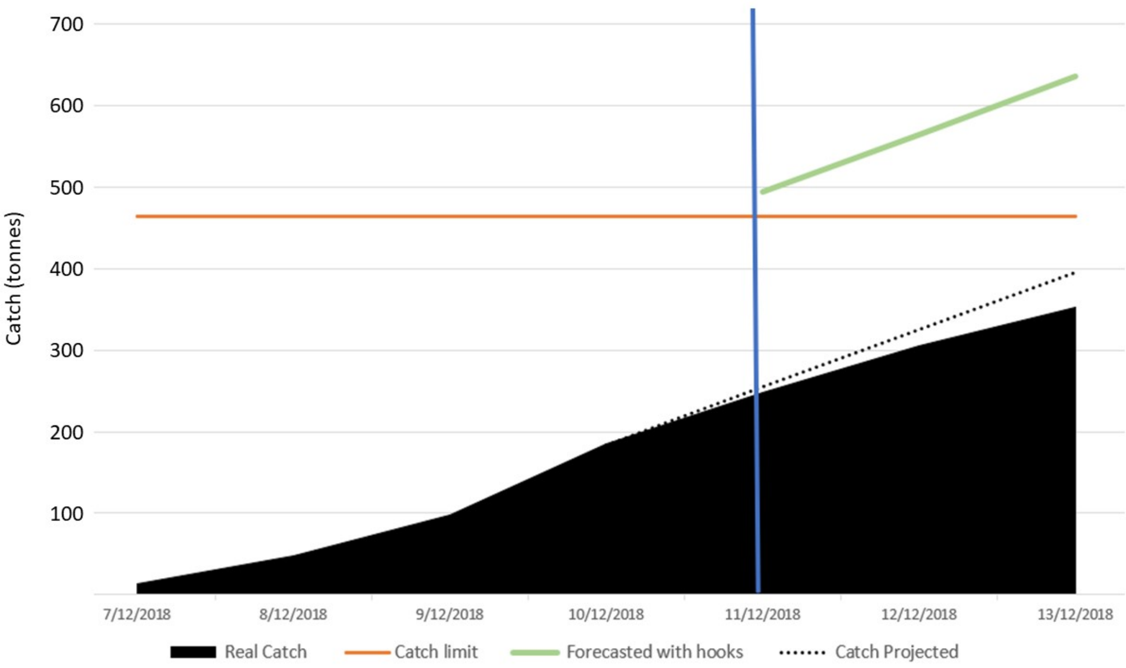


Figure 1: Progression of catches and closure forecasting for the special research zone (SRZ) in 2018/19. The Secretariat issued a notification that the fishery would close at 0930 UTC on 12 December, with no more gear to be set after 0930 UTC on 11 December. At the time of the notification on 11 December, the catch forecasted with hooks in the water was 494.3 tonnes, compared to a catch limit of 474 tonnes.

Fisheries Documents

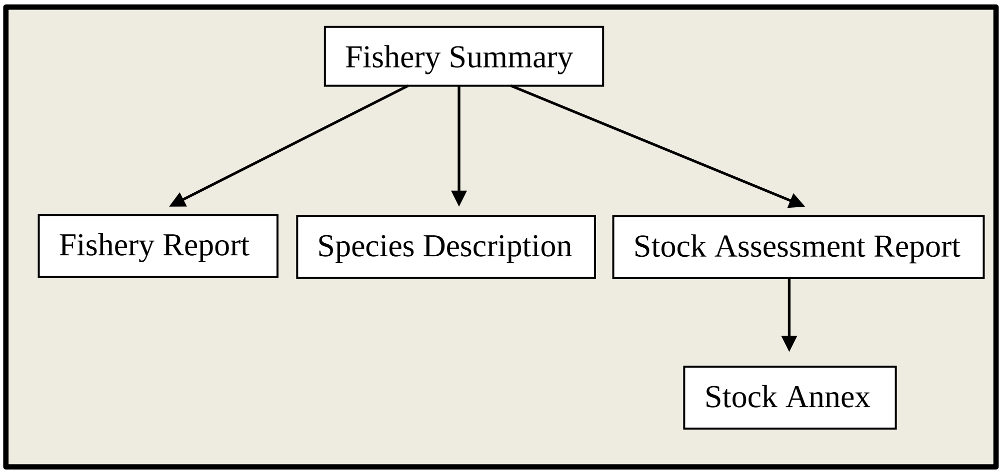


Figure 2: Hierarchical structure of the public domain Fisheries Documents.

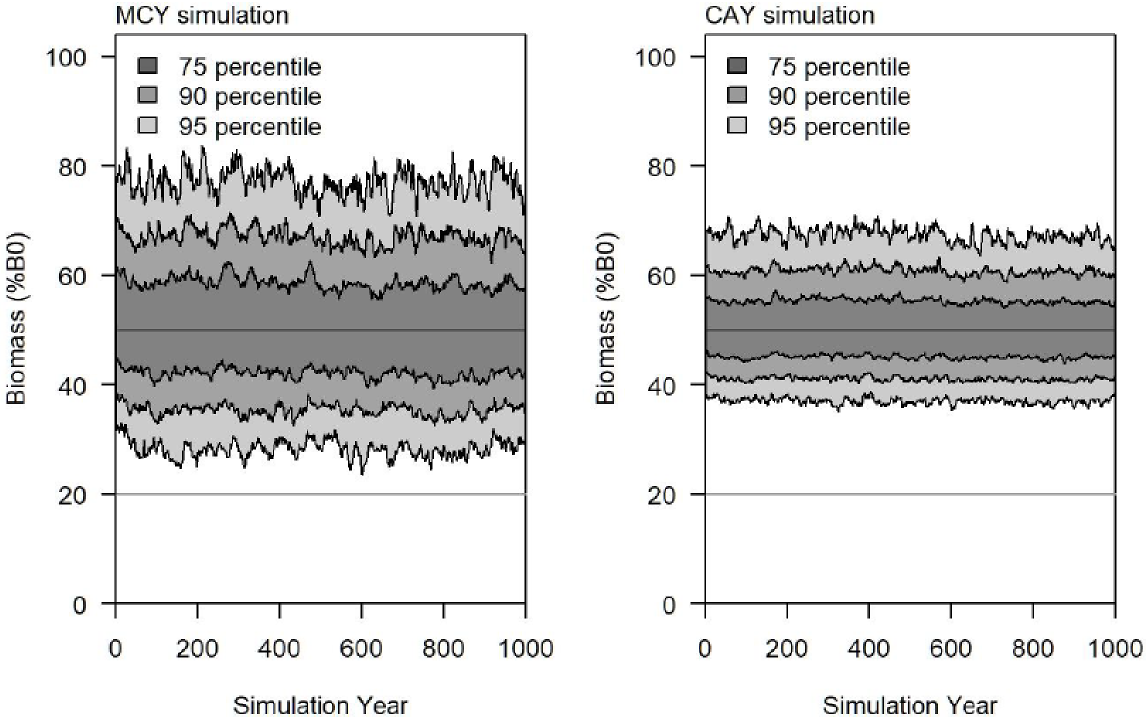


Figure 3: Trajectory of expected values of SSB (% B_0) from 1 000 years of simulating 1 000 Markov Chain Monte Carlo (MCMC) realisations for a constant catch (maximum constant yield, MCY, left panel) and a constant exploitation rate (constant annual yield, CAY, right panel) for the Ross Sea base case model (R1.3) following the CCAMLR decision rule with a target of 50% of B_0 and a limit of 20% of B_0.

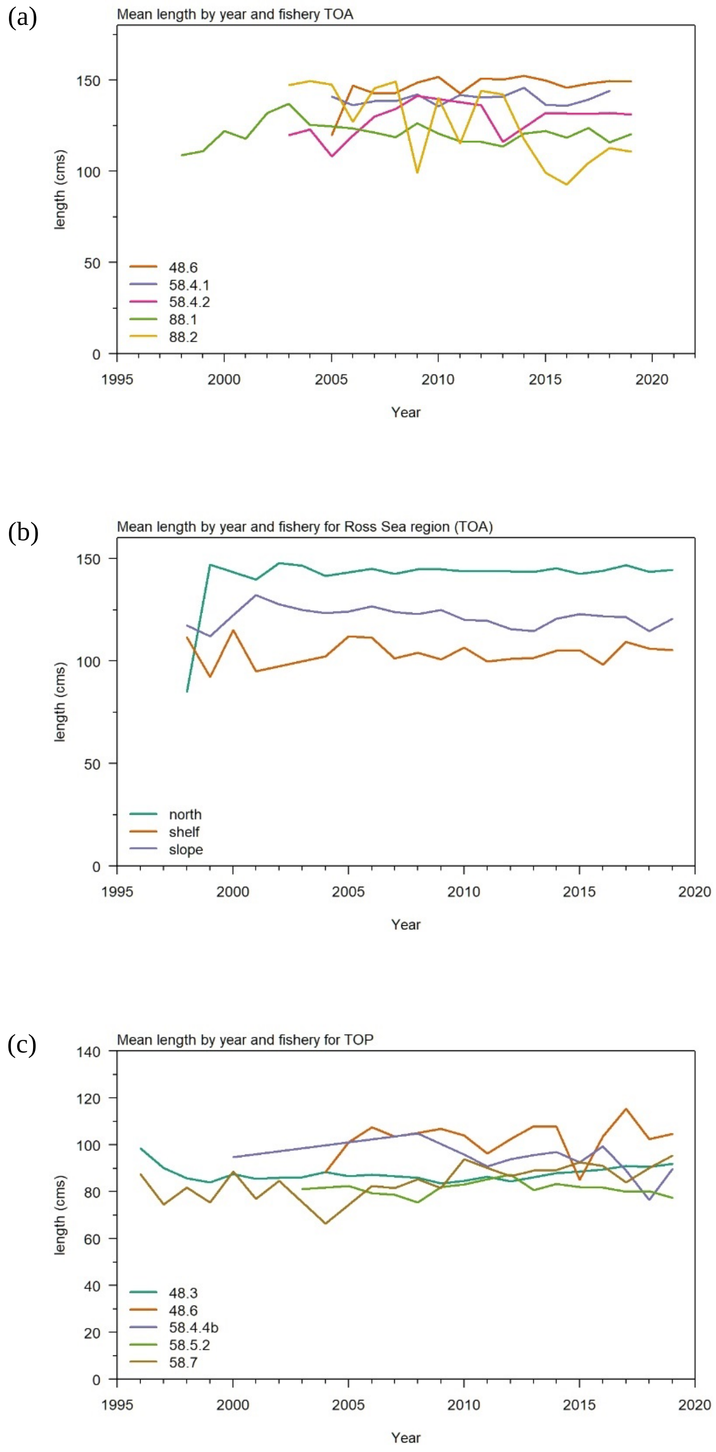
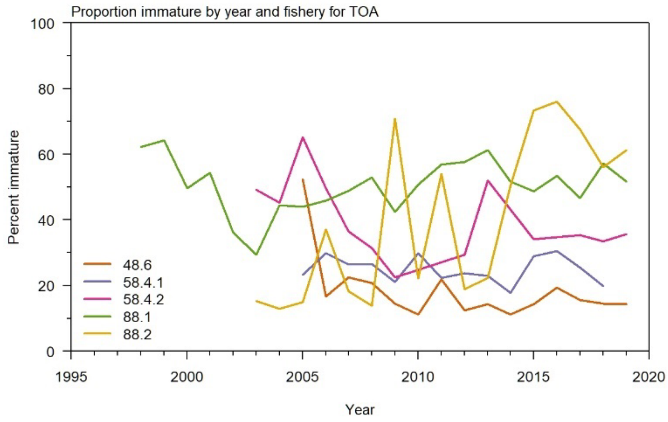
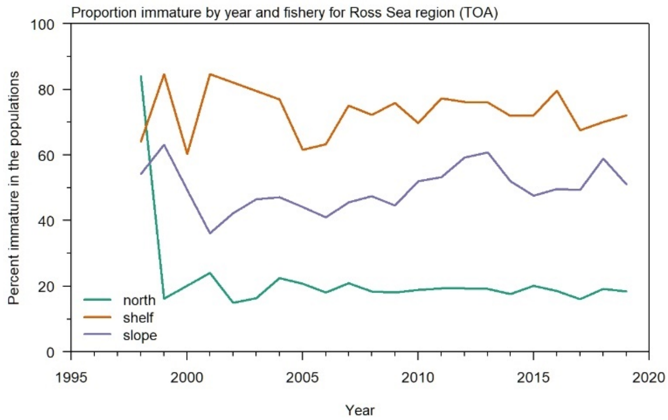


Figure 4: Mean length by year in catches of Antarctic toothfish (*Dissostichus mawsoni*) fisheries in: (a) across the Convention Area, (b) in the Ross Sea, and (c) Patagonian toothfish (*D. eleginoides*) fisheries across the Convention Area.

(a)



(b)



(c)

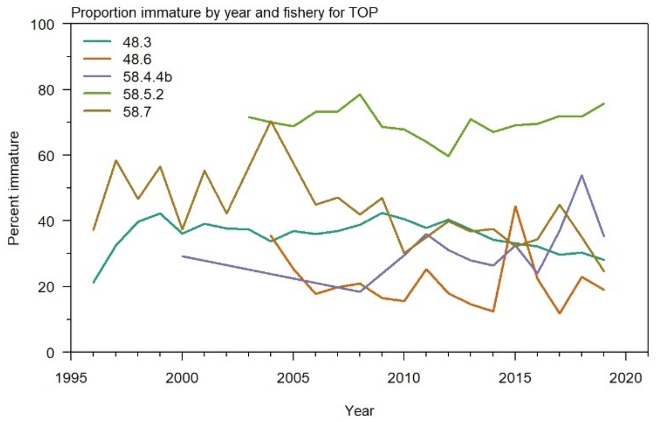


Figure 5: Percent immature fish by year in catches of Antarctic toothfish (*Dissostichus mawsoni*) fisheries: (a) across the Convention Area, (b) in the Ross Sea, and (c) Patagonian toothfish (*D. eleginoides*) fisheries across the Convention Area.

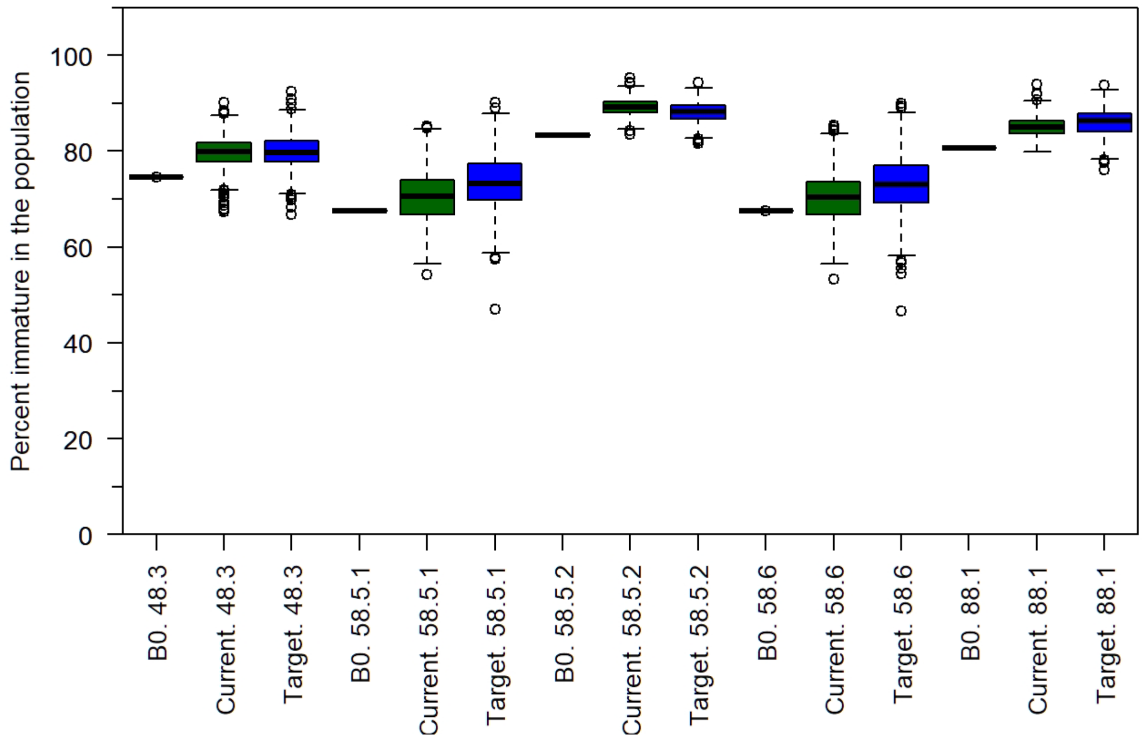


Figure 6: Percent immature fish when the stock is at B_0, in the current year 2019, and at target level at the end of the 35-year projection period, as estimated by the CASAL stock assessment models for the Patagonian toothfish (*Dissostichus eleginoides*) fisheries in Subareas 48.3 and 58.6 and Divisions 58.5.1 and 58.5.2, and for the Antarctic toothfish (*D. mawsoni*) fishery in Subarea 88.1 and small-scale research units (SSRUs) 882A–B.

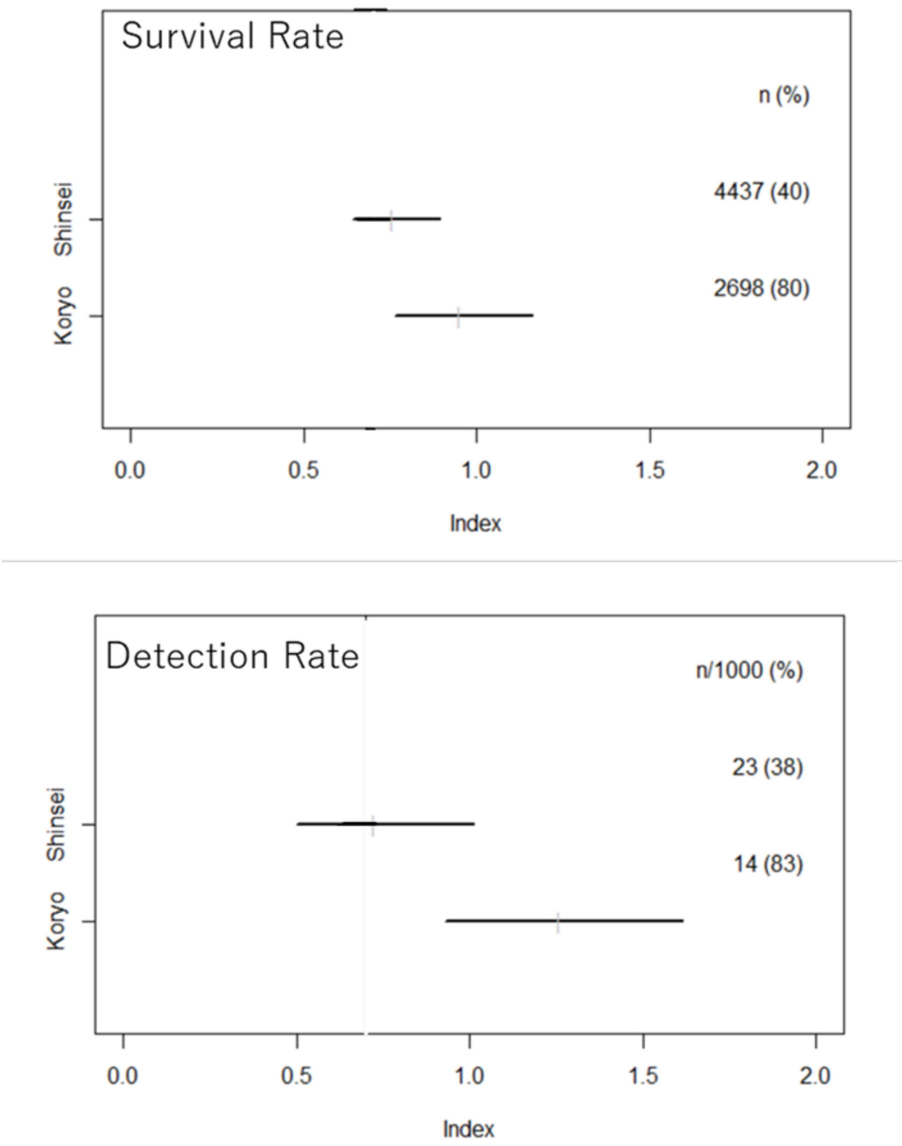


Figure 7: The tag-detection and survivability statistics calculated for the *Shinsei Maru No. 3* and *Koryo Maru No. 11* using data from Subarea 48.6.

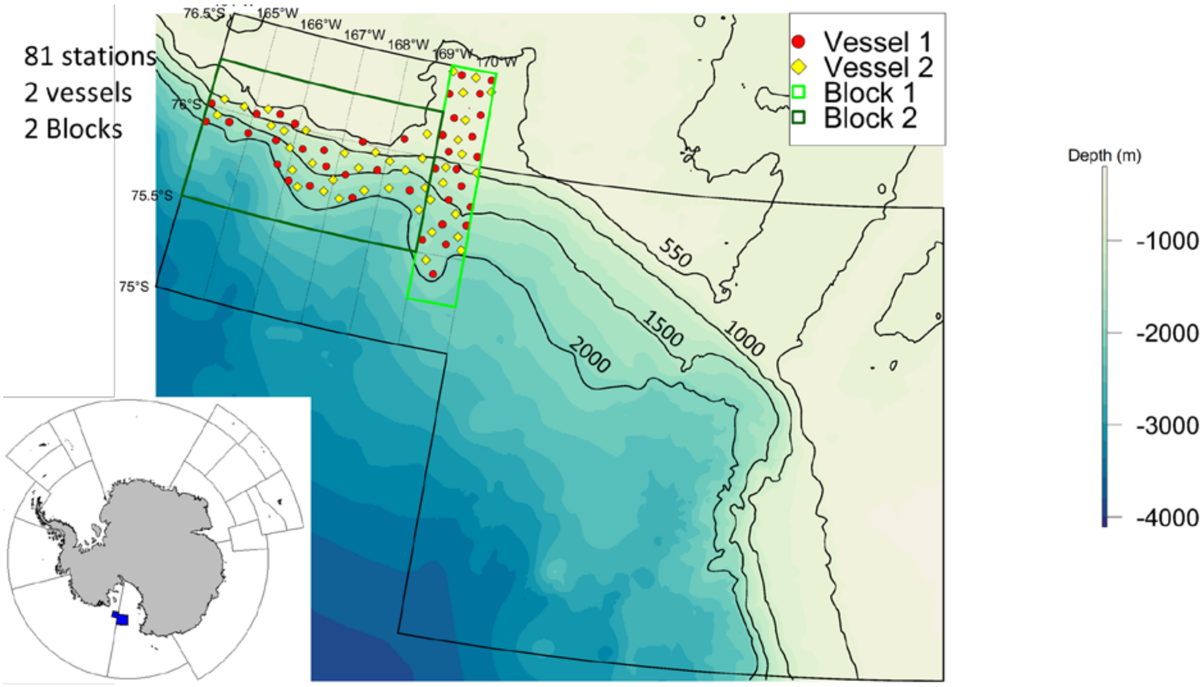


Figure 8: Map of the stations in the special research zone (SRZ) proposed to be conducted as part of the research plan in WG-FSA-2019/42 Rev. 1, following discussion during the Working Group meeting.

Appendix A

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Working Group on Fish Stock Assessment
(Hobart, Australia, 7 to 18 October 2019)

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Fisheries Monitoring and Compliance	
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Compliance Support Officer	Abigael Proctor
Compliance Officer	Eldene O’Shea
Data Administration Officer	Alison Potter
Fisheries Monitoring and Compliance Data Officer	Henrique Anatole
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Finance Assistant	Christina Macha
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Human Resource Officer	Angie McMahon
Communications	
Communications Manager	Doro Forck
Publications Officer	Belinda Blackburn
Web Project Officer	Dane Cavanagh
French Translator/Team Coordinator	Gillian von Bertouch
French Translator	Floride Pavlovic
French Translator	Bénédicte Graham
Russian Translator/Team Coordinator	Ludmilla Thornett
Russian Translator	Blair Denholm
Russian Translator	Vasily Smirnov
Spanish Translator/Team Coordinator	Jesús Martínez
Spanish Translator	Marcia Fernández
Spanish Translator	Alejandra Sycz
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Data and Information Systems	
Data and Information Systems Manager	Tim Jones
Systems Analyst	Ian Meredith
Data Steward	Dr Elanor Miller
Data Systems Analyst	Gary Dewhurst
IT Support Assistant	Data 3 (Patrick Moore)

Appendix B

Agenda

Working Group on Fish Stock Assessment
(Hobart, Australia, 7 to 18 October 2019)

1. Opening of the meeting

   1.1 Organisation of the meeting and adoption of the agenda

2. Review of data available

   2.1 Data management
   2.2 Catch and effort data and biological observations from CCAMLR fisheries
   2.3 Fishery Report updates

3. Review of updated stock assessments and provision of management advice (all fisheries)

   3.1 *Champsocephalus gunnari*
      3.1.1 *C. gunnari* in Subarea 48.3
      3.1.2 *C. gunnari* in Division 58.5.2

   3.2 *Dissostichus* spp.
      3.2.1 *Dissostichus eleginoides* in Subarea 48.3
      3.2.2 *Dissostichus* spp. in Subarea 48.4
      3.2.3 *Dissostichus eleginoides* in Area 58
      3.2.4 *Dissostichus mawsoni* in the Ross Sea region

4. Research to inform current or future assessments in data-limited fisheries notified under Conservation Measures 21-01, 21-02 and 24-01

   4.1 Generic issues
      4.1.1 Tagging performance
      4.1.2 Process for reviewing research proposals

   4.2 Management area research reviews and management advice
      4.2.1 *Dissostichus* spp. in Area 48
      4.2.2 *Dissostichus* spp. in Area 58
      4.2.3 *D. mawsoni* in Area 88
      4.2.4 Other fisheries research including crabs

5. Scheme of International Scientific Observation

6. Non-target catch and ecosystem impacts of fishing

   6.1 Incidental mortality of seabirds and marine mammals

   6.2 Invertebrate by-catch and vulnerable marine ecosystems (VMEs)
      6.2.1 Updates of fishing footprints
      6.2.2 Modelling benthic taxa distributions and habitats
      6.2.3 Review of listing of VME indicator taxa

   6.3 Marine debris

7. Future work

   7.1 Organisation of intersessional activities
   7.2 Notifications of other scientific research

8. Other business

9. Advice to the Scientific Committee

10. Adoption of the report and close of the meeting.

Appendix C

List of Documents

Working Group on Fish Stock Assessment
(Hobart, Australia, 7 to 18 October 2019)

WG-FSA-2019/01	Report of the Convener of the COLTO–CCAMLR Toothfish Catch and Effort Data Workshop (Cape Town, South Africa, 30 July to 1 August 2019) Secretariat and R. Arrangio
WG-FSA-2019/02	A preliminary assessment for mackerel icefish (*Champsocephalus gunnari*) in Division 58.5.2, based on results from the 2019 random stratified trawl survey D. Maschette, G. Nowara and D. Welsford
WG-FSA-2019/03	Estimates of abundance of *Dissostichus eleginoides* and *Champsocephalus gunnari* from the random stratified trawl survey in the waters surrounding Heard Island in Division 58.5.2 for 2019 G.B. Nowara, T.D. Lamb and P. Ziegler
WG-FSA-2019/04	A versatile approach to minimise damage or loss of longline gear due to sea-ice S. Hain, T. Brey and K. Teschke
WG-FSA-2019/05	Movements of tagged Antarctic toothfish (*Dissostichus mawsoni*) in Subarea 48.6 in relation to stock structure hypotheses T. Ichii, M. Okazaki, T. Okuda and S. Somhlaba
WG-FSA-2019/06 Rev. 1	Measurement of capacity in CCAMLR exploratory fisheries in Subareas 88.1 and 88.2: Secretariat update 2019 Secretariat
WG-FSA-2019/07	Characterisation of the toothfish fishery in the Ross Sea region (Subarea 88.1 and SSRUs 88.2A–B) through 2018/19 J. Devine, S. Parker and A. Dunn
WG-FSA-2019/08	Assessment models for Antarctic toothfish (*Dissostichus mawsoni*) in the Ross Sea region to 2018/19 A. Dunn
WG-FSA-2019/09	Stock Annex for the stock assessment of Ross Sea region Antarctic toothfish (*Dissostichus mawsoni*) A. Dunn and S. Parker

WG-FSA-2019/10	Diagnostic plots for the assessment models for Antarctic toothfish (*Dissostichus mawsoni*) in the Ross Sea region to 2018/19 A. Dunn
WG-FSA-2019/11	Revised growth and length-weight parameters for Antarctic toothfish in the Ross Sea region (881 & 882AB) A. Dunn and S. Parker
WG-FSA-2019/12	Summary of the toothfish fishery and tagging program in the Amundsen Sea region (SSRUs 882C–H) to 2018/19 J. Devine and S. Parker
WG-FSA-2019/13	Research data collection in CCAMLR longline fisheries for toothfish using electronic monitoring on fishing vessels J.M. Fenaughty
WG-FSA-2019/14	The CCAMLR Taxon Data Project Secretariat
WG-FSA-2019/15 Rev. 1	Implementation of the CCAMLR Scheme of International Scientific Observation during 2018/19 Secretariat
WG-FSA-2019/16 Rev. 2	Summary of incidental mortality associated with fishing activities collected in scientific observer and vessel data during the 2019 season Secretariat
WG-FSA-2019/17	Research plan for toothfish survey in Subarea 48.1 by the Ukrainian vessel *CALIPSO* in a season 2019/20 Delegation of Ukraine
WG-FSA-2019/18	Gear loss reported by longline fishing vessels for the 2018 and 2019 fishing seasons Secretariat
WG-FSA-2019/19	Preliminary assessment of genetic diversity in bycatch-caught darkbelly skate (*Bathyraja meridionalis*) from South Georgia S. Pérez-Espona, W.P. Goodall-Copestake, P. Hollyman and M. Belchier
WG-FSA-2019/20	Report of the UK Groundfish Survey at South Georgia (CCAMLR Subarea 48.3) in January/February 2019 S. Gregory, P. Hollyman, T. Earl, A. Clement, J. Visagie, L. Featherstone and M. Belchier

WG-FSA-2019/21	Progress on the integrated stock assessment by CASAL for Antarctic toothfish *Dissostichus mawsoni* in Subarea 48.6 K. Sawada and T. Okuda
WG-FSA-2019/22	Annual report of research fishing operations at Subarea 48.6 in the 2018/19 fishing season Delegations of Japan, Spain and South Africa
WG-FSA-2019/23 Rev. 1	Revised proposal for continuation of a multi-member longline survey on Antarctic toothfish (*Dissostichus mawsoni*) in Statistical Subarea 48.6 in 2019/20 by Japan, South Africa and Spain Delegations of Japan, South Africa and Spain
WG-FSA-2019/24	Use of cameras and sensors to monitor the behaviour and benthic impact of longline gears C. Darby
WG-FSA-2019/25	Preliminary results from the third year of a survey into the connectivity of toothfish species in Subareas 48.2 and 48.4 G. Robson, A. Riley and P. Hollyman
WG-FSA-2019/26	Feeding ecology of the two sympatric fish species Notothenia rossii and *N. coriiceps* from western Antarctic Peninsula: a fatty acids and stable isotopes approach E. Moreira, M. Novillo, K. Mintenbeck, E. Barrera-Oro and M. De Troch
WG-FSA-2019/27	Preliminary tag-recapture based population assessment of Antarctic toothfish (*Dissostichus mawsoni*) in Subarea 48.4 T. Earl and A. Riley
WG-FSA-2019/28	Assessment of Patagonian toothfish (*Dissostichus eleginoides*) in Subarea 48.3 T. Earl
WG-FSA-2019/29	Assessment of Patagonian toothfish (*Dissostichus eleginoides*) in Subarea 48.4 T. Earl and E. MacLeod
WG-FSA-2019/30	Preliminary assessment of mackerel icefish *Champsocephalus gunna*ri in Subarea 48.3 – Based on the 2019 Groundfish Survey T. Earl
WG-FSA-2019/31	Report on fishing effort and seabird interactions during the season extension trials in the longline fishery for Patagonian toothfish (*Dissostichus eleginoides*) in Statistical Division 58.5.2 P. Ziegler, T. Lamb, S. Wotherspoon and J. Dell

WG-FSA-2019/32	Draft integrated stock assessment for the Heard Island and McDonald Islands Patagonian toothfish (*Dissostichus eleginoides*) fishery in Division 58.5.2 P. Ziegler
WG-FSA-2019/33	Catch removals due to killer and sperm whale interactions across sub-Antarctic fisheries P. Tixier, P. Burch, F. Massiot-Granier, P. Ziegler, D. Welsford, M.-A. Lea, M.A. Hindell, C. Guinet, S. Wotherspoon, N. Gasco, C. Péron, G. Duhamel, R. Arangio, R. Tascheri, S. Somhlaba and J.P.Y. Arnould
WG-FSA-2019/34	Disentangling the influence of three major threats on the demography of an albatross community J.B. Cleeland, D. Pardo, B. Raymond, G.N. Tuck, C.R. McMahon, R.A. Phillips, R. Alderman, M.-A. Lea and M.A. Hindell
WG-FSA-2019/35	Comparison of age readings by two readers and preliminary results of age and growth of *Dissostichus mawsoni* in Subarea 88.3 M. Kim, S. Chung, S. Choi, C.P. Sutton and S.J. Parker
WG-FSA-2019/36	Population structure of the Antarctic toothfish, *Dissostichus mawsoni* from the Areas 58 and 88 in the Antarctic Ocean based on mitochondrial and microsatellite DNA markers H.-K. Choi, J.E. Jang, S.Y. Byeon, S. Chung, S.-G. Choi, H.-W. Kim and H.J. Lee
WG-FSA-2019/37	Molecular analysis of stomach contents from Antarctic toothfish (*Dissostichus mawsoni*) collected from Area 58 and 88 from 2016 to 2018 S.R. Lee, S.-G. Choi, S. Chung, D.H. An and H.-W. Kim
WG-FSA-2019/38	New results of oceanological research obtained on Ukrainian longline vessels in the CCAMLR area of responsibility in the season 2018/19 V. Paramonov, L. Pshenichnov, I. Slypko, P. Zabroda, A. Bazhan and T. Pestovskyi
WG-FSA-2019/39	Zooplankton collections during austral summer 2018/19 Ukrainian long-line operations in the Pacific and Atlantic sector of the Southern Ocean E. Pakhomov, L. Pshenichnov, K. Demianenko, D. Marichev, P. Zabroda, I. Slypko, T. Pestovskyi and A. Bazhan

WG-FSA-2019/40	Revision of the precautionary approach to ensuring the rational use of the living resource (*Dissostichus eleginoides*) in Subarea 48.3 (full version) Delegation of the Russian Federation
WG-FSA-2019/41	Report on implementation of research program for study of species composition, biology and resource potential of craboids (Anomura, Decapoda) in the Antarctic Pacific in 2019 Delegation of the Russian Federation
WG-FSA-2019/42 Rev. 1	Research program to examine the life- cycle and resource potential of *Dissostichus* spp. in the Special Research Zone within the Ross Sea region marine protected area (RSRMPA) in 2019–2027 Delegation of the Russian Federation
WG-FSA-2019/43	Withdrawn
WG-FSA-2019/44	Continuation of multi-Member research on the *Dissostichus mawsoni* exploratory fishery in East Antarctica (Divisions 58.4.1 and 58.4.2) from 2018/19 to 2021/22 Delegations of Australia, France, Japan, Republic of Korea and Spain
WG-FSA-2019/45	Patagonian toothfish in the South Indian Ocean outside CCAMLR waters: a preliminary analysis of the SIOFA Patagonian toothfish population R. Sarralde, L.J. López-Abellán and S. Barreiro
WG-FSA-2019/46	VME detection thresholds: provision of a beta version of a R library to compute detection probabilities and preliminary results on the case of the sea pens (Pennatulacea) of the CCAMLR Division 58.4.4b A. Martin and M. Eléaume
WG-FSA-2019/47	2019 update of ongoing work on age and growth of Antarctic toothfish (*Dissostichus mawsoni*) from Divisions 58.4.1 and 58.4.2 Delegations of Australia, Republic of Korea and Spain
WG-FSA-2019/48	Correlation of sea-surface temperature (SST) with sea-ice concentration (SIC) between Subarea 48.6 and other areas such as Ross Sea, Weddell Sea T. Namba, R. Sarralde, S. Somhlaba and J. Pompert

WG-FSA-2019/49	Possibility of predicting sea-ice concentration (SIC) in research block (RB) 48.6-5 (Southern part of Subarea 48.6) using sea surface temperature (SST) in RB 48.6-2 (Northern part of 48.6) T. Namba, R. Sarralde, S. Somhlaba and J. Pompert
WG-FSA-2019/50	Effective, cost-limited and easy-to-implement photo-identification from fishing vessels: an alternative to no effort at all N. Gasco, P. Tixier and C. Lemarchand
WG-FSA-2019/51	Report on the research for *Dissostichus* spp. in Subarea 48.2 by the Ukraine in 2015–2019 Delegation of Ukraine
WG-FSA-2019/52	Proposal for multi-Member research on *Dissostichus* spp. in Divisions 58.4.1 and 58.4.2 from 2019/20 to 2021/22 Delegation of the Russian Federation
WG-FSA-2019/53	Report on fish by-catch during research fishing activities in Division 58.4.4b between 2008 and 2018 C. Péron, C. Chazeau, N. Gasco and F. Massiot-Granier
WG-FSA-2019/54	No boundaries for whales interacting with fishing activities targeting Patagonian toothfish (*Dissostichus eleginoides*) N. Gasco, P. Tixier, F. Massiot-Granier, C. Péron and R. Sarralde
WG-FSA-2019/55	Proposal for a revised summary table used for assessment of new and ongoing research plans C. Péron and D. Welsford
WG-FSA-2019/56	Report on fish by-catch during exploratory fishing activities in Division 58.4.3a (Elan Bank) between 2008 and 2018 C. Péron, C. Chazeau, N. Gasco and F. Massiot-Granier
WG-FSA-2019/57 Rev. 1	An integrated stock assessment for the Crozet Islands Patagonian toothfish (*Dissostichus eleginoides*) fishery in Subarea 58.6 F. Massiot-Granier, G. Duhamel and C. Péron
WG-FSA-2019/58	An integrated stock assessment for the Kerguelen Island EEZ Patagonian toothfish (*Dissostichus eleginoides*) fishery in Division 58.5.1 F. Massiot-Granier, G. Duhamel and C. Péron
WG-FSA-2019/59	Otolith morphological analysis cannot distinguish Antarctic toothfish (*Dissostichus mawsoni*) stocks in the Southern Ocean L. Wei, G.P. Zhu, T. Okuda, S. Parker, I. Slypko and S. Somhlaba

WG-FSA-2019/60	Observation on the interactions between marine mammals and mid-water krill trawl Y. Ying, G. Fan, X. Zhao, J. Zhang, X. Wang and J. Zhu
WG-FSA-2019/61	Progress report on collaborative research for otolith chemistry of Antarctic toothfish *Dissostichus mawsoni* in the Southern Ocean G.P. Zhu
WG-FSA-2019/62	CASAL model evaluation incorporating the calculation of harvest rate for *D. eleginoides* at Division 58.4.4b T. Okuda and F. Massiot-Granier
WG-FSA-2019/63	Modelling egg and larval transport of Antarctic toothfish (*Dissostichus mawsoni*) in the East Antarctic region: preliminary result using satellite data M. Mori, K. Mizobata, T. Okuda and T. Ichii
WG-FSA-2019/64	Revised proposal for the ongoing research plan on Patagonian toothfish (*Dissostichus eleginoides*) in Division 58.4.4b (2016/17–2020/21) Delegations of Japan and France
WG-FSA-2019/65	Annual report of research fishing operations at Division 58.4.4b in the 2018/19 fishing season Delegations of Japan and France
WG-FSA-2019/66	Aligning toothfish fishery status with the CCAMLR regulatory framework C.D. Jones
WG-FSA-2019/67	Proposed revision to the estimation of fisheries footprints Secretariat

Other documents

WG-FSA-2019/P01	Stock connectivity of Antarctic toothfish D. Maschette, S. Wotherspoon, A. Polanowski, B. Deagle, D. Welsford and P. Ziegler. 2019. Final Report, FRDC Project 2017/021. Australian Antarctic Division and the Fisheries Research and Development Corporation. Kingston, Australia. ISBN 978-1-876934-33-0.
WG-SAM-2019/02	Integrated research proposal for *Dissostichus* spp. in Subarea 88.3 by the Republic of Korea, New Zealand and Ukraine Delegations of the Republic of Korea, New Zealand and Ukraine

WG-SAM-2019/03	2019 Ross Sea shelf survey results and notification for research in 2020 S. Parker and C. Jones
CCAMLR-38/02	Developing guidelines for conversion factors in new and exploratory toothfish fisheries Delegation of New Zealand
CCAMLR-38/12 Rev. 1	IUU fishing activity and trends in 2018/19 and IUU Vessel Lists Secretariat
CCAMLR-38/BG/07 Rev. 1	Fishery Notifications 2019/20 Secretariat
CCAMLR-38/BG/11	Reconciliation of CDS data with monthly fine-scale catch and effort data Secretariat
CCAMLR-38/BG/12	Fishery monitoring and closure procedures Secretariat
CCAMLR-38/BG/17 Rev. 1	Technical procedure for retrieval and handling of unidentified fishing gear in the Convention Area Secretariat
CCAMLR-38/BG/40	An introduction to electronic monitoring Delegation of the United Kingdom
SC-CAMLR-38/05	Report of the Working Group on Statistics, Assessments and Modelling (Concarneau, France, 17 to 21 June 2019)
SC-CAMLR-38/09	Outcomes from a review of the CCAMLR Marine Debris Program Secretariat
SC-CAMLR-38/12	Resource support for conducting scientific programs in the Ross Sea region MPA: comments and proposals Delegation of the Russian Federation
SC-CAMLR-38/15	The CCAMLR Decision Rule, strengths and weaknesses Delegation of the United Kingdom
SC-CAMLR-38/BG/01	Catches of target species in the Convention Area Secretariat

Terms of reference for WG-ASAM

Terms of reference for WG-ASAM

1. The Working Group on Acoustics, Survey and Analysis Methods (WG-ASAM) was established by the Scientific Committee as an expert group to examine issues related to the research on Antarctic Marine living Resources using hydro-acoustic technologies. The general terms of reference of the working group includes, but not limited to:

(i) identify new and develop standard acoustic methodology and protocols for the research and monitoring of Antarctic marine living resources, including survey design

(ii) conduct regular assessment and provide advice on area-scale or subarea-scale or division-scale acoustic survey estimates of Antarctic krill to the Scientific Committee and its relevant subsidiary bodies where appropriate

(iii) provide technical advice to scientific observers and the fishing industry for acoustic data collection on board fishing vessels

(iv) conduct annual analysis of the acoustic data collected from CCAMLR-nominated transects and submitted to the Secretariat.

Procedure for estimating two-hour catches during continuous trawl fishing for krill using daily flow-scale records split according to the distribution of two-hour catches derived from holding tank volume monitoring

Procedure for estimating two-hour catches during continuous trawl fishing for krill using daily flow-scale records split according to the distribution of two-hour catches derived from holding tank volume monitoring

1. Every day, the total catch in weight (W_{day}) is the accumulated catch that passed across the flow scale during a 24-hour period. The total daily catch is recorded every day at the same time, preferably at 00:00 UTC.

2. In order to split the total catch during the day (W_{day}) into two-hour catches, a catch distribution by two-hour intervals is derived by continuous monitoring of the catch added to the holding tanks[1], as follows:

(i) The krill catch added to holding tanks in a two-hour interval is estimated from changes in filling levels of the tanks between the start and end of that time interval. Based on predetermined measurements of the volume of full tanks, the filling level changes can be used to derive a volume added to each tank. (Since capacities may differ between tanks, measurements of catch represented by a full tank have to be made for individual tanks).

(ii) Tanks can be fully or partially drained during a two-hour period. The tank filling volume is recorded at the start and end of any filling or draining operation and the draining and filling of a tank must not occur simultaneously.

(iii) Volumes added in a two-hour interval are converted to weights assuming a constant or measured water content of the krill + water mixture added to the tank. If water content is not monitored, it should be set constant at 30%.

(iv) The estimate of the vessel's catch in weight added to the tanks in a two-hour interval is the sum of weight estimates across all tanks.

(v) At the end of each day (00.00 UTC), a distribution of catches by two-hour intervals is derived as proportions of the total recorded for that day (i.e. the sum of two-hour catches recorded).

3. The distribution of two-hour catch estimates obtained in paragraph 2(v) above is used to proportionally split the total daily catch recorded at the flow scale (W_{day}) into two-hour catches.

4. The estimated two-hour catches should be adjusted for variable water content at the flow scale during the day. Drip loss measurements should therefore be made repeatedly during the day, preferably 12 times.

5. The two-hour catches, adjusted for drip loss, are recorded on the C1 form.

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[1] When referring volumes of catch added during two-hour intervals, the lag between the time a catch occurs in the trawl mouth and the time it enters the holding tanks should be taken into account. Lag times should be measured experimentally. Experiments on Norwegian krill vessels have resulted in estimated average lags of approx. 8 minutes.

6. Geographical position of the vessel at the start of each two-hour interval is recorded in the logbook and on the C1 form.

7. Samples of krill for size distributions as well as by-catch samples are extracted prior to the catch entering the holding tanks. These samples should be referred to the appropriate two-hour catch as recorded on the C1 form, thereby ensuring reference to catch-specific data on fishing location for individual two-hour catches.

CCAMLR–COLTO Tagging Workshop

CCAMLR–COLTO Tagging Workshop

Date and location:	July–August 2020, Nelson, New Zealand
Co-conveners:	Dr S. Parker (New Zealand) and Mr R. Arangio (COLTO)
Objective:	Provide a suitable environment to exchange information and share experience to document current best practices used in tagging toothfish in CCAMLR longline fisheries and to use this documentation to support the training of all involved in at-sea tagging operations for toothfish.
Target attendees:	CCAMLR Members, fishing industry crew and operators, CCAMLR Scheme of International Scientific Observation (SISO) observers, national (Member) observers, observer trainers, any others involved in CCAMLR tagging.
Invited experts:	Two fish-tagging and fish-handling experts in large fish tagging (e.g. sablefish/cod/tuna).
Duration:	2.5 days
Outputs:	Documentation of best-practice toothfish tagging procedures and provision of material suitable for the preparation of multi-media training resources for all involved in the CCAMLR toothfish tagging program.
Funding required:	COLTO – meeting venue and meeting operations CCAMLR – attendance of up to two international fish tagging and fish handling experts (US$10 000) to cover travel and accommodation related costs. These experts will be identified and invited by the Scientific Committee Bureau (SCB). CCAMLR – capacity fund contribution to support Members to attend the workshop. This to be administered by the Secretariat based on Member applications and recommendations from the SCB (US$12 000).

Proposed agenda topics:

1. Best practices to retrieve, tag and return live toothfish to ensure the best chance of fish survival.

2. Recording and reporting on tagging and recapture information.

3. Develop and document all relevant material and information to produce best-practice guidelines, improve training resources and comprehensively document this in a dynamic document.

Terms of reference of the intersessional correspondence group on marine debris (ICG-MD)

Terms of reference of the intersessional correspondence group on marine debris (ICG-MD)

1. The intersessional correspondence group on marine debris (ICG-MD) shall be tasked with developing the objectives and expected outcomes of the marine debris program in order to provide recommendations that will improve its operation and utility. The ICG-MD shall:

(i) be open to participation by all Members and be composed of any Members that wish to participate from the Commission and the Scientific Committee

(ii) be open to interested observer organisations following invitation from the ICG-MD

(iii) consider the objectives of the marine debris program and develop an approach to meet the agreed objective(s), including:

(a) development of an approach to use current data holdings to measure changes in debris levels and to quantify levels of debris across the Convention Area

(b) development of an approach to use opportunistically collected marine debris data

(c) incorporating new methodology for measuring debris levels and/or updating current methodology in line with globally accepted standards, including consideration of:

- standardised sampling units to provide a comparative index
- categorisation of debris items

(d) expanding monitoring efforts to effectively capture spatial and temporal trends

(iv) coordinate work intersessionally through a marine debris e-group.

Annex 12

Terms of reference of the General Science Capacity Fund

Terms of reference of the General Science Capacity Fund

Objective

1. The Fund's primary purpose is to secure wider participation, not least from young scientists, in the work of the Scientific Committee, to promote burden sharing and build capacity within the Scientific Committee, assisting with the collection, study and exchange of information relating to the marine living resources to which the Convention applies.

2. The aim of the fund will be:

(i) increasing participation in the work of SC-CAMLR working groups and developing an increased awareness and understanding of the work of SC-CAMLR

(ii) resourcing and delivering scientific activities, including field programs, needed for providing advice by the Scientific Committee to the Commission.

Special activities

3. The fund will support Special Activities identified by the Scientific Committee that meet the following criteria:

(i) activities aimed at increasing participation in the work of SC-CAMLR working groups and developing an increased awareness and understanding of the work of the Scientific Committee

(ii) activities aimed at delivering key scientific data or analyses of importance to the Scientific Committee that require collaboration between Members

(iii) specific research programs that are requested by working groups or the Scientific Committee, that could not normally be undertaken by the Secretariat.

4. Activities that are addressed in the terms of reference and objectives of other CCAMLR funding sources will not be considered for Special Activity status for additional funding from the GSCF.

5. The Scientific Committee shall request approval of nominated Special Activities from the Commission. The Commission reserves the right to withdraw approval from existing Special Activities when their timeframe expires, when the GSCF funds are exhausted, or at any other time following consultation with the Scientific Committee.

6. When the Scientific Committee agrees a Special Activity that may receive funding from the GSCF it shall define a set of selection criteria for funding against that Special Activity. These shall define, at a minimum:

(i) the objectives of the Special Activity, including the timeframe over which it will operate

(ii) the contribution of that activity to the work plan of the Scientific Committee and the expected advice that the Scientific Committee will be able to provide as a result

(iii) specifics of the Scientific Committee work program and details of the research required, and the specific reference to Scientific Committee background documents and decisions that detail these requirements.

7. The Scientific Committee shall annually define the deadlines and timeframes of the call for proposals for funding against each Special Activity.

8. Applications for projects will only be accepted if they meet the requirements of delivery against named Special Activities.

9. Applications for funding of projects that address the requirements of the Special Activity will be reviewed by the General Science Capacity Fund Management Group comprising the Scientific Committee Chair and Vice-Chairs, Working Group Conveners and the Secretariat.

Procedures

10. The Fund will be operated according to the following provisions.

11. Proposals for projects to be supported by the Fund may be made by Members, by the Commission or the Scientific Committee and their subsidiary bodies, or by the Secretariat. In their submission, details will be given as to how they address the selection criteria of a Special Activity approved by the Scientific Committee and the Commission as eligible for the Fund.

12. Proposals shall be submitted to the CCAMLR Secretariat according to the deadline specified in the relevant call for proposals announced by the Scientific Committee.

13. Proposals, at a minimum, shall include the following:

(i) a description of the project and/or scope of the mechanism/activity

(ii) a statement of the anticipated benefit to the Member(s) and CCAMLR

(iii) an outline of how the project meets the requirements of delivery against the selection criteria for the Specific Activity

(iv) details of the project timeline, budget and when the outcomes will be reported to CCAMLR.

14. The Management Group will review any proposals received, assessing them on the basis of whether they will contribute to the achievement of the Special Activity, and provide an initial recommendation on whether a proposal should be supported by the General Science Capacity Fund. This initial review and recommendation will be distributed to all Members via a Scientific Committee circular. Members will then have an opportunity to comment on this recommendation within a defined time limit (e.g. one month). If no objections are received

during that time, then the initial recommendation will be upheld and funds will be allocated accordingly.

15. The recommendation of the Management Group shall take into account the current and future balance of the fund and shall not recommend projects beyond the current and projected instantaneous capacity of the fund.

16. Projects will be funded 30% of the approved budget upon the signing of the Deed of Funding by all relevant parties.

17. Interim payments will be released as outlined in the Deed of Funding, typically upon the reaching of milestones or the acceptance of interim reports.

18. The last payment will be made when the final report is accepted by the Panel and the Commission meeting of that year.

Administrative arrangements and reporting

19. The Financial Regulations of the Commission shall apply to the Fund, except in so far as these provisions provide or the Commission decides otherwise.

20. The Secretariat shall report to the annual meeting of the Scientific Committee regarding the financial status and activities of the Fund, including its income and expenditure. Progress reports from each project will be submitted by the project manager and be included as part of this reporting. Progress reports must include details of the expenditures.

21. The Scientific Committee shall review all ongoing projects at its annual meeting as a standing agenda item and reserves the right, after notice, to cancel a project at any time. Such a decision would be exceptional, but would be based upon lack of progress made to date, and the likelihood of lack of progress in the future.

22. The Commission may modify these administrative provisions at any time.

Glossary of acronyms and abbreviations used in SC-CAMLR reports

Glossary of acronyms and abbreviations used in SC-CAMLR reports

AAD	Australian Government Antarctic Division
ACAP	Agreement on the Conservation of Albatrosses and Petrels
ACAP BSWG	ACAP Breeding Sites Working Group (BSWG)
ACC	Antarctic Circumpolar Current
ACW	Antarctic Circumpolar Wave
ADCP	Acoustic Doppler Current Profiler (mounted on the hull)
ADL	Aerobic Dive Limit
AEM	Ageing Error Matrix
AFMA	Australian Fisheries Management Authority
AFZ	Australian Fishing Zone
AIS	Automatic Identification System
AKES	Antarctic Krill and Ecosystem Studies
ALK	Age–length Key
AMD	Antarctic Master Directory
AMES	Antarctic Marine Ecosystem Studies
AMLR	Antarctic Marine Living Resources
AMSR-E	Advanced Microwave Scanning Radiometer – Earth Observing System
ANDEEP	Antarctic Benthic Deep-sea Biodiversity
APBSW	Bransfield Strait West (SSMU)
APDPE	Drake Passage East (SSMU)
APDPW	Drake Passage West (SSMU)
APE	Antarctic Peninsula East (SSMU)
APEC	Asia-Pacific Economic Cooperation
APECS	Association of Polar Early Career Scientists

APEI	Elephant Island (SSMU)
APEME Steering Committee	Steering Committee on Antarctic Plausible Ecosystem Modelling Efforts
APIS	Antarctic Pack-Ice Seals Program (SCAR-GSS)
APW	Antarctic Peninsula West (SSMU)
ARK	Association of Responsible Krill harvesting companies
ASE	Assessment Strategy Evaluation
ASI	Antarctic Site Inventory
ASIP	Antarctic Site Inventory Project
ASMA	Antarctic Specially Managed Area
ASOC	Antarctic and Southern Ocean Coalition
ASPA	Antarctic Specially Protected Area
ASPM	Age-Structured Production Model
ATCM	Antarctic Treaty Consultative Meeting
ATCP	Antarctic Treaty Consultative Party
ATME	Antarctic Treaty Meeting of Experts on the Impacts of Climate Change for Management and Governance of the Antarctic region
ATS	Antarctic Treaty System
ATSCM	Antarctic Treaty Special Consultative Meeting
AVHRR	Advanced Very High Resolution Radiometry
BAS	British Antarctic Survey
BED	Bird Excluder Device
BICS	Benthic Impact Camera System
BIOMASS	Biological Investigations of Marine Antarctic Systems and Stocks (SCAR/SCOR)
BROKE	Baseline Research on Oceanography, Krill and the Environment
BRT	Boosted Regression Trees

CAC	Comprehensive Assessment of Compliance
cADL	calculated Aerobic Dive Limit
CAF	Central Ageing Facility
CAML	Census of Antarctic Marine Life
CAMLR Convention	Convention on the Conservation of Antarctic Marine Living Resources
CAML SSC	CAML Scientific Steering Committee
CAR	Comprehensiveness, Adequacy, Representativeness
CASAL	C++ Algorithmic Stock Assessment Laboratory
CBD	Convention on Biodiversity
CCAMLR	Commission for the Conservation of Antarctic Marine Living Resources
CCAMLR-2000 Survey	CCAMLR 2000 Krill Synoptic Survey of Area 48
CCAMLR-IPY-2008 Survey	CCAMLR-IPY 2008 Krill Synoptic Survey in the South Atlantic Region
CCAS	Convention on the Conservation of Antarctic Seals
CCEP	CCAMLR Compliance Evaluation Procedure
CCSBT	Commission for the Conservation of Southern Bluefin Tuna
CCSBT-ERS WG	CCSBT Ecologically Related Species Working Group
CDS	Catch Documentation Scheme for *Dissostichus* spp.
CDW	Circumpolar Deep Water
CEMP	CCAMLR Ecosystem Monitoring Program
CEP	Committee for Environmental Protection
CF	Conversion Factor
CircAntCML	Circum-Antarctic Census of Antarctic Marine Life
CITES	Convention on International Trade in Endangered Species
CM	Conservation Measure

CMIR	CCAMLR MPA Information Repository
CMIX	CCAMLR’s Mixture Analysis Program
CMP	Conservation Management Plan
CMS	Convention on the Conservation of Migratory Species of Wild Animals
COFI	Committee on Fisheries (FAO)
COLTO	Coalition of Legal Toothfish Operators
CoML	Census of Marine Life
COMM CIRC	Commission Circular (CCAMLR)
COMNAP	Council of Managers of National Antarctic Programs (SCAR)
CON	CCAMLR Otolith Network
COTPAS	CCAMLR Observer Training Program Accreditation Scheme
CPD	Critical Period–Distance
CPPS	Permanent Commission on the South Pacific
CPR	Continuous Plankton Recorder
CPUE	Catch-per-unit-effort
CQFE	Center for Quantitative Fisheries Ecology (USA)
CS-EASIZ	Coastal Shelf Sector of the Ecology of the Antarctic Sea-Ice Zone (SCAR)
CSI	Combined Standardised Index
CSIRO	Commonwealth Scientific and Industrial Research Organisation (Australia)
CT	Computed Tomography
CTD	Conductivity Temperature Depth Probe
CV	Coefficient of Variation
C-VMS	Centralised Vessel Monitoring System
CVS	Concurrent Version System
CWP	Coordinating Working Party on Fishery Statistics (FAO)

DCD	*Dissostichus* Catch Document
DMSP	Defense Meteorological Satellite Program
DPM	Dynamic Production Model
DPOI	Drake Passage Oscillation Index
DSAG	Data Services Advisory Group
DQA	Data quality assurance
DVM	Diel vertical migration
DWBA	Distorted wave Born approximation model
EAF	Ecosystem Approaches to Fishing
EASIZ	Ecology of the Antarctic Sea-Ice Zone
E-CDS	Electronic Web-based Catch Documentation Scheme for *Dissostichus* spp.
ECOPATH	Software for construction and analysis of mass-balance models and feeding interactions or nutrient flow in ecosystems (see www.ecopath.org)
ECOSIM	Software for construction and analysis of mass-balance models and feeding interactions or nutrient flow in ecosystems (see www.ecopath.org)
EEZ	Exclusive Economic Zone
EG-BAMM	Expert Group on Birds and Marine Mammals (SCAR)
EIV	Ecologically Important Value
ENFA	Environmental Niche Factor Analysis
ENSO	El Niño Southern Oscillation
EOF/PC	Empirical Orthogonal Function/Principal Component
EoI	Expression of Intent (for activities in the IPY)
EPOC	Ecosystem, productivity, ocean, climate modelling framework
EPOS	European *Polarstern* Study
EPROM	Erasable Programmable Read-Only Memory

eSB	Electronic version of CCAMLR's *Statistical Bulletin*
ESS	Effective Sample Size(s)
FAO	Food and Agriculture Organization of the United Nations
FBM	Feedback Management
FEMA	Workshop on Fisheries and Ecosystem Models in the Antarctic
FEMA2	Second Workshop on Fisheries and Ecosystem Models in the Antarctic
FFA	Forum Fisheries Agency
FFO	Foraging–Fishery Overlap
FIBEX	First International BIOMASS Experiment
FIGIS	Fisheries Global Information System (FAO)
FIRMS	Fishery Resources Monitoring System (FAO)
FMP	Fishery Management Plan
FOOSA	Krill–Predator–Fishery Model (previously KPFM2)
FPI	Fishing-to-Predation Index
FRAM	Fine Resolution Antarctic Model
FV	Fishing Vessel
GAM	Generalised Additive Model
GATT	General Agreement on Tariffs and Trade
GBIF	Global Biodiversity Information Facility
GBM	Generalised Boosted Model
GCMD	Global Change Master Directory
GDM	Generalised Dissimilarity Modelling
GEBCO	General Bathymetric Chart of the Oceans
GEOSS	Global Earth Observing System of Systems
GIS	Geographic Information System
GIWA	Global International Waters Assessment (SCAR)

GLM	Generalised Linear Model
GLMM	Generalised Linear Mixed Model
GLOBEC	Global Ocean Ecosystems Dynamics Research
GLOCHANT	Global Change in the Antarctic (SCAR)
GMT	Greenwich Mean Time
GOOS	Global Ocean Observing System (SCOR)
GOSEAC	Group of Specialists on Environmental Affairs and Conservation (SCAR)
GOSSOE	Group of Specialists on Southern Ocean Ecology (SCAR/SCOR)
GPS	Global Positioning System
GSCF	General Science Capacity Fund
GUI	Graphical User Interface
GRT	Gross Registered Tonnage
GTS	Greene et al., (1990) linear TS versus length relationship
GYM	Generalised Yield Model
HAC	A global standard being developed for the storage of hydroacoustic data
HCR	Harvest Control Rule
HIMI	Heard Island and McDonald Islands
IA	Impact Assessment
IAATO	International Association of Antarctica Tour Operators
IASOS	Institute for Antarctic and Southern Ocean Studies (Australia)
IASOS/CRC	IASOS Cooperative Research Centre for the Antarctic and Southern Ocean Environment
IATTC	Inter-American Tropical Tuna Commission
ICAIR	International Centre for Antarctic Information and Research
ICCAT	International Commission for the Conservation of Atlantic Tunas
ICED	Integrating Climate and Ecosystem Dynamics in the Southern Ocean

ICES	International Council for the Exploration of the Sea
ICESCAPE	Integrating Count Effort by Seasonally Correcting Animal Population Estimates
ICES WGFAST	ICES Working Group on Fisheries Acoustics Science and Technology
ICFA	International Coalition of Fisheries Associations
ICG-SF	Intersessional Correspondence Group on Sustainable Financing
ICSEAF	International Commission for the Southeast Atlantic Fisheries
ICSU	International Council for Science
IDCR	International Decade of Cetacean Research
IFF	International Fishers' Forum
IGBP	International Geosphere-Biosphere Programme
IGR	Instantaneous Growth Rate
IHO	International Hydrographic Organisation
IKMT	Isaacs-Kidd Midwater Trawl
IMAF	Incidental Mortality Associated with Fishing
IMALF	Incidental Mortality Arising from Longline Fishing
IMBER	Integrated Marine Biogeochemistry and Ecosystem Research (IGBP)
IMO	International Maritime Organization
IMP	Inter-moult Period
IOC	Intergovernmental Oceanographic Commission
IOCSOC	IOC Regional Committee for the Southern Ocean
IOFC	Indian Ocean Fisheries Commission
IOTC	Indian Ocean Tuna Commission
IPHC	International Pacific Halibut Commission
IPOA	International Plan of Action
IPOA-Seabirds	FAO International Plan of Action for Reducing Incidental Catch of Seabirds in Longline Fisheries

IPY	International Polar Year
IRCS	International Radio Call Sign
ISO	International Organization for Standardization
ISR	Integrated Study Region
ITLOS	International Tribunal for the Law of the Sea
IUCN	International Union for the Conservation of Nature and Natural Resources – the World Conservation Union
IUU	Illegal, Unreported and Unregulated
IW	Integrated Weight
IWC	International Whaling Commission
IWC-IDCR	IWC International Decade of Cetacean Research
IWC SC	Scientific Committee of the IWC
IWL	Integrated Weighted Line
IYGPT	International Young Gadoids Pelagic Trawl
JAG	Joint Assessment Group
JARPA	Japanese Whale Research Program under special permit in the Antarctic
JGOFS	Joint Global Ocean Flux Studies (SCOR/IGBP)
KPFM	Krill–Predatory–Fishery Model (used in 2005)
KPFM2	Krill–Predatory–Fishery Model (used in 2006) – renamed FOOSA
KYM	Krill Yield Model
LADCP	Lowered Acoustic Doppler Current Profiler (lowered through the water column)
LAKRIS	Lazarev Sea Krill Study
LBRS	Length-bin Random Sampling
LMM	Linear Mixed Model
LMR	Living Marine Resources Module (GOOS)
LSSS	Large-Scale Server System

LTER	Long-term Ecological Research (USA)
M	Natural Mortality
MARPOL Convention	International Convention for the Prevention of Pollution from Ships
MARS	Multivariate Adaptive Regression Splines
MAXENT	Maximum Entropy modelling
MBAL	Minimum Biologically Acceptable Limits
MCMC	Markov Chain Monte Carlo
MCS	Monitoring Control and Surveillance
MDS	Mitigation Development Strategy
MEA	Multilateral Environmental Agreement
MEOW	Marine Ecoregions of the World
MFTS	Multiple-Frequency Method for in situ TS Measurements
MIA	Marginal Increment Analysis
MIZ	Marginal Ice Zone
MLD	Mixed-layer Depth
MODIS	Moderate Resolution Imaging Spectroradiometer
MoU	Memorandum of Understanding
MP	Management Procedure
MPA	Marine Protected Area
MPD	Maximum of the Posterior Density
MRAG	Marine Resources Assessment Group (UK)
MRM	Minimum Realistic Model
MSE	Management Strategy Evaluation
MSY	Maximum Sustainable Yield
MV	Merchant Vessel
MVBS	Mean Volume Backscattering Strength

MVP	Minimum Viable Populations
MVUE	Minimum Variance Unbiased Estimate
NAFO	Northwest Atlantic Fisheries Organization
NASA	National Aeronautical and Space Administration (USA)
NASC	Nautical Area Scattering Coefficient
NCAR	National Center for Atmospheric Research (USA)
NEAFC	North East Atlantic Fisheries Commission
NCP	Non-Contracting Party
NGO	Non-Governmental Organisation
NI	Nearest Integer
NIWA	National Institute of Water and Atmospheric Research (New Zealand)
nMDS	non-Metric Multidimensional Scaling
NMFS	National Marine Fisheries Service (USA)
NMML	National Marine Mammal Laboratory (USA)
NOAA	National Oceanic and Atmospheric Administration (USA)
NPOA	National Plan of Action
NPOA-Seabirds	FAO National Plans of Action for Reducing Incidental Catch of Seabirds in Longline Fisheries
NRT	Net Registered Tonnage
NSF	National Science Foundation (USA)
NSIDC	National Snow and Ice Data Center (USA)
OBIS	Ocean Biogeographic Information System
OCCAM Project	Ocean Circulation Climate Advanced Modelling Project
OCTS	Ocean Colour and Temperature Scanner
OECD	Organisation for Economic Cooperation and Development
OM	Operating Model
PaCSWG	Population and Conservation Status Working Group (ACAP)

PAR	Photosynthetically Active Radiation
PBR	Permitted Biological Removal
PCA	Principal Component Analysis
PCR	Per Capita Recruitment
pdf	Portable Document Format
PF	Polar Front
PFZ	Polar Frontal Zone
PIT	Passive Integrated Transponder
PRP	CCAMLR Performance Review Panel
PS	Paired Streamer Line
PSAT	Pop-up satellite archival tag
PTT	Platform Terminal Transmitter
RES	Relative Environmental Suitability
RFB	Regional Fishery Body
RFMO	Regional Fishery Management Organisation
RMT	Research Midwater Trawl
ROV	Remotely-Operated Vehicle
RPO	Realised Potential Overlap
RTMP	Real-Time Monitoring Program
RV	Research Vessel
RVA	Register of Vulnerable Areas
SACCB	Southern Antarctic Circumpolar Current Boundary
SACCF	Southern Antarctic Circumpolar Current Front
SAER	State of the Antarctic Environment Report
SAF	Sub-Antarctic Front
SBDY	Southern Boundary of the ACC

SBWG	Seabird Bycatch Working Group (ACAP)
SCAF	Standing Committee on Administration and Finance (CCAMLR)
SCAR	Scientific Committee on Antarctic Research
SCAR-ASPECT	Antarctic Sea-Ice Processes, Ecosystems and Climate (SCAR Program)
SCAR-BBS	SCAR Bird Biology Subcommittee
SCAR-CPRAG	Action Group on Continuous Plankton Recorder Research
SCAR-EASIZ	Ecology of the Antarctic Sea-Ice Zone (SCAR Program)
SCAR-EBA	Evolution and Biodiversity in Antarctica (SCAR Program)
SCAR-EGBAMM	Expert Group on Birds And Marine Mammals
SCAR-GEB	SCAR Group of Experts on Birds
SCAR-GOSEAC	SCAR Group of Specialists on Environmental Affairs and Conservation
SCAR-GSS	SCAR Group of Specialists on Seals
SCAR-MarBIN	SCAR Marine Biodiversity Information Network
SCAR/SCOR-GOSSOE	SCAR/SCOR Group of Specialists on Southern Ocean Ecology
SCAR WG-Biology	SCAR Working Group on Biology
SC-CAMLR	Scientific Committee for the Conservation of Antarctic Marine Living Resources
SC CIRC	Scientific Committee Circular (CCAMLR)
SC-CMS	Scientific Committee for CMS
SCIC	Standing Committee on Implementation and Compliance (CCAMLR)
SCOI	Standing Committee on Observation and Inspection (CCAMLR)
SCOR	Scientific Committee on Oceanic Research
SCP	Systematic Conservation planning
SD	Standard Deviation
SDWBA	Stochastic Distorted-wave Born Approximation

SEAFO	South East Atlantic Fisheries Organisation
SeaWiFS	Sea-viewing Wide Field-of-view Sensor
SG-ASAM	Subgroup on Acoustic Survey and Analysis Methods
SGE	South Georgia East
SGSR	South Georgia–Shag Rocks
SGW	South Georgia West (SSMU)
SIBEX	Second International BIOMASS Experiment
SIC	Scientist-in-Charge
SIOFA	Southern Indian Ocean Fisheries Agreement
SIR Algorithm	Sampling/Importance Resampling Algorithm
SISO	Scheme of International Scientific Observation (CCAMLR)
SKAG	SCAR Krill Action Group
SMOM	Spatial Multispecies Operating Model
SNP	Single Nucleotide Polymorphism
SO-CPR	Southern Ocean CPR
SO GLOBEC	Southern Ocean GLOBEC
SOI	Southern Oscillation Index
SO JGOFS	Southern Ocean JGOFS
SOMBASE	Southern Ocean Molluscan Database
SONE	South Orkney North East (SSMU)
SOOS	Southern Ocean Observing System
SOPA	South Orkney Pelagic Area (SSMU)
SOS Workshop	Southern Ocean Sentinel Workshop
SOW	South Orkney West (SSMU)
SOWER	Southern Ocean Whale Ecology Research Cruises
SPA	Specially Protected Area

SPC	Secretariat of the Pacific Community
SPGANT	Ocean Colour Chlorophyll-*a* algorithm for the Southern Ocean
SPM	Spatial Population Model
SPRFMO	South Pacific Regional Fisheries Management Organisation
SRZ	Special research zone
SSB	Spawning Stock Biomass
SSG-LS	The Standing Scientific Group on Life Sciences (SCAR)
SSM/I	Special Sensor Microwave Imager
SSMU	Small-scale Management Unit
SSMU Workshop	Workshop on Small-scale Management Units, such as Predator Units
SSRU	Small-scale Research Unit
SSSI	Site of Special Scientific Interest
SST	Sea-Surface Temperature
STC	Subtropical Convergence
SWIOFC	Southwest Indian Ocean Fisheries Commission
TASO	ad hoc Technical Group for At-Sea Operations (CCAMLR)
TDR	Time Depth Recorder
TEWG	Transitional Environmental Working Group
TIRIS	Texas Instruments Radio Identification System
TISVPA	Triple Instantaneous Separable VPA (previously TSVPA)
ToR	Term of Reference
TrawlCI	Estimation of Abundance from Trawl Surveys
TS	Target Strength
TVG	Time Varied Gain
UBC	University of British Columbia (Canada)
UCDW	Upper Circumpolar Deep Water

UN	United Nations
UNCED	UN Conference on Environment and Development
UNCLOS	UN Convention on the Law of the Sea
UNEP	UN Environment Programme
UNEP-WCMC	UNEP World Conservation Monitoring Centre
UNFSA	the United Nations Fish Stock Agreement is the 1995 United Nations Agreement for the Implementation of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks
UNGA	United Nations General Assembly
UPGMA	Unweighted Pair Group Method with Arithmetic Mean
US AMLR	United States Antarctic Marine Living Resources Program
US LTER	United States Long-term Ecological Research
UV	Ultra-Violet
UW	Unweighted
UWL	Unweighted Longline
VME	Vulnerable Marine Ecosystem
VMS	Vessel Monitoring System
VOGON	Value Outside the Generally Observed Norm
VPA	Virtual Population Analysis
WAMI	Workshop on Assessment Methods for Icefish (CCAMLR)
WC	Weddell Circulation
WCO	World Customs Organization
WFC	World Fisheries Congress
WCPFC	Western and Central Pacific Fisheries Commission
WG-CEMP	Working Group for the CCAMLR Ecosystem Monitoring Program (CCAMLR)

WG-EMM	Working Group on Ecosystem Monitoring and Management (CCAMLR)
WG-EMM-STAPP	Subgroup on Status and Trend Assessment of Predator Populations
WG-FSA	Working Group on Fish Stock Assessment (CCAMLR)
WG-FSA-SAM	Subgroup on Assessment Methods
WG-FSA-SFA	Subgroup on Fisheries Acoustics
WG-IMAF	Working Group on Incidental Mortality Associated with Fishing (CCAMLR)
WG-IMALF	ad hoc Working Group on Incidental Mortality Arising from Longline Fishing (CCAMLR)
WG-Krill	Working Group on Krill (CCAMLR)
WG-SAM	Working Group on Statistics, Assessments and Modelling
WMO	World Meteorological Organization
WOCE	World Ocean Circulation Experiment
WSC	Weddell–Scotia Confluence
WS-Flux	Workshop on Evaluating Krill Flux Factors (CCAMLR)
WS-MAD	Workshop on Methods for the Assessment of *D. eleginoides* (CCAMLR)
WSSD	World Summit on Sustainable Development
WS-VME	Workshop on Vulnerable Marine Ecosystems
WTO	World Trade Organization
WWD	West Wind Drift
WWF	World Wide Fund for Nature
WWW	World Wide Web
XBT	Expendable Bathythermograph
XML	Extensible Mark-up Language
Y2K	Year 2000
YCS	Year-class Strength(s)