SC-CAMLR-XXXVII

**SCIENTIFIC COMMITTEE FOR THE CONSERVATION
OF ANTARCTIC MARINE LIVING RESOURCES**

REPORT OF THE THIRTY-SEVENTH MEETING OF THE SCIENTIFIC COMMITTEE

HOBART, AUSTRALIA
22–26 OCTOBER 2018

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Chair of the Scientific Committee
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Abstract

This document presents the adopted report of the Thirty-seventh Meeting of the Scientific Committee for the Conservation of Antarctic Marine Living Resources held in Hobart, Australia, from 22 to 26 October 2018. 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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Report of the Thirty-seventh
Meeting of the Scientific Committee
(Hobart, Australia, 22 to 26 October 2018)

Opening of the meeting

1.1 The Scientific Committee for the Conservation of Antarctic Marine Living Resources met from 22 to 26 October 2018 at the CCAMLR Headquarters in Hobart, Tasmania, Australia. The meeting was chaired by Dr M. Belchier (UK).

1.2 The Chair welcomed to the meeting representatives from Argentina, Australia, Belgium, Brazil, Chile, People's Republic of China (China), European Union (EU), France, Germany, India, Italy, Japan, Republic of Korea (Korea), New Zealand, Norway, Poland, 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 Other Contracting Parties, Bulgaria, Canada, Cook Islands, Finland, Greece, Mauritius, Netherlands, Islamic Republic of Pakistan, Republic of Panama, Peru and Vanuatu were invited to attend the meeting as Observers. The Chair welcomed a representative from the Netherlands to the meeting. Luxembourg and Ecuador were also invited and attended the meeting.

1.4 The Chair 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. The Chair noted that this was the first time that IAATO had attended the Scientific Committee and welcomed them as Observers to the Scientific Committee.

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

1.6 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.

1.7 The report of the Scientific Committee was prepared by O.A. Bergstad (Norway), C. Cárdenas (Chile), C. Darby (UK), M. Doyle (Secretariat), A. Dunn (New Zealand), M. Eléaume (France), J. Fenaughty and D. Freeman (New Zealand), I. Forster (Secretariat), G. Funnell (New Zealand), S. Grant (UK), E. Grilly (Secretariat), C. Heinecken (South Africa), J. Hinke and C. Jones (USA), S. Kawaguchi and N. Kelly (Australia), P. Koubbi (EU), A. Lowther (Norway), D. Maschette (Australia), S. Parker (New Zealand), P. Penhale (USA),

A. Van de Putte (Belgium), K. Reid (Secretariat), G. Robson (UK), M. Santos (Argentina), M. Söffker (EU), S. Thanassekos (Secretariat), P. Trathan (UK), G. Watters (USA) and P. Ziegler (Australia).

Adoption of the agenda

1.8 The Scientific Committee discussed the Provisional Agenda which had been circulated as SC CIRC 18/59 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

1.9 Dr Belchier noted the Scientific Committee's work in the 2017/18 intersessional period. The following meetings had taken place:

(i) Workshop for the Development of a *Dissostichus mawsoni* Population Hypothesis for Area 48 (WS-DmPH-18), 19 to 21 February 2018, Berlin, Germany (SC-CAMLR-XXXVII/01). Convened Drs Darby and Jones and attended by 29 scientists from 11 Members with 14 papers considered

(ii) Subgroup on Acoustic Survey and Analysis Methods (SG-ASAM), 30 April to 4 May 2018, Punta Arenas, Chile (Annex 4). Convened by Dr X. Zhao (China) and attended by 18 scientists from 6 Members with 9 papers considered

(iii) Independent Stock Assessment Review for Toothfish, 18 to 22 June 2018, Norwich, UK (Annex 5). Convened by Dr C. Reiss (USA) and involving the participation of a Review Panel comprising three independent stock assessment experts

(iv) Working Group on Statistics, Assessments and Modelling (WG-SAM), 25 to 29 June 2018, Norwich, UK (Annex 6). Convened by Dr Parker and attended by 28 scientists from 12 Members with 36 papers considered

(v) Workshop on Spatial Management (WS-SM-18), 2 to 6 July 2018, Cambridge, UK (Annex 7). Convened by Dr Grant and attended by 52 scientists from 17 Members with 21 papers considered

(vi) Working Group on Ecosystem Monitoring and Management (WG-EMM), 9 to 13 July 2018, Cambridge, UK (Annex 8). Convened by Dr Belchier and attended by 61 scientists from 20 Members with 65 papers considered

(vii) Working Group on Fish Stock Assessment (WG-FSA), 8 to 19 October 2018, Headquarters, Hobart (Annex 9). Convened by Dr D. Welsford (Australia) and attended by 52 scientists from 16 Members with 77 papers considered.

1.10 Dr Belchier noted the very large volume of intersessional work undertaken in 2018 and thanked the conveners, hosts and local organisers for their support. He noted that in the eight weeks of meetings during 2018, there were 222 papers considered and this demonstrated not only the commitment of CCAMLR scientists but also the flexibility of those scientists to work in focused workshops and working groups.

1.11 Dr Belchier also thanked the Members of the Scientific Committee Bureau for their engagement through the year and noted that this was the first year of operation of the Bureau (SC-CAMLR-XXXVI, paragraph 16.8) and that it had played an instrumental role in the planning and coordination of the intersessional work of the Scientific Committee.

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

Statistics, assessments and modelling

2.1 The Scientific Committee reviewed advice from WG-SAM (Annex 6). WG-SAM is following a five-year work plan from the Scientific Committee set out in SC-CAMLR-XXXVI/BG/40.

2.2 There were three main areas of work covered at the 2018 meeting:

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

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

(iii) data acquisition and management.

2.3 Although the work plan for the meeting included nine topics, the Scientific Committee noted that papers were only submitted on three topics, and the review of research plans and proposals took the majority of the time available at the meeting.

2.4 The Scientific Committee noted that the review of research plans is currently conducted by both WG-SAM and WG-FSA, and the significant time that research proposals are taking within WG-SAM and WG-FSA was to the detriment of their other tasks. It further noted that a number of discussions that were conducted at WG-SAM were repeated at WG-FSA as common issues arose in the review of research proposals.

2.5 Under the theme of assessments to estimate sustainable yield in established/assessed fisheries, the Scientific Committee welcomed the further development by New Zealand of the CASAL2 modelling framework, particularly, the opportunities to use its advanced capabilities, such as changes in productivity parameters, that may arise from changes in environmental conditions.

2.6 The Scientific Committee noted the recommendation from WG-SAM to consider holding a focus topic or workshop on toothfish tagging practices to better inform tagging practices by all Members fishing in the Convention Area, as these data serve as a primary driver underpinning current stock assessments of toothfish. Such a focus topic would benefit from invited experts (paragraph 3.56 and Annex 6, paragraph 5.8).

2.7 The Scientific Committee noted that the ongoing toothfish tagging program is a key part of its stock assessment processes that leads to management advice and that this had been highlighted as world leading by the Independent Review Panel. A workshop that includes those tagging on vessels, those collating and analysing the data and those that have developed and use satellite tags, would maintain and develop CCAMLR's expertise in this area.

2.8 The Scientific Committee noted that WG-SAM had specified a set of criteria by which to streamline reviews and improve the quality of feedback to proponents. WG-SAM provided a number of recommendations for all research plans (Annex 6, paragraph 6.1) and the Scientific Committee agreed that these should be adopted as part of the regular review process by Scientific Committee working groups.

2.9 The Scientific Committee noted that several WG-SAM technical work items are still to be progressed, such as further development and implementation of CASAL2, the progression of krill management methods, addressing outcomes of the independent stock assessment review and the transition from local biomass estimates to the stock assessments for areas currently under research plans. These are in addition to items identified for next year from the 2017 Scientific Committee workplan (SC-CAMLR-XXXVI/BG/40). The Scientific Committee noted that WG-SAM highlighted that, based on the success of recent workshops, these items may be better addressed through targeted workshops where other experts may be included to progress the work faster. The Scientific Committee discussed this under further work for the Scientific Committee working groups (paragraphs 13.1 to 13.13).

2.10 The Scientific Committee noted that Dr S. Parker (New Zealand) had been the Convener of WG-SAM for four years. The Scientific Committee thanked him for his leadership of WG-SAM during the last four years, particularly in progressing the coordination and review of data-limited research plans. The Scientific Committee welcomed the nomination of Dr C. Péron (France) as the Co-convener for WG-SAM in 2019 with Dr Parker.

Acoustic survey and analysis methods

2.11 The Scientific Committee thanked the participants of SG-ASAM-18, noting the progress made on the monitoring of echosounder performance, in particular, echosounder calibration using the seabed as a reference target (Annex 4, paragraphs 2.1 to 2.6) and internal tests of echosounder performance (Annex 4, paragraph 2.7). It also noted progress on methods for the collection and analysis of krill acoustic data from fishing vessels, including the comparison of the swarm-based and dB-difference window target identification methods (Annex 4, paragraphs 3.1 to 3.12).

2.12 The Scientific Committee noted the planned acoustic surveys for krill scheduled for 2019, including the krill survey in Division 58.4.1 (Annex 8, paragraphs 3.20 to 3.22) and the proposed multi-Member krill synoptic survey in Area 48 (Annex 8, paragraphs 5.1 to 5.15 and Annex 8, paragraphs 3.1 to 3.19).

2.13 The Scientific Committee agreed that the primary scientific objectives for the synoptic survey in Area 48 (Annex 8, paragraph 3.19) were:

(i) provide an overall reference, in terms of abundance and distribution, to krill assessments in the fishing areas and provide an indication of biomass within the survey area

(ii) analyse large-scale distribution in relation to environmental conditions to inform analyses of impacts of climate change

(iii) evaluate and develop survey strategies incorporating the future utilisation of fishing vessels

(iv) undertake a synoptic assessment of biomass, distribution and population characteristics in those areas currently fished

(v) provide information pertinent to the development of risk assessment, feedback management (FBM) and the spatial management considerations in Domain 1

(vi) provide ocean-scale opportunity for sampling of krill biology and other taxa.

2.14 The Scientific Committee noted SC-CAMLR-XXXVII/12 which provided additional information and revised details about the synoptic survey in Area 48. It noted that the fieldwork was well organised and thanked the participants for their contribution. The Scientific Committee noted that there may be too little time between the end of the fieldwork and the planned intersessional meetings in 2019 when a joint workshop between SG-ASAM, WG-EMM and WG-SAM had been scheduled, for analysis of results. Nevertheless, it recommended that SG-ASAM meet during the first week of WG-EMM-19 in order to make progress with analyses, recognising that complete analysis of results would take time and would require a future meeting of SG-ASAM. It recognised that a joint meeting of SG-ASAM and WG-EMM would allow acousticians and ecologists to meet to prioritise how analyses might best be pursued.

2.15 The Scientific Committee agreed that analysis of the acoustic data would be of considerable importance to CCAMLR and therefore, that all interested Members should have the opportunity to contribute to the analyses.

2.16 The Scientific Committee agreed that standardised marine mammal and seabird observation would greatly enhance the ecological utility of the Area 48 survey. It welcomed information that approximately 70% of the transect distance covered would include predator observations as both the *Cabo de Hornos* and *Kronprins Haakon* would have marine mammal observers on board. The Scientific Committee encouraged all other participating vessels to include dedicated marine mammal observers and to use the same standardised methodologies.

2.17 The Scientific Committee recommended that use of modified International Whaling Commission (IWC) observing protocols would be preferable to the proposed observation protocols detailed in WS-SISO-17/05 as these would allow for ecological modelling of cetacean sightings. It also proposed that, where feasible, marine mammal observations should be focussed in krill and/or known marine mammal hotspots, rather than along open-ocean transects.

2.18 SC-CAMLR-XXXVII/16 considered a number of aspects related to the design of the Area 48 survey. In particular, it noted that the 2019 survey will use a different acoustic analytical approach (the swarm-based approach, SC-CAMLR-XXXVI, Annex 4) compared with that used for the CCAMLR 2000 Krill Synoptic Survey of Area 48 (the dB-difference window approach, Annex 4) for the identification of Antarctic krill (*Euphausia superba*) (SC-CAMLR-XXIX, Annex 5). It also noted that the survey is constrained by available ship time so will collect acoustic data during both day and night, and that therefore krill diel vertical migration will be an important factor in assessing krill biomass. It noted further that there was no standard net configuration across the ships participating in the survey, as some vessels plan to use commercial nets, whilst others plan to use scientific sampling nets. SC-CAMLR-XXXVII/16 concluded that given these important sources of uncertainty the results of the 2019 survey and the CCAMLR-2000 Survey will not be comparable. The authors of SC-CAMLR-XXXVII/16 highlighted that in an era of rapid warming, uncertainties about changes in krill stock assessment are important.

2.19 In considering the issues highlighted in SC-CAMLR-XXXVII/16, the Scientific Committee agreed that use of both the swarm-based approach and the dB-difference window approach would be important when analysing the acoustic data from the 2019 survey; further, that retrospective analysis of the CCAMLR-2000 survey data using the swarm-based approach would be important. This would then allow for greater comparison between the two surveys.

2.20 The Scientific Committee recognised that vessels participating in the 2019 survey would have a mixture of acoustic frequencies, with some vessels having three frequencies available, some two frequencies, and one with a single frequency, but that 80% of the transect coverage would be by vessels with three frequencies. Use of traditional acoustic analyses would therefore be limited to those parts of the survey area covered by appropriate frequency combinations. The Scientific Committee noted that given the difference in available acoustic sampling, quantification of uncertainty would be important.

2.21 The Scientific Committee noted that planned use of moorings and gliders would enhance understanding about krill diel vertical migration, including the use of historic data from existing mooring and glider deployments. It recognised that the survey would be undertaken at a time of year when night was short in duration. Nonetheless, the Scientific Committee encouraged data collection on day/night differences in krill distribution throughout the duration of the survey in 2019.

2.22 The Scientific Committee noted that details of any analytical methods used to make comparisons between krill samples from different nets were important, and that consideration of this issue by WG-SAM would be valuable. It recognised that use of different nets would not compromise determination of krill length frequency for informing acoustic analyses, but may limit certain ecological analyses.

2.23 The Scientific Committee encouraged continued use of the CCAMLR e-group on the Area 48 krill survey in 2019 to ensure coordination, including for data management.

2.24 The survey coordination group and interested Members participating in the 2019 synoptic survey met on 25 September 2018 in order to continue discussions about standardisation of acoustic methods, as well as about other methods that will be used to collect data during the survey. All participants have confirmed that they are aware of, and will follow, the processes and procedures identified in relevant documents previously submitted to SG-ASAM and WG-EMM (SG-ASAM-18/07, WG-EMM-18/12 and 18/23). At their meeting, all participants concluded that there were no outstanding issues of concern in planning the forthcoming fieldwork. The Scientific Committee requested that the survey coordination group upload the documents identifying all the standard methods to the CCAMLR e-group, in order that all interested Members have a ready reference.

2.25 The Scientific Committee welcomed information from the Secretariat that it has had preliminary discussions about data management with the 2019 Synoptic Survey coordination group. It encouraged further engagement in order that realistic expectations of support were developed.

2.26 The Scientific Committee thanked those Members planning to participate in the 2019 synoptic survey. It recalled the value of the CCAMLR-2000 Survey, including how it had informed CCAMLR's management of krill over the past 20 years. The Scientific Committee looked forward to receiving results from the 2019 survey for informing its future deliberations on krill. It recognised that use of fishing vessels as platforms for collecting large-scale acoustic information on krill for informing management was a new development offering considerable future potential for CCAMLR.

Harvested species

Krill resources

Fishing activity

3.1 The Scientific Committee reviewed krill fishing activity for 2016/17 and 2017/18 (SC-CAMLR-XXXVII/BG/04). The Scientific Committee noted that:

(i) in 2016/17 (1 December 2016 to 30 November 2017), nine vessels fished in Subareas 48.1, 48.2 and 48.3 and the total catch of krill reported was 237 450 tonnes of which 149 334 tonnes, 69 044 tonnes and 18 559 tonnes were taken from Subareas 48.1, 48.2 and 48.3 respectively

(ii) in 2017/18 (to 30 September 2018), nine vessels fished in at least one of the three Subareas 48.1, 48.2 and 48.3; the total catch of krill reported in catch and effort reports was 306 391 tonnes of which 151 564 tonnes, 131 406 tonnes and 23 175 tonnes were taken from Subareas 48.1, 48.2 and 48.3 respectively. Subarea 48.1 was closed on 25 June 2018.

3.2 The Scientific Committee highlighted that the catch in 2018 up to 30 September is the highest catch since the early 1990s. Fishing had taken place in Subarea 48.2 in the period from July to September for the first time in recent years. The Scientific Committee noted that this increase in catches and the seasonal distribution of the fishery underlined the timeliness of progressing the development of the management scenarios for the krill fishery.

3.3 The Scientific Committee noted that changes in fishing patterns were likely due to a combination of factors that included management restrictions (i.e. fishery closures), abundance of krill and other operational considerations.

3.4 The Scientific Committee noted that data and information from the krill fishery and/or scientific surveys and sampling will provide data to enhance spatially and temporally relevant knowledge on interactions between krill and apex predators and the potential impacts of krill fishing.

Revised krill logbook for the 2019 season

3.5 The Scientific Committee noted the discussion at WG-EMM on the proposed change in the krill trawl logbook used by observers that were recommended by the 2017 Workshop on the Scheme of International Scientific Observation (WS-SISO-17) (SC-CAMLR-XXXVI/08) (Annex 8, paragraphs 2.13 and 2.14).

3.6 The Scientific Committee endorsed the proposed changes and the inclusion of invertebrate by-catch reporting in addition to finfish. The Scientific Committee noted that the proposed new format had been developed via the Scheme of International Scientific Observation e-group.

Continuous trawl catch recording

3.7 The Scientific Committee noted the discussion at WG-EMM-18 on catch reporting for vessels utilising the continuous fishing system (Annex 8, paragraphs 2.44 to 2.54). It recognised that the uncertainties associated with the historical reported catch data is higher than has been previously assumed (paragraph 5.11).

3.8 The Scientific Committee noted that while the total catch, and catches reported as part of monthly or five-day catch and effort reporting would not be impacted, the C1 data should be used with caution when conducting fine-scale (i.e. haul-by-haul) analyses.

3.9 The Scientific Committee noted that in the context of:

(i) Conservation Measure (CM) 23-06 (closure of the fishery), the reporting procedures do not impact on CCAMLR management of the vessel catch and the overall krill fishery

(ii) CM 21-03 (two-hourly catch reporting by vessels using a continuous fishing system), the method used to estimate the catches (holding tank krill depth) is considered appropriate but requires standardisation, in terms of an agreed protocol that is consistent across vessels and in its application on the vessel.

3.10 The Scientific Committee agreed that analysis of the continuous trawl data, particularly catch-per-unit-effort (CPUE) standardisation and analysis and the investigation of krill swarm dynamics, should proceed with caution and provide clarity on the temporal scale of aggregation of the two-hourly catch reporting periods.

3.11 The Scientific Committee noted that estimating the vessel catch level associated with observer by-catch samples collected during a specific two-hourly catch reporting period is not possible, and therefore it is not possible to quantify the level of fish by-catch for fishing vessels using the continuous trawl system (Annex 9, paragraph 6.46).

3.12 Dr Bergstad reported that consistency has been achieved between vessels and skippers in the procedures for estimation of two-hour catches. However, it would seem difficult to improve the precision further with the current processing and operational procedures.

3.13 The Scientific Committee noted Norway's intention to pursue other options, in particular, the acoustic recording and quantification of catches in the trawl mouth, and it looked forward to receiving such a project proposal from Norway describing timelines for reporting the outcomes back to the Scientific Committee.

3.14 The Scientific Committee noted that it had agreed a derogation from the prohibition of the use of net monitoring cables in CM 25-03 to trial actions to implement and develop such methods (SC-CAMLR-XXXV, paragraphs 4.10 to 4.13; SC-CAMLR-XXXVI, paragraphs 3.10 and 3.11). However, no reports have been received in respect of this trial and the derogation in CM 25-03 had now lapsed.

3.15 While the Scientific Committee supported the undertaking of such trials, it noted that it is important that proposals for subsequent trials would need to be considered by the Scientific Committee in order to further evaluate the safety of the use of this cable in respect to the risks of incidental mortality of seabirds.

SCAR Krill Action Group (SKAG)

3.16 The Scientific Committee noted the WG-EMM discussion on the formation of a SCAR Krill Action Group (SKAG) (Annex 8, paragraphs 7.1 to 7.3) and also welcomed updates provided in SC-CAMLR-XXXVII/23 on the outcome of the first SKAG meeting held in July in Cambridge, UK, following WG-EMM-18.

3.17 The Scientific Committee noted that SKAG would provide an important interface between the broader krill research community, SCAR and CCAMLR, and will make an important contribution to provide an expanded breadth of information that will help inform and progress discussion on management of the krill fishery and spatial management.

3.18 The Scientific Committee recognised the opportunity for SKAG to facilitate the attendance of a diverse range of krill experts from outside CCAMLR. The annual SKAG meetings are proposed to be scheduled in association with WG-EMM meetings to facilitate the attendance of relevant experts.

3.19 The Scientific Committee noted the proposal in SC-CAMLR-XXXVII/23 for an allocation of A$13 000 from CCAMLR to support the attendance of additional krill scientists who would not normally attend WG-EMM to attend the annual SKAG meeting. The Scientific Committee expressed its support for the proposed funding and recommended the Standing Committee on Administration and Finance (SCAF) consider this proposal.

ASOC

3.20 The Scientific Committee noted SC-CAMLR-XXXVII/BG/17 from ASOC which provided views on achieving precautionary ecosystem-based management for the Antarctic krill fishery.

3.21 The Scientific Committee thanked ASOC for the report and noted recommendations to include implication statements of climate change on Antarctic marine living resources in all working papers and fisheries reports (SC-CAMLR-XXXVII/BG/26).

Ecosystem effects of krill fishing

CCAMLR Ecosystem Monitoring Program (CEMP)

3.22 The Scientific Committee endorsed the recommendation of WG-EMM to revise CCAMLR Ecosystem Monitoring Program (CEMP) e-forms as described in WG-EMM-18/27 and 18/46, noting that such revisions are intended to increase data provision to CEMP and to progress the use of camera data in the collection of multiple CEMP parameters. The Scientific Committee welcomed progress on the use of cameras to provide ecosystem monitoring data and noted that such progress was a result of multi-Member collaborative research supported by the CEMP Fund. It further noted the planned demonstration of software being developed by Australia to support analysis of photographs collected from nest cameras deployed throughout the Convention Area.

3.23 The Scientific Committee discussed the recommendation of WG-EMM to consider a review of the ecosystem monitoring requirement of CCAMLR, given the current priorities of the Scientific Committee, in which the current CEMP would be one important component (Annex 8, paragraphs 4.34 to 4.39).

3.24 The Scientific Committee noted that such a review is important and that a staged-approach to a review (Annex 8, paragraph 4.38) would be helpful. The Scientific Committee recognised that the current CEMP is not an exhaustive inventory of data that might be useful for management purposes and that other organisations (e.g. SOOS) also collected data that could be considered. The Scientific Committee noted that data fit for management purposes may not be encompassed in the current CEMP and noted that data with proper documentation, transparency and access could be useful and considered by the Scientific Committee and its working groups in developing management advice.

3.25 The Scientific Committee recommended the development of a management procedure for krill that identifies ecosystem monitoring data requirements prior to a review of CEMP. In doing so, CEMP could then be reviewed and revised to deliver on such data requirements.

3.26 The Scientific Committee welcomed the introduction of three papers from Ukraine (SC-CAMLR-XXXVII/BG/05, BG/06 and BG/20). These papers described data from penguin population monitoring studies and a validation of camera-based methods for nest monitoring. The Scientific Committee encouraged continued research in this region and looked forward to discussing these data during the intersessional period.

Experimental approaches to assessing ecosystem impacts of krill fishing

3.27 SC-CAMLR-XXXVII/10 highlighted that prior research, including work funded by the CEMP Special Fund, has demonstrated spatial overlap of predator habitat use and krill fishing locations (e.g. Hinke et al., 2017; Warwick-Evans et al., 2018; Trathan et al., 2018). It also noted that, under precautionary krill management, CEMP indices may only reflect environmental variability and it might be difficult to detect fishery impacts under some circumstances. It also noted that current research does not readily assess responses to fishing, but that identifying such responses to krill fishing may be achieved through an experimental framework.

3.28 The Scientific Committee noted a number of issues for further consideration in order to successfully assess responses to an experimental framework. For example, the effects of krill movement and the availability of krill-dependent and related predators for monitoring. The Scientific Committee noted that research on krill movement could be advanced with the use of krill fishing vessels and new technologies (e.g. gliders and moorings) to help understand interactions between fisheries and krill populations.

3.29 The Scientific Committee also noted that implementation of experimental approaches may be complex, and that other methods based on observational data may offer an alternative for identifying potential fishery impacts. For example, WG-EMM-16/45 had suggested that krill fishing in the Antarctic Peninsula region may have negatively impacted penguins. The Scientific Committee recalled that those findings remain preliminary, but that further monitoring may provide the sample sizes necessary to robustly estimate such impacts. In particular, estimates of regional krill biomass are needed and the Scientific Committee noted that fishing vessels may be able to provide such data.

3.30 The Scientific Committee recalled the need to harmonise approaches to krill fishery management, including experimental approaches, with the Domain 1 marine protected area (D1MPA) proposal (CCAMLR-XXXVII/31).

3.31 The Scientific Committee observed that the D1MPA proponents progressed in that direction by including krill fishery research zones (KFRZ) that could be used in an experimental framework (CCAMLR-XXXVII/31; SC-CAMLR-XXXVII/BG/07).

3.32 The Scientific Committee also noted that the work during the intersessional period, including a krill fishery management workshop in 2019 proposed in SC-CAMLR-XXXVII/24, would provide opportunities for further consideration of such harmonisation and progress.

Feedback management strategies

3.33 The Scientific Committee noted the analysis in SC-CAMLR-XXXVII/BG/12 that modelled an FBM strategy for the krill fishery based on short-term (five year) trends in small-scale management unit (SSMU)-specific krill biomass and penguin population sizes. Such strategies were explored because they represent relatively simple FBM implementations and could be informed by acoustic surveys from krill fishing vessels and efforts to census penguin populations on regional scales. As implemented in the model, the results were inconclusive with respect to reducing risks of krill harvesting on predator performance, likely because the redistribution of fishing effort occurred only within coastal SSMUs. The Scientific Committee also noted that the treatment of the biomass and distribution of kill across SSMUs in the model may not reflect the spatio–temporally dynamic nature of krill distributions, thus limiting an assessment of the FBM procedure.

3.34 The Scientific Committee noted that the results presented in SC-CAMLR-XXXVII/BG/12 highlighted how the frequency of feedback can affect the model outcome. The Scientific Committee noted the importance of accounting for the life histories of predator species that are the basis of FBM strategies to ensure correspondence of predator response times.

3.35 SC-CAMLR-XXXVII/BG/24 highlighted concerns that current krill fishery management discussions are being conducted under the assumption that the fishery is already having an ecosystem impact and neglects available long-term data over the 35-year history of the krill fishery, as well as other relevant investigations. The authors propose that efforts should be focused on understanding aspects of krill flux and retention, whether the current fishing levels do actually impact krill-dependent predators at relevant scales, broadening the consideration of monitoring indices to do this beyond those developed for penguins. Developing scientifically based criteria and diagnostics to assess the possible ecosystem impacts of the fishery should account for the mixed effects of fishing, environmental variability (or climatic change), and the competitive relationship between predator species, including recovering populations of marine mammals. The authors further suggested a retrospective analysis of available long-term multivariate datasets to develop such understanding and proposed candidate datasets to examine in order to achieve this. In tandem with these efforts, the authors recommended the consideration of data relevant to two natural ecosystem experiments in Subarea 48.3 related to krill abundance and predator responses, which may shed light on the role of environmental variability in characterising fishery–predator interactions.

3.36 The Scientific Committee noted the importance of conducting such analyses and reiterated the importance of maintaining krill monitoring indices for such work. With respect to analyses suggested for data from Subarea 48.3, the Scientific Committee also noted the need to reconcile the disconnect between fishing during winter versus predator monitoring that is conducted primarily during summer. The Scientific Committee also noted that, given the precautionary management of the krill fishery which was designed to minimise impacts on predators, the detection of impacts in CEMP indices in analyses like those suggested in SC-CAMLR-XXXVII/BG/24 has been difficult. The consequences of marine mammal recovery and climate change also need to be considered.

Fish resources

Catches in the current season

3.37 SC-CAMLR-XXXVII/BG/01 Rev. 4 provided an update of catches in 2017/18 up to 30 September 2018. This paper also included a map of the Convention Area showing all areas for which a catch limit is in place.

3.38 The Scientific Committee noted a number of areas/subareas where the proportion of the catch limit taken was low or zero (SC-CAMLR-XXXVII/BG/01 Rev. 4, Table 3) and requested that Members notify WG-FSA of their intention to fish in the periods between WG-FSA and the end of the season in exploratory fisheries or research plans under CM 24-01 to assist in the provision of advice and the review of ongoing research fishing.

3.39 The Scientific Committee noted that CCAMLR-XXXVII/BG/14 reported differences between C2 catch records and green weights as estimated using the raised Catch Documentation Scheme for *Dissostichus* spp. (CDS) product weights in some areas. The Scientific Committee noted that such a comparison provides a useful annual diagnostic highlighting where uncertainty may be occurring in catch data reporting and recommended that the CDS information should be included in Table 3 of SC-CAMLR-XXXVII/BG/01 Rev. 4.

Data management

3.40 The Scientific Committee noted that the Data Management Group (DMG) was an interim group tasked to enhance the information exchange between the Secretariat and data users, and discussed the role of the DMG in progressing data-related issues.

3.41 The Scientific Committee recommended that the DMG be renamed to 'Data Services Advisory Group' (DSAG) to more closely reflect the scope of its tasks as per updated terms of reference in Annex 10.

3.42 The Scientific Committee further recommended:

(i) all working groups include a standing agenda item on data and data services

(ii) an annual DSAG convener's report be provided to the Scientific Committee and its working groups

(iii) a contact person within each working group be nominated to improve information exchange between the DSAG and the Scientific Committee and its working groups

(iv) the membership of the DSAG be by nomination of Scientific Committee Representatives

(v) the DSAG e-group be visible to all authorised users of the CCAMLR website

(vi) the DSAG consider the priorities presented in Annex 9, Table 1, and additionally:

(a) conduct a survey on the data flow and data request process, and summarise the information to the Scientific Committee in 2019

(b) report on progress throughout the data warehouse development, currently on the Scope of Stage 1

(c) develop a timeline for data submissions (e.g. STATLANT data) and expected transition of data from the current database to the new data warehouse.

3.43 The Scientific Committee welcomed the nominations of Mr Dunn and Dr Van de Putte as Co-conveners of the DSAG and thanked Dr Reiss, the outgoing Convener of the DMG, for running it so well.

3.44 The Scientific Committee noted issues with the current C2 form that were highlighted in Annex 9, paragraphs 2.12 to 2.17 and recommended:

(i) the Secretariat initiate a consultation with all Members on how vessels record catch data, and if any issues are encountered using the current C forms, with deadline for comments by 15 March 2019

(ii) following the results of the consultation, the Secretariat undertake a revision of the C2 form and present this through the Data Forms e-group for consideration and potential trial by Members. Results from this process should be presented to WG-FSA-19

(iii) the development of a fishery data reporting manual by the Secretariat with clear instructions on how to achieve vessel reporting requirements using CCAMLR forms drawing on the fishery data manual (WG-FSA-99/08) as appropriate

(iv) the formation of a list of fishery data coordinators (analogous to the Scheme of International Scientific Observation (SISO) technical coordinators) to facilitate easier communication between the Secretariat and Members on vessel data issues

(v) a focussed fishing data workshop be held, similar to WS-SISO-17 (SC-CAMLR-XXXVI/08), and attended by a range of stakeholders, including those who complete catch reporting forms on the vessels, to review fishery data submission issues that have been raised in working groups

(vi) the same introduction schedule as agreed for new observer forms be applied to any new fishery data forms to allow adequate time for training and testing

(vii) clarification be provided by the Standing Committee on Implementation and Compliance (SCIC) on how hauls that are incomplete at the end of a reporting period should be recorded in C forms.

3.45 The Scientific Committee welcomed an offer by COLTO to work with the Secretariat to facilitate a workshop, open to all CCAMLR Members including SISO observers and industry members, with a particular focus on best practice for CCAMLR data forms, toothfish and skate tagging processes, by-catch reporting and the use of electronic monitoring (e-monitoring). COLTO has hosted multiple industry–science workshops in recent years, and this would present another opportunity to positively work with interested parties to achieve best practices within CCAMLR.

Procedures for the use of catch and effort data in fishery management

3.46 The Scientific Committee noted a revised approach for catch and effort monitoring, and the calculation of closure dates for the 2018/19 season in the Ross Sea region (Annex 11). The two-stage decision process uses all available data to manage exploratory longlining in a way that provides timely updates to Members and issues closure notices according to the catch limits in place. This process also accommodates situations where the catch limit in place might be exceeded prior to sufficient catch and effort data becoming available from the fishery with which the Secretariat can advise a closure date in accordance with CM 31-02, paragraph 2. The within-season forecast process has been used in 2017/18 to close the fishery in Subarea 88.1 south of 70°S where the catch reached 99% of the catch limit.

3.47 The Scientific Committee recalled previous discussions on capacity management (SC-CAMLR-XXXVI, paragraph 3.133) and noted that the large number of fishing vessels operating in the areas with small catch limits could impact on the ability of the Scientific Committee to provide robust management advice.

3.48 The Scientific Committee recommended that the process described in Annex 11 be used to achieve the aim of not exceeding the overall catch limit and the required distribution of fishing effort in a way that balances the impact of both under- and over-runs in the area north of 70°S in the Ross Sea region and to change CM 41-09 accordingly.

3.49 The Scientific Committee requested that the Secretariat provide a report of the application of these rules in the Ross Sea region exploratory fishery in 2019 for review by the Scientific Committee in 2019.

3.50 The Scientific Committee noted that testing the algorithm for early season closure, using historic catch data for vessels in the area of the fishery immediately prior to the start of the fishery, was restricted by the requirement of CM 10-04, Annex 10-04/B, paragraph 3.6 to de-identify vessels in the vessel monitoring system (VMS) data. The Scientific Committee agreed that this requirement may unintentionally restrict scientific analyses and requested that the ongoing need for this requirement be reviewed by the Commission.

Fishery Report updates

3.51 The Scientific Committee noted that including sections in Fishery Reports on changes in model parameters and productivity assumptions which consider the impact of observed changes in biological parameters on management advice could be a useful way to highlight issues related to climate change and requested that WG-FSA-19 update CCAMLR's Fishery Reports according to Annex 9, paragraphs 2.28 to 2.33.

Review of updated stock assessments and provision of management advice (all fisheries)

3.52 The Scientific Committee noted the report from the CCAMLR Independent Stock Assessment Review for Toothfish held in June 2018 which can be found in Annex 5. The primary objective for the expert group 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 improvements to the assessment methods where appropriate.

3.53 The Scientific Committee thanked the Convener, Dr Reiss, the expert group and the participants for the thorough review. It noted that valuable lessons were learned with regard to preparing for reviews and, in particular, the need for standardised documentation of inputs to, and outputs from, stock assessments.

3.54 The expert group made a number of recommendations which the Scientific Committee agreed should continue to be evaluated in future research and presented to the appropriate working group. The expert group recommendations and the target group, priorities and timelines suggested by the Scientific Committee are presented in Annex 9, Table 3. In particular, the Scientific Committee noted the expert group's conclusions that:

(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.

3.55 The Scientific Committee recommended that an intersessional e-group be created to develop a standardised format for a stock assessment annex to be added to the Fishery Reports.

3.56 The Scientific Committee noted that topic-specific workshops with invited experts were a useful process to progress CCAMLR's work program, including how to best conduct assessments and provide catch advice in data-limited fisheries or evaluate ecosystem drivers in assessment models.

Status and trends

Icefish assessments

Champsocephalus gunnari in Subarea 48.3

3.57 The fishery for mackerel icefish (*Champsocephalus gunnari*) in Subarea 48.3 operated in accordance with CM 42-01 and associated measures. Details of this fishery and the stock assessment *C. gunnari* are contained in the Fishery Report (www.ccamlr.org/node/75667). In 2017/18, the catch limit for *C. gunnari* was 4 733 tonnes. By 30 September 2018, no fishing had taken place in Subarea 48.3, but vessels were expected to start fishing in October.

Advice to the Commission

3.58 The Scientific Committee recommended that the catch limit for *C. gunnari* in Subarea 48.3 of 3 269 tonnes for 2018/19 in CM 42-01 remain in place.

C. gunnari in Division 58.5.1

3.59 There was no new information available for this fishery.

C. gunnari in Division 58.5.2

3.60 The fishery for *C. gunnari* in Division 58.5.2 operated in accordance with CM 42-02 and associated measures. Details of this fishery and the stock assessment of *C. gunnari* are contained in the Fishery Report (www.ccamlr.org/node/75667). In 2017/18, the catch limit for *C. gunnari* was 526 tonnes. Fishing was conducted by one vessel and the total reported catch up to 30 September 2018 was 402 tonnes.

3.61 An updated short-term assessment was conducted using the Generalised Yield Model (GYM), to estimate the one-sided bootstrap lower 95% confidence bound of total biomass of 2 964 tonnes of age 1+ to 3+ fish from the 2018 survey and fixed model parameters. Estimates of yield indicate that 443 tonnes of icefish could be taken in 2018/19 and 320 tonnes in 2019/20.

Advice to the Commission

3.62 The Scientific Committee recommended that the catch limit for *C. gunnari* in Division 58.5.2 should be set at 443 tonnes in 2018/19 and at 320 tonnes in 2019/20.

Toothfish assessments

Dissostichus eleginoides in Subarea 48.3

3.63 The fishery for Patagonian toothfish *(Dissostichus eleginoides*) in Subarea 48.3 operated in accordance with CM 41-02 and associated measures. Details of this fishery and the stock assessment of *D. eleginoides* are contained in the Fishery Report (www.ccamlr.org/node/75667). In 2017/18, the catch limit for *D. eleginoides* was 2 750 tonnes. Fishing was conducted by six vessels using longlines and the total reported catch up to 30 September 2018 was 1 995 tonnes.

3.64 SC-CAMLR-XXXVII/BG/25 presented a review of variability in *D. eleginoides* biological parameters in longline fishery catches in Subarea 48.3, noting declines in the length and weight at first maturity of females and males, increases in the proportion of immature fish and a reduced number of large spawning fish in historic catches from 1985 to 2004. The authors also noted that despite an increase in fishing depth from 2002 to 2004, young fish remained predominant in catches in Subarea 48.3 and are dominated by young recruiting fish, and that unstandardised length frequency of toothfish in the catches in South Georgia for the period 2008–2017 showed a decline in the mean length of fish in the catch in the more recent years.

3.65 Dr S. Kasatkina (Russia) noted that analysis presented is based on available data from the CCAMLR working group, Fishery Reports and publications, and recalled that a decrease in the length and weight of first matured females and males, a reduced number of large spawning fish in particular indicates a change in the length structure of spawning *D. eleginoides* (Brigden et al., 2017).

3.66 Dr Darby noted that the analyses in SC-CAMLR-XXXVII/BG/25 and Brigden et al. (2017) had both used unstandardised data, and that consequently their conclusions were therefore similarly erroneous.

3.67 Dr Kasatkina advocated that the *D. eleginoides* population in Subarea 48.3, which has been fished for more than 40 years, requires protection via the imposition of restrictions on fishing and changes to conservation measures, because the changes of toothfish parameters indicate irrational use of the fish stocks, which is not consistent with Article II of the CAMLR Convention.

3.68 Dr Kasatkina invited the Scientific Committee to urgently consider the following:

1. In the area of South Georgia (Subarea 48.3), to limit the size of *D. eleginoides* to 90 cm in the longline catches. All the caught fish less than 90 cm shall be released into the habitat.

2. To authorise fishing at depths of 1 000 m.

3. To reduce the catch limit of *D. eleginoides* in Subarea 48.3 to 500 tonnes, according to the fishing area with depths from 1 000 to 2 250 m.

4. To consider the closure of fishery for *D. eleginoides* from 2020 in the South Georgia Island area (Subarea 48.3) until an international survey on stock assessment and data processing.

3.69 The authors of the paper advocated that the *D. eleginoides* population in Subarea 48.3, which has been fished for more than 40 years, requires protection via the imposition of restrictions on fishing and changes to conservation measures, because CCAMLR’s precautionary approach to the management of this resource has not been likely effective.

3.70 The Scientific Committee noted that the exclusive use of unstandardised 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. In addition, the Scientific Committee noted that the CCAMLR decision rules account for the expected catch-at-length in the fishery, such that the long-term objective is likely to be achieved even if a proportion of the catch are juveniles.

3.71 The Scientific Committee noted that *D. eleginoides* stocks in this area are characterised by maturing fish (60–90 cm in length) throughout the depth profile. Larger fish are increasingly caught at depth, but the immature length ranges are also present in the catches. Moving fishing to deeper waters does not reduce the proportional abundance of the maturing fish substantially. The Scientific Committee further noted that the analyses of maturity trends presented in the paper were collected over a short historic time period and had not been standardised for effects such as sample size, sampling location and time, length distribution and depth which are key processes that will impact on the interpretation of these data.

3.72 The Scientific Committee noted that *D. eleginoides* in Subarea 48.3 was assessed biennially with an integrated stock assessment. This assessment is reviewed by WG-FSA and additionally in 2018, was reviewed by an independent expert review panel (Annex 5). The review panel considered that the assessment was appropriate for the precautionary management of the stock and consistent with CCAMLR's approach to management. The assessment showed that fits to the observations which incorporated information on catch at length data, including changes over time, were adequate. The conclusions drawn from the information presented in SC-CAMLR-XXXVII/BG/25 were therefore not consistent with the results of the agreed CCAMLR assessment which uses all available information.

3.73 The Scientific Committee noted that 2018 was an intersessional year for the biennial integrated stock assessment in Subarea 48.3. It recalled advice from the Commission for a biennial assessment in this area unless WG-SAM recommended new methods for use in the stock assessment, parameters in the stock assessment were revised significantly, or a large illegal, unreported and unregulated (IUU) catch occurred (not included in the assessment) (CCAMLR-XXVI, paragraph 4.57). The Scientific Committee concluded that a biennial assessment was still appropriate in this instance.

3.74 Dr E. Marschoff (Argentina) noted that SC-CAMLR-XXXVII/BG/25 and other documents dealt with issues derived from different interpretations of the Chairman's Statement of 1980, a question discussed by the Commission at its fifteenth meeting (CCAMLR-XV, paragraphs 13.1 to 13.41). At that time the Commission, '…pending resolution of those differences, expressed the hope that the parties would act in such fashion that cooperation under CCAMLR is not affected, and that the goodwill expressed by both parties will continue' (CCAMLR-XV, paragraph 13.41(iii)).

3.75 Mr S. Leonidchenko (Russia) noted that in preparing SC-CAMLR-XXXVII/BG/25, Russia did not aim to formulate a position on political issues, including territorial ones, and requested that the paper be considered exclusively as scientific content.

3.76 Dr Darby noted that this was a matter for the Commission.

Advice to the Commission

3.77 On the basis of these discussions, the Scientific Committee recommended that the management advice for *D. eleginoides* in Subarea 48.3 in CM 41-02 remain unchanged for 2018/19.

D. mawsoni in Subarea 48.4

3.78 The fishery for Antarctic toothfish (*D. mawsoni*) in Subarea 48.4 operated in accordance with CM 41-03 and associated measures. Details of this fishery and the stock assessment of *D. mawsoni* are contained in the Fishery Report (www.ccamlr.org/node/75667). In 2017/18, the catch limit for *D. mawsoni* in Subarea 48.4 was 37 tonnes. The total reported catch by two vessels was 20 tonnes. An additional 18 tonnes were allocated as an upper catch limit for the effort-limited research survey to the south of the fishery (WG-FSA-16/40 Rev. 1), of which 5 tonnes were taken.

3.79 Noting that the observed short residence time for tagged *D. mawsoni* on the seamounts in Subarea 48.4 is similar to that of other *D. mawsoni* seamount stocks, the biomass estimate for *D. mawsoni* in Subarea 48.4 was calculated limiting tag availability to three years at liberty as agreed at WG-FSA-16 (SC-CAMLR-XXXV, Annex 7, paragraph 3.30). A geometric mean of the relatively short time assessment series was used as the basis for the final stock abundance of 1 000 tonnes. At a harvest rate of $\gamma = 0.038$, this indicated a yield of 37 tonnes in 2018/19 for *D. mawsoni* in Subarea 48.4.

Advice to the Commission

3.80 The Scientific Committee recommended that the catch limit for *D. mawsoni* in Subarea 48.4 should be set at 37 tonnes for 2018/19.

D. eleginoides in Subarea 48.4

3.81 The fishery for *D. eleginoides* in Subarea 48.4 operated in accordance with CM 41-03 and associated measures. Details of this fishery and the stock assessment of *D. eleginoides* are contained in the Fishery Report (www.ccamlr.org/node/75667). In 2017/18, the catch limit for *D. eleginoides* in Subarea 48.4 was 26 tonnes. The total reported catch by two vessels was 17 tonnes.

Advice to the Commission

3.82 The Scientific Committee recommended that the catch limit for *D. eleginoides* in Subarea 48.4 of 26 tonnes for 2018/19 in CM 41-03 remain in place.

D. eleginoides in Division 58.5.1 inside the French EEZ

3.83 Details of this fishery and the stock assessment of *D. eleginoides* are contained in the Fishery Report (www.ccamlr.org/node/75667). The fishery for *D. eleginoides* in Division 58.5.1 is conducted in the French exclusive economic zone (EEZ). In 2017/18, the catch limit for *D. eleginoides* was 5 300 tonnes. Fishing was conducted by seven vessels using longlines and the total reported catch up to 30 September 2018 was 3 307 tonnes.

D. eleginoides in Division 58.5.1 outside the French EEZ

3.84 No new information was available on the state of fish stocks in Division 58.5.1 outside areas of national jurisdiction.

Advice to the Commission

3.85 The Scientific Committee recommended that the prohibition of directed fishing for *D. eleginoides*, described in CM 32-02, remain in force in 2018/19.

D. eleginoides in Division 58.5.2

3.86 The fishery for *D. eleginoides* in Division 58.5.2 operated in accordance with CM 41-08 and associated measures. Details of this fishery and the stock assessment of *D. eleginoides* are contained in the Fishery Report (www.ccamlr.org/node/75667). In 2017/18, the catch limit for *D. eleginoides* was 3 525 tonnes. Fishing was conducted by four vessels using bottom trawls and longlines, and the total reported catch up to 30 September 2018 was 1 931 tonnes.

Advice to the Commission

3.87 The Scientific Committee recommended that the catch limit for *D. eleginoides* in Division 58.5.2 of 3 525 tonnes for 2018/19 in CM 41-08 remain in place.

D. eleginoides in Subarea 58.6 inside the French EEZ

3.88 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).

D. eleginoides in Subarea 58.6 outside the French EEZ

3.89 No new information was available on the state of fish stocks in Subarea 58.6 outside areas of national jurisdiction.

Advice to the Commission

3.90 The Scientific Committee, therefore, recommended that the prohibition of directed fishing for *D. eleginoides*, described in CM 32-02, remain in force in 2018/19.

New and exploratory fisheries

3.91 The Scientific Committee noted the discussion of WG-FSA on the proposal from the Secretariat on a revised approach for catch and effort monitoring, and the calculation of closure dates for the 2018/19 season in the Ross Sea (WG-FSA-18/07). This process included a two-stage decision process that uses all available data to manage exploratory longlining in a way that provides timely updates to Members, and issues closure notices according to the catch limits in place.

3.92 The Scientific Committee noted that the priority lies on achieving the aim of not exceeding the overall catch limit in the whole area, which was 3 157 tonnes for the Ross Sea region, while balancing the impacts of both under- and over-runs in the area north of 70°S. The process presented in Annex 11 represents a good way to manage this fishery, where its sustainability and catch limits are maintained as well as providing the data needed to manage this fishery over time (paragraphs 3.46 to 3.50).

3.93 The Scientific Committee noted that part of the issues identified in WG-FSA-18/07 was due to a large number of vessels operating in an area with limited catch limit, which has been identified by the Scientific Committee over the past years (WG-FSA-17/05 and 18/15), which makes it more difficult to forecast and manage accurately on a daily basis. While the presented process is likely to improve forecasting accuracy, the question of capacity should be considered further going forward.

3.94 The Scientific Committee asked the Commission to consider the issue highlighted by WG-FSA, that testing the closure algorithm on historic catch data was to some degree restricted by the requirement of CM 10-04, Annex 10-04/B, paragraph 3.6, to anonymise vessels in the VMS data, and requested that the ongoing need for this requirement be reviewed by the Commission.

General issues

3.95 The Scientific Committee considered the further development of the linear trend method for estimates of local biomass, and endorsed the method as suitable for providing interim management advice as it was considered to provide precautionary advice (paragraph 3.113 and Annex 9, Figure 4). Further work will be required to fully account for the uncertainty in the estimates of mean trend.

3.96 The Scientific Committee considered discussions around tagging performance, noting the successful deployment of a cradle mechanism to improve tag survival in large toothfish on a Spanish vessel. The Scientific Committee recalled advice from WG-SAM to request vessels to record specifics around the use of holding tanks, and the previous Scientific Committee advice to develop a tagging pro forma to collect information around the tagging processes on board a vessel.

3.97 The Scientific Committee endorsed the vessel tagging procedure survey form in Annex 9, Appendix E, and recommended that it be circulated by the Secretariat to Members' observer technical coordinators.

3.98 The Scientific Committee considered the request by WG-FSA to provide clarification on the objectives, priorities and definitions of data-poor exploratory fisheries. The Scientific Committee recalled that discussions on this subject have been held for many years, without progress being made, and that this point was also highlighted in the CCAMLR Performance Review.

3.99 The Scientific Committee noted that research in many of the areas denoted as 'data-poor' has progressed knowledge on stocks and ecosystems in these regions, advancing the science and understanding in these fisheries, so that the description of 'data-poor' would no longer be appropriate. It agreed that the term 'data-limited' be a more appropriate description for research areas and fisheries where a time series of information is available.

Review of research plans

3.100 The Scientific Committee recalled that WG-FSA was reviewing research proposals as submitted, rather than taking revisions during the meeting and noted the results of those reviews in Annex 9, Tables 5, 6 and 7.

3.101 The Scientific Committee noted that within CM 21-02, there is a requirement for a data collection plan, a fishery operations plan and a research plan for areas included in paragraph 6(iii) of that conservation measure. WG-FSA had requested the Scientific Committee to review whether there is still a need for a data collection plan and fishery operations plan, considering that all of this information is now contained in the research plan.

3.102 The Scientific Committee recalled that CM 21-02, paragraph 6(iii), provided a link to Annex 24-01/A, format 2, where the detailed research plan format can be found, providing a structure for research plans submitted under CM 21-02, including data collection and fishery operation details, which makes separate data collection plans and fishery operation details superfluous. The Scientific Committee endorsed the recommendation to remove the requirement for data collection plans and fishery operations plans from CM 21-02 for those notifications requiring a research plan.

3.103 The Scientific Committee noted that the work of WG-SAM and WG-FSA over the past few years has substantially improved the review process, and facilitated the task of the Scientific Committee to evaluate research plans and research proposals. However, the focus of these working groups on the evaluation of research plans led to both working groups being unable to complete all of their priority tasks for this year.

3.104 In view of this increased workload of the working groups, the Scientific Committee considered the issues with research plans being submitted and subsequently undergoing two reviews, one at WG-SAM and another at WG-FSA. The Scientific Committee agreed that there is a duplication of effort that is creating workload pressures within the working groups and it may be able to harmonise across the two working groups by only reviewing once. The Scientific Committee noted that often, the advice of WG-SAM is not substantially different to advice from WG-FSA.

3.105 The Scientific Committee discussed reducing the review of research plans to an annual schedule. The Scientific Committee noted that there would still be the ability for review of proposals through direct correspondence between Members, other working groups, or e-groups intersessionally. Any proposal would, however, still need to be reviewed by WG-FSA and be submitted for review under normal WG-FSA submission rules.

3.106 Some Members noted that moving to an annual review process may create issues where if a proposal is assessed as requiring significant alteration, it would be another year before the plan could be resubmitted for review, and that the two-stage review process should be retained, as the expertise within WG-SAM and WG-FSA was different, providing valuable input for new research proposals.

3.107 The Scientific Committee integrated the current advice from Annex 6, paragraph 6.1, into CM 24-01, Annex 24-01/A, format 2, to create a complete set of instructions for the development of research plans and proposals (Annex 13) to the Scientific Committee. It considered whether new research proposals could be submitted to WG-SAM for review, but that ongoing research proposals could be submitted to WG-FSA for a single annual review, but did not have sufficient time to achieve agreement.

3.108 The Scientific Committee noted that the review process was detailed within several conservation measures and asked the Commission to consider how this issue could be progressed, bearing in mind its work priorities (paragraphs 13.1 to 13.13), and considering what the risk to Article II would be if research proposal reviews were delayed or not completed.

3.109 On the duration of new research proposals, the Scientific Committee recalled advice from WG-SAM (Annex 6, paragraph 6.1) and recommended that new research proposals under CM 24-01 should be limited to a maximum of three years.

Research proposal standardisation

3.110 The Scientific Committee noted the work of WG-SAM and WG-FSA in producing a process for assessing research proposals in a consistent and scientifically robust manner. For the current research proposals, a series of tables assessing the proposals and providing catch limits was presented in the WG-FSA report (Annex 9, Tables 4 and 8).

3.111 The Scientific Committee noted that Annex 9, Tables 5 to 7, were useful as summaries of proposal evaluations and that compared to last year, some evaluations were worse, providing less information, less certainty, and more scores of 'not enough information in the proposal' to evaluate. The Scientific Committee expressed concern about recommending research proposals where not enough information was provided, making the likelihood of success uncertain. However, it noted that some research plans have been in place and performing adequately for several years.

3.112 With regard to setting catch limits in research blocks, the Scientific Committee recalled the development of the trend analysis decision framework (SC-CAMLR-XXXVI, paragraph 3.77). These were further developed by WG-SAM and were applied by WG-FSA to produce Annex 9, Tables 4 and 8, to provide advice on catch limits for research blocks in Areas 48, 58 and 88.

3.113 The Scientific Committee recommended the values in Annex 9, Tables 4 and 8 be used to determine catch limits for 2018/19 (Table 1).

3.114 ASOC presented SC-CAMLR-XXXVII/BG/28 and expressed concern that current research and exploratory fishing activities are often uncoordinated and unfocused, with limited ability to increase the regional understanding of exploited species or their ecosystem impacts. ASOC recommended that CCAMLR form regional high-level strategies detailing area-based objectives for fisheries research, establish standardised requirements for fisheries research, and align exploratory fishing activities with regionally set research priorities.

Area 48

3.115 The Scientific Committee reviewed the report from WS-DmPH-18 following the Scientific Committee terms of reference in SC-CAMLR-XXXVI, Annex 10. The Workshop developed three alternative hypotheses about the stock structure for this species in Area 48, identified data gaps and research needed to test and further refine those hypotheses.

3.116 The Scientific Committee agreed that the Workshop represented a successful model for bringing together data from multiple disciplines to efficiently develop hypotheses, and that much of the work needed can be progressed through data and sample analysis and through the use of emerging technologies such as pop-up satellite archival tag (PSAT) tagging technologies. It further noted that some multi-Member studies are already underway, such as the use of otolith microchemistry to examine stock structure and that other multi-Member research could be conducted to bring together many smaller datasets to inform stock structure.

Subarea 48.1

3.117 The Scientific Committee noted WG-FSA discussions of WG-FSA-18/20 Rev. 1, a proposal by Ukraine to carry out a scientific survey of *Dissostichus* spp. by bottom longline in the eastern part of Subarea 48.1 under CM 24-01.

3.118 The Scientific Committee noted that the proposal should be evaluated as submitted to avoid confusion, as revisions to the research are difficult to track during the meeting. Ukraine noted that the revised proposal comprises nine stations in research block 481_1 (northernmost), 20 stations in research block 481_2 (central block), and no fishing would occur in research block 481_3 (southernmost block) in recognition of the likely impacts sea-ice would have on accessibility. The Scientific Committee noted that, with the revised design, the research was unlikely to have a significant impact on dependent and related species. The Scientific Committee recommended that any future research proposal address the likely impacts of the research under Article II, as specified in CM 24-01, Annex 24-01/A, format 2.

3.119 The Scientific Committee noted that this initiative could provide important information that would assist in testing population hypotheses developed during WS-DmPH-18. Further, the Scientific Committee noted that the fixed effort survey would be at the coordinates provided in the Table 1 in WG-FSA-18/20 Rev. 1. The Scientific Committee expressed concern about the potential impact on vulnerable marine ecosystems (VMEs) in the area, but noted that precautionary requirements prescribed in CMs 22-06 and 22-07 would be required for this research. As such, no lines will be set less than 1 n mile from the midpoint of the registered VME in research block 481_2.

3.120 The Scientific Committee further noted that Ukraine would deploy and report on seabed habitats and VME taxa using benthic cameras. The Scientific Committee welcomed the use of benthic cameras during this research, and noted that the scientific e-monitoring on the vessel could be used to help evaluate the relationship between VME organisms on the sea floor, and the presence of VMEs caught and returned to the surface by longlines. Ukraine undertook to report on results of scientific e-monitoring and benthic camera data during the forthcoming intersessional working group meetings.

3.121 The Scientific Committee noted that the sea-ice in the area may be an issue for the safety of the vessel, on human life and the ecological impact of any at-sea accident and expressed its concern that research in this area could increase the risk of negative ecosystem impacts.

3.122 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 (central block) following coordinates set out in WG-FSA-18/20 Rev. 1, Table 1. Results from this research will be presented intersessionally at WG-FSA. The maximum catch limit for the fixed effort survey is 40 tonnes.

Subarea 48.2

3.123 The Scientific Committee noted that the proposal by Ukraine for Subarea 48.2 (WG-FSA-18/49), as evaluated by WG-FSA (Annex 9, paragraphs 4.55 to 4.61 and Table 5), did not provide the information necessary to determine the likelihood of success. The Scientific Committee noted that this research survey has been ongoing for four years of a five-year program, and that this would be the final year of this research.

3.124 The Scientific Committee noted that this research survey has a substantial difference between the catch reported in the CDS and the C2 data (paragraphs 12.2 and 12.3). The difference in the catch rates (up to 30%) could impact the Scientific Committee advice on this survey and continuation of this survey after 2018/19 should be re-examined following the investigation by Ukraine (paragraph 12.5) and advice from WG-FSA to the Scientific Committee.

3.125 The Scientific Committee agreed that Ukraine will collect otoliths and age otoliths to develop an age–length key (ALK), sampling fish during the survey in 5 cm length bins. The Scientific Committee further agreed that, as this is the final year of a five-year research plan, a full report of results will be provided in 2019.

3.126 The Scientific Committee recommended that this research could proceed as a fixed effort survey, with 48 longline sets according to WG-FSA-18/49, with the maximum catch limit 75 tonnes.

Subareas 48.2 to 48.4 connectivity

3.127 The Scientific Committee noted that the research plan in Subareas 48.2 and 48.4 (WG-FSA-18/31) was progressing and entering the third year of the at-sea sampling phase. Over the following two years, the research will integrate the data collected into the stock hypothesis for Area 48 (Annex 9, paragraphs 4.62 to 4.68).

3.128 The Scientific Committee recommended that the survey be conducted in 2018/19, with research catch limits of 23 tonnes in the eastern area of Subarea 48.2 and 18 tonnes in the southern area of Subarea 48.4.

Subarea 48.6

3.129 The Scientific Committee noted the discussion at WG-FSA (Annex 9, paragraphs 4.71 to 4.92) on a proposal by Japan, South Africa and Spain to continue the longline research survey for *D. mawsoni* in Subarea 48.6 and noted the review using the agreed criteria set out in SC-CAMLR-XXXVI, Annex 7, paragraph 4.7 and shown in Annex 9, Table 5.

3.130 The Scientific Committee noted that this research plan has been progressing since the 2013/14 season and the details of that progress were presented in previous years (WG-SAM-14/01, WG-FSA-14/17, WG-SAM-15/06, WG-FSA-15/16 Rev. 1, WG-SAM-16/07, WG-FSA-16/32 Rev. 1, WG-SAM-17/03, WG-SAM-17/10, WG-FSA-17/08, WG-FSA-17/10 and WS-DmPH-18/06). The Scientific Committee noted that participating Members committed to recover the delay of achieving data and sample analytical milestones, as highlighted in Annex 6, paragraphs 6.26 to 6.29 and Annex 9, paragraphs 4.87 and 4.88 and Table 5, to advance the stock assessment of *D. mawsoni* as a key objective of this research program, and also the knowledge about marine ecosystems in this research area. The following data and sample analyses will be conducted in 2019 using the available data and reported to WG-SAM-19 and WG-FSA-19:

(i) Review the stock hypothesis with the area-wide habitat linkage, including movement analysis, especially from fish that moved between subareas that could be used to verify the proposed hypothesis.

(ii) Developing integrated stock assessment models using CASAL framework considering data weighting, stock hypotheses and different levels of IUU catches in sensitivity run.

(iii) Progress analytical approaches to CPUE standardisation in Subarea 48.6.

(iv) Processing and reading a minimum of 200 otoliths, Japan and Spain to update ALKs, and conducting calibration analysis between readers.

(v) Updating biological parameters for the population, suitable for inclusion in CASAL: ALK, growth curves, maturity ogives.

(vi) Spatial modelling of fish by-catch pattern according to standardised procedures to investigate the potential impacts on the wider ecosystem.

(vii) Spatial analysis of VME by-catch pattern, and deployment of benthic video cameras to investigate the potential impacts on the wider ecosystem and substrate composition. It is expected that this coming season we will be able to record extensive footage in order to better estimate the Spanish longline footprint evaluating the horizontal movement of the lines.

(viii) Update analyses of sea-ice and oceanography (e.g. sea-surface temperature (SST)). In-situ data for sea-ice and SST will be analysed in consultation with Germany and SST using satellite data and numerical model (HYCOM).

(ix) Summarising marine mammal depredation and marine mammal observation, to document potential interaction of mammals with the vessels.

(x) Analyse between five and 10 *D. mawsoni* tissue samples for DNA by research block for genetic analysis to further contribute to the stock hypothesis development.

(xi) A long series of tag-recapture data and catch at age is needed to estimate the natural mortality using tagging data. Sensitivity analysis will be done, and as long as the proposal is progressing, it will potentially be possible to achieve this multi-year milestone.

3.131 The Scientific Committee noted that the participants in this proposed research plan have further considered the comments by WG-FSA-18 regarding analyses to be conducted in the 2018/19 season (Annex 9, paragraph 4.89), and that the proponents agreed to add the following points to those already outlined in the proposal (WG-FSA-18/34):

(i) cameras will be deployed on the *Tronio*, and video data will be analysed in order to establish the impact of Spanish longline gear on benthic sessile organisms

(ii) deploy six PSATs to verify movement and improve stock hypothesis. Three PSATs will be set to pop up after nine months and three PSATs will pop up after one year of liberty

(iii) collect conductivity temperature depth probe (CTD) data for oceanographic studies. Water current data at depth will be analysed in order to evaluate the geostrophic current by means of salinity and sea temperature with a numerical model data (HYCOM)

(iv) ensure appropriate spatial distribution of catch effort, and some spatial overlap between vessels, to compare vessel effects. Options that might be considered would include either of the following:

(a) vessels fishing close to each given that areas are small

(b) spatial overlap over seasons (i.e. trotline fishing vessels going into the same place where Spanish longline vessels had fished in the previous season).

3.132 The Scientific Committee recognised the commitment to achieve a substantial work load and goals both in terms of data collection and subsequent data analysis and presentation, and commended the associated commitment in resources to progress the items identified in the paragraphs above and achieve the objectives of this program.

3.133 The Scientific Committee agreed that this research should proceed and the catch limits given in Table 1 should apply.

Area 58

Divisions 58.4.1 and 58.4.2

3.134 The Scientific Committee noted that WG-FSA-18 had reviewed a number of papers on research conducted from the final year of the multi-Member research plan by Australia, France, Japan, Korea and Spain in Divisions 58.4.1 and 58.4.2. These papers included research on toothfish movement derived from PSATs, toothfish diet composition, feeding strategies and reproductive ecology, otolith age readings, fish and macro-invertebrate by-catch analyses, the development of case-control tagging performance statistics, improvements to a toothfish habitat model and progress in developing a CASAL model for *D. mawsoni* in these divisions (Annex 9, paragraphs. 4.98 to 4.108).

3.135 The Scientific Committee also noted a proposal for a new four-year research plan by Australia, France, Japan, Korea and Spain in Divisions 58.4.1 and 58.4.2 (WG-FSA-18/59). This proposal had been evaluated against the criteria set out in SC-CAMLR-XXXVI, Annex 7, paragraph 4.7 (Annex 9, Table 6), with recommended catch limits in research blocks for Division 58.4.1 and 58.4.2 calculated using the updated trend analysis rules (Annex 9, Table 4).

3.136 SC-CAMLR-XXXVII/BG/23 questioned the performance of the multi-Member research plan by Australia, France, Japan, Korea and Spain in Division 58.4.1 arguing that the different gear types of longline gear and configurations used by the different vessels prevented data collected on CPUE, size composition, or mark-recapture results from being summarised and used as a time series to estimate abundance.

3.137 Dr Kasatkina made the following statement:

> *'Russia noted that in the period 2013/14–2017/18 the implementation of research programs in Division 58.4.1 was based on data collected by several vessels in each research block. These vessels operated using different types of longline gears, line length and number of hooks. The type of longline changed over the years and research blocks and the effect of longline gear type is reflected in length composition, age composition, ratio of mature fish and mark-recapture results.*
>
> *The use of different gear types for the implementation of a multi-Member research should be considered as a critical factor for the efficiency and reliability of multi-year programs in Division 58.4.1. Clarity is needed regarding the quality of the information obtained, the possibility of achieving the goals and objectives of the research program in Division 58.4.1, in particular, such as: (i) development of a hypothesis for toothfish stock structure across East Antarctica, and links with other areas using data on toothfish biomass, distribution, biology, demography and movement; (ii) estimation of toothfish maturity parameters; (iii) estimates of local biomass within research blocks by Petersen tag-recapture models; initial integrated stock assessment models for toothfish within research blocks or across small-scale research units (SSRUs) and divisions; (iv) estimation of spatial distribution, relative abundance, and life history of main by-catch species.*
>
> *Russia also expressed concern regarding the calculation of the catch limit for the researches in Division 58.4.1. In particular it was noted that different gear types had been used in the research blocks in different years, there had also been a low level of tag recapture in this area. Analysis of the impact of gear type in the regression technique used to set research block catch limits and the sensitivity to the level of tag recapture, has not been performed and this uncertainty may have impacted the precautionary catch limit advice to the Scientific Committee (Annex 9, paragraph 4.115). It was recalled that the allowable catch was set at 210 tonnes for exploratory fishery in the seasons 2008/09–2012/13 according to the size of* Dissostichus *spp. population (SC-CAMLR-XXVII, Annex 5, paragraph 5.29). At the same time catch limit for researches in the period 2013/14–2017/18 ranged from 724 to 564 tonnes. Analysis of possible impact of such catch limits on the stock status of* Dissostichus *spp. had not been performed following the requirements for streamlining research programs (SC-CAMLR-XXIV, Annex 7, paragraph 5.11).*

Russia noted that the research in Division 58.4.1. for the coming four years from 2018/19 to 2021/22 (WG-SAM-18/17), was suggested to continue with the use of different types of fishing gear, including the Mustad autoline system (Australia and France), Spanish longline (Spain) and trotline (Japan and Korea). It was highlighted that it is needed to clarify efficiency of this multi-year survey and the quality of the results obtained. Such an analysis is necessary to assess the appropriateness of continuing programs and developing approaches for improving the methodology for data collection (SC-CAMLR-XXXVI, paragraph 3.114).

Based on the deliberations and exchange of views in WG-FSA and SC-CAMLR Russia cannot support the view that the research in Division 58.4.1 is sufficiently scientifically substantiated and therefore underlines that no consensus has been reached on these studies.'

3.138 The Scientific Committee noted that the research plan had been extensively reviewed over the last three years by every WG-SAM and WG-FSA meeting and had achieved all research milestones (Annex 9, Table 6).

3.139 The Scientific Committee recalled discussions relating to the use of different longline gear types in research plans (SC-CAMLR-XXXVI, paragraph 3.115). It noted that a number of standardisation methods exist and are used routinely within CCAMLR working groups to control for the potential effects of gear type, vessel, area, depth and other variables associated with the variable of interest (e.g. catch rate, fish size) (Annex 9, paragraphs 4.27 to 4.30). Methods have also been developed to standardise differences in tagging programs, such as the case-control analysis (WG-SAM-14/30), and these data have been used in integrated stock assessments.

3.140 Methods that account for differences in gear types and vessels have been applied to Division 58.4.1, including standardisation of catch rates, mean length, the proportion of mature females and sex ratio (WG-FSA-11/35, WG-FSA-17/16), trends in by-catch abundance (WG-FSA-17/23, WG-FSA-18/28), and estimation of vessel effective tagging survival and detection rates (WG-FSA-18/58 Rev. 1).

3.141 The Scientific Committee noted that in a majority of exploratory fisheries and research plans under CM 24-01, different gear types and vessels are used to conduct research, and therefore Dr Kasatkina's concerns apply as well to all of these activities and are not specific to Division 58.4.1.

3.142 The Scientific Committee noted that since last year precautionary catch limits have been calculated based on the application of the trend analysis rule (Annex 9, paragraph 4.119) which has resulted in increasing and decreasing catch limits in research blocks across the Convention Area in Areas 48, 58 and 88 (Table 1).

3.143 On behalf of the research proponents, Dr Ziegler noted that the milestones of the new research plan include the ongoing evaluation of the effects of different gear types and vessels in addressing the objectives of the research.

3.144 All Members of the Scientific Committee, except the representatives of Russia, noted their disappointment that there was no consensus at this meeting, despite consensus at WG-FSA-18 which had concluded that this proposal satisfies all criteria for a scientific research plan under CM 21-02, paragraph 6(iii).

3.145 These Members also noted that the new and previous multi-Member research plans were consistent with the recommendations from the CCAMLR Performance Review, encouraging the integration of research on a regional level. The multilateral project was addressing high levels of science and progressing regional knowledge of toothfish stock and ecology.

Division 58.4.3a

3.146 The Scientific Committee noted that WG-FSA-18 had reviewed a joint proposal by France and Japan to continue research in Division 58.4.3a (WG-FSA-18/61). The outcomes of this review can be found in Annex 9, Table 4, including footnotes.

3.147 The Scientific Committee considered the request by WG-FSA to consider the prospect of this research plan being successful, given the low catches and hence low number fish being tagged since 2014, low numbers of recaptures, low catch yielding low numbers of otoliths available for ageing, and ageing not being progressed, and the high proportion of by-catch.

3.148 Dr Eléaume thanked the Scientific Committee and its working groups for the feedback received on this research plan, which was evaluated by the CCAMLR scientists, including those from France. He highlighted that all collected and analysed data was presented, including on the objective and milestones that were not met. In view of this, Dr Eléaume noted that the main objective of estimating toothfish biomass cannot be achieved principally because of the rate of by-catch and benthic VME indicator species caught. Therefore, the fishery in this region should be closed for a period of time, during which French scientists would complete the research and analyses already committed to, for future consideration of WG-SAM and WG-FSA.

3.149 The Scientific Committee noted that Japanese scientists renewed their commitment to continue and strengthen its on water and data and sample research/analysis efforts in both Divisions 58.4.3a and 58.4.4b, while recognising the concerns expressed regarding capacity to fulfil the research plans. They noted that the announced replacement of the *Shinsei Maru No. 3* will improve the efficiency and capacity of on the water research in the future.

3.150 By suspending the contribution to data collection by the *Mascareignes III*, collecting macrobenthic samples fixed in alcohol will be unavailable due to limited sample storage and restrictions of Japanese legislations. However, the *Shinsei Maru No. 3* will complete all other macrobenthos data collection as described in the research plan i.e. all the specimens of benthic invertebrates caught on the longlines will be collected and weighed by the observer, including both VME and non-VME taxa.

3.151 The French vessel *Mascareignes III* will suspend its research fishing in this area until further analyses are conducted on existing data to reduce skate and VME by-catch levels and strengthen biomass estimation of *D. eleginoides*. During the suspension period, France will collaborate with Japan to advance relevant milestones in Annex 12, including to:

(i) conduct a retrospective analysis of fish by-catch species: analysis of temporal and spatial trends in by-catch species CPUE, with a focus on skates. Ongoing research projects on skate by-catch and post-release survival rate conducted in Division 58.5.1 will contribute to improving our understanding of the high level of skate by-catch

(ii) conduct further analyses on macro-invertebrates and habitats to map their distributions and build on results from Division 58.5.1 to establish thresholds for move-on rules

(iii) collaborate with Japanese scientists on the development of a stock assessment model with the existing data (up to 2017/18).

Results of these data and sample analyses will be presented to the relevant working group of the Scientific Committee.

3.152 Prof. J. Morishita (Japan) expressed a wish for the *Shinsei Maru No. 3* to continue fishing in this area, and conduct its research fishing in this area and noted that Japan would advance relevant milestones in Annex 12, including to:

(i) enhance toothfish research and collect by-catch data for a future comparative study

(ii) cover research items conducted by France during the suspension period

(iii) completely overlap the operation position of the French vessel with high by-catch for comparative analysis

(iv) continue the tagging program, carefully considering the effect of increasing tagging ratio

(v) use a holding tank on board to retain tagged toothfish in presence of predators

(vi) consider e-monitoring onboard to estimate reporting rate

(vii) age otoliths previously collected at this area

(viii) develop stock hypothesis for *D. eleginoides*

(ix) introduce a new Japanese vessel that will start operation in April 2020 and is expected to increase survey capacity

(x) advance biomass estimation using CASAL:

  (a) update biological parameters (growth curve and maturity ogive) by using already corrected data as described in Table 1 (Japan, France)

  (b) evaluate the difference of effective tagging survival and tag-detection rate among fleets for WG-SAM-19 (France, Japan)

  (c) estimate IUU catches, based on recent result from East Antarctica and using sensitivity run in CASAL (Japan)

(xi) depredation analyses:

  (a) interaction rate (France, Japan)

  (b) photo ID: responsibility for photo analysis will be with France.

3.153 The Scientific Committee appreciated the work conducted in the margins of this meeting on developing further details on how to achieve the research objectives, and how to find solutions to the issues raised. The points set out in the paragraphs above were considered by the Scientific Committee. Consensus could not be reached.

3.154 Several points were noted as to why for some Members consensus could not be reached:

(i) the benefit of continuing this research in terms of collecting further data and estimating the biomass of *D. eleginoides* in this region did not outweigh the risks of not being within sustainable limits for this stock, and not being consistent with Article II

(ii) the evaluation conducted at WG-FSA identified several footnotes that were not addressed sufficiently to move forward on these issues (such as the likelihood of this research achieving its milestones in a timely manner)

(iii) consistent with the approach taken to other research plans by other proponents (e.g. Ukraine, France), based on the evidence in delivery to date, it was not clear whether there was sufficient research capacity to complete data and sample analyses for all proposals submitted with Japanese participation

(iv) the proposed division of labour between proponents indicated a change whereby one proponent would primarily collect data going forward, while the other would primarily analyse existing samples and data, which would not be compatible with continuing this research.

3.155 Some Members expressed that they welcomed the commitment to continue analysis and research on data and samples already collected, but noted that these milestones would need to be achieved first before a sustainable exploratory fishery in this area could be further considered.

3.156 Prof. Morishita thanked the Scientific Committee for all comments and feedback received, and recognised the concerns raised. He acknowledged that there was some delay in producing the agreed milestones, but noted that this area still remained an area of interest for Japanese research. He expressed the commitment to follow the points presented in paragraph 3.152 and noted that the failure to achieve consensus was unfortunate. Prof. Morishita renewed his offer to continue discussion and further consideration based on the comments received.

3.157 The Scientific Committee recommended that, should the proposal be progressed, the setting of catch limits be consistent with Table 1.

Division 58.4.4b

3.158 The Scientific Committee noted WG-FSA comments on the proposal set out in WG-FSA-18/44 (Annex 9, paragraph 4.134) by France and Japan that Division 58.4.4 is a closed area, and (i) that proposed research designs have not been implemented, (ii) low and declining catch rates, (iii) low numbers of historical tag recaptures, (iv) low expected numbers of future recaptures due to low catches, and (v) limited milestone achievement (Annex 9, paragraph 4.137).

3.159 France and Japan indicated that they had committed to recover the delay in achieving the agreed milestones by increasing the capacity of their research team, redesigning the survey to avoid sea pen hotspots, and working to develop a robust biomass estimate.

3.160 A revised proposal was developed during the meeting of the Scientific Committee to address concerns raised at WG-FSA-18 and the Scientific Committee, and is summarised in Annex 12 (Research plan Division 58.4.4b).

3.161 The Scientific Committee recommended that Japan and France conduct the survey for the 2018/19 season according to the plan set out in Annex 12, with a catch limit of 19 tonnes in research block 5844b_1, and 22 tonnes in research block 5844b_2, using the trend analysis decision framework.

Area 88

3.162 Dr Kasatkina presented SC-CAMLR-XXXVII/20, reviewing the procedure established by the Secretariat to monitor catch and effort in the context of results from the 2017/18 fishing season.

3.163 The Scientific Committee noted that three papers were submitted by the Secretariat to Agenda Item 14 (paragraphs 14.1 to 14.3) that address these concerns in respect to the Secretariat's procedures and capacity in fisheries and data management.

3.164 The Scientific Committee noted the discussions of WG-FSA on fisheries monitoring in the Ross Sea region (Subarea 88.1 and SSRUs 882A–B), including fishery summaries and biological characteristics of *D. mawsoni* catch. It noted that although new areas were opened to the fishery as part of the establishment of the Ross Sea region MPA (RSRMPA), most of the fishing effort was carried out in the historically fished areas.

Winter survey

3.165 The Scientific Committee considered the proposal from New Zealand on conducting a winter survey and the associated discussions of WG-FSA (Annex 9, paragraphs 4.141 to 4.146), and noted that the survey takes place outside the season defined in CM 41-09, providing data and information for the winter season. The Scientific Committee noted that the survey was effort-limited, and that due to the ice conditions in the region during the time of the survey, it was likely that the catches would remain well below the 97 tonne catch limit.

3.166 Therefore, the Scientific Committee recommended that the survey proceed in 2018/19 as presented, that catch should be taken from the Ross Sea northern catch limit of the next season, and to adjust the catch limit of that season by the actual catch taken during the survey.

Shelf survey

3.167 The Scientific Committee noted the advice of WG-FSA that the shelf survey contributes information on the relative magnitude of recruitment year classes in the toothfish stock assessment of the Ross Sea region, and the comments of the independent review panel (Annex 5) that noted the importance of developing time series of standardised surveys to reducing the uncertainty of recruitment estimation in assessments (Annex 9, Table 3).

3.168 The Scientific Committee noted the discussions on the shelf survey (Annex 9, paragraphs 4.147 to 4.151), and its previous advice on the matter, endorsing that, in absence of a scientific rationale for changing its previous advice, the survey catch be allocated from the total stock catch limit.

3.169 The Scientific Committee recommended that the catch limit be set at 65 tonnes for the 2018/19 Ross Sea shelf survey.

3.170 For the winter survey, the Scientific Committee recommended that the catch limit be set at 97 tonnes for the 2018/19 season, noting that it is an effort-limited survey, and that the actual catch is deducted from the catch limit for the 2019/20 Ross Sea region north of 70°S.

3.171 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 2018/19 season be 3 157 tonnes, with 464 tonnes allocated to the special research zone (SRZ), 587 tonnes north of 70°S, 2 041 tonnes south of 70°S, and 65 tonnes for the Ross Sea shelf survey.

Activities in the special research zone (SRZ)

3.172 The Scientific Committee noted the discussions of WG-FSA on a proposal for a research survey to be conducted by four vessels within the SRZ of the RSRMPA (WG-FSA-18/31 Rev. 1), which was previously considered by WG-SAM (WG-SAM-18/07). The program presented objectives on investigating 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 within SSRU 882A. The Scientific Committee welcomed the link of the outcomes of this research with the topics from the research and monitoring plan (RMP) (SC-CAMLR-XXXVI/20) presented in the proposal, and recalled recommendations from WG-SAM and WS-SM-18 regarding guidelines for fisheries research conducted in the MPA (Annex 6, paragraphs 6.45 to 6.47, Annex 7, paragraph 6.2).

3.173 The Scientific Committee considered how this proposal would be able to operate within the Olympic fishery in this region. It noted that while the SRZ general objectives are outlined within CM 91-05, there is no mechanism to separate effects of the Olympic fishery and structured research plans. It considered that such surveys provide the opportunity to distinguish effects of the Olympic fishery locally, or examine the impact of the Olympic fishery on surveys through methods such as linear and mixed models.

3.174 The Scientific Committee recommended that where research surveys take place in the same location or in proximity to the Olympic fishery in the Ross Sea region, these should not occur at the same time, and that when analyses are presented that they consider the impact of the Olympic fishery on locations where research fishing has been carried out.

3.175 The Scientific Committee considered the discussions of WG-FSA and the review in Annex 9, paragraphs 4.155 to 4.168 and Table 7, on the tag performance of one vessel proposed to take part in this survey, on gear standardisation, and on issues regarding fixed stations in the research design.

3.176 The Scientific Committee was not able to reach consensus on the progression of this research proposal.

Subarea 88.2

3.177 The Scientific Committee considered the recommendations of WG-FSA on the exploratory fishery in the Amundsen Sea region. The exploratory toothfish fishery has operated in SSRUs 882C–H since 2003 and a research plan was developed in 2015 to focus research into research blocks in the southern region and into SSRU 882H (Annex 9, paragraphs 4.172 to 4.183).

3.178 The Scientific Committee noted that the current research plan and catch limit distribution by area had advanced the information required for the assessment of the stock, but further development of the stock assessment is needed. Progress towards a full integrated assessment for the area relies on adequate mark-recapture and ageing data. The Scientific Committee noted the recommendation from WG-FSA to request that integrated research plans be developed by Members allowing the development of tag release and recapture data from the southern research blocks and spatial coverage of effort into all research blocks.

3.179 The Scientific Committee noted that this information from this region was to some extent different to some other areas where individual research plans, as set out in CM 24-01, Annex 24-01/A, format 2, apply, as there is a reasonably good understanding of the stock and its links to other areas, on tagging data and the stock assessment, but that there was a lack of spatial coverage across research blocks and in information on biological parameters in some areas.

3.180 The Scientific Committee noted that currently CM 21-02, paragraph 6(iii) (notifications for participation in exploratory fisheries for *Dissostichus* spp.) included Statistical Subarea 48.6 and Divisions 58.4.1, 58.4.2 and 58.4.3a, and requested the Commission add the areas covered by SSRUs 882C–H for future notifications.

3.181 An updated pro forma 'Format for submitting finfish research proposals in accordance with paragraph 3 of Conservation Measure 24-01 and paragraph 6(iii) of Conservation Measure 21-02' was submitted to the Scientific Committee (and attached to this report in Annex 13). The Scientific Committee agreed that if this form was used it would reduce the need for a review at WG-SAM, and proposals would only need to be reviewed at WG-FSA.

3.182 The Scientific Committee requested that the Commission amend Annex 24-01/A, format 2, as presented in Annex 13 for future submission of research proposals.

3.183 The Scientific Committee noted that WG-FSA presented two options for a catch limit for SSRU 882H. The first option relied on using all tag releases and recaptures, and the second option adjusted the tag information by effective tag release and recaptures.

3.184 The Scientific Committee noted that while the effective tag recovery was used within the CASAL framework, it had not been evaluated for use in the Chapman estimator, and recommended a review of its application and the subsequent application in the trend analysis approach. Additional information on this stock suggested that both proposed limits were precautionary, and that the preliminary integrated assessment presented for Subarea 88.2 showed that the overall aggregate catch for this region was consistent with the CCAMLR decision rules.

3.185 The Scientific Committee noted that in research block 882_2, where adequate recaptures were available, both of the methods gave the same management advice.

3.186 The Scientific Committee noted that the advice for research blocks 882_1 to _4 used the trend analyses rules as for other research blocks in the CCAMLR region and recommended the catch limits for these research blocks as given in Table 1.

3.187 The Scientific Committee agreed that given the likely sustainability of the current catch limit in SSRU 882H and that this was lower than the value estimated by the linear trend analysis when not using the effective tag releases and recaptures, it recommended that the catch limit of 200 tonnes for SSRU 882H be applied for the 2018/19 season.

3.188 The Scientific Committee requested that WG-SAM and WG-FSA evaluate the procedures of including information on effective tag recaptures as much as possible for the Scientific Committee to consider at its annual meeting in 2019, as the options presented by both methods differed by around 30%. As similar issues may arise in other areas, there is an urgency to understanding the potential impact of effective tag recaptures on catch limit advice.

Subarea 88.3 toothfish

3.189 The Scientific Committee noted that the research plan detailed in WG-FSA-18/42 was for three years, with 2020 being the last year prior to a new proposal being developed. The Scientific Committee noted that Ukraine has withdrawn its proposal to conduct research in Subarea 88.3 in 2018/19 (WG-FSA-18/16).

3.190 The Scientific Committee noted that some research blocks in Subarea 88.3 overlap with the Domain 1 MPA proposal and that coordination of the objectives of the research and MPA would need to be harmonised to ensure the objectives of the MPA are achieved.

3.191 The Scientific Committee noted that the participation of Ukraine in the collaborative research program in Subarea 88.3 with Korea and New Zealand in 2019/20 would bring additional value to the program by allowing the calibration of an additional vessel, increasing the number of fish scanned for tags, and providing an additional vessel using scientific e-monitoring to enhance observer data collection. The Scientific Committee noted that the three Members would work together intersessionally to develop a single integrated proposal for review next year.

3.192 The Scientific Committee recommended that the catch limit sharing mechanism described in Annex 9, paragraph 4.198 be used to increase the likelihood of achieving research objectives and recommended that the catch limits be implemented as in the 2017/18 season (Table 1).

Scientific research exemption

Subareas 88.2 and 88.3 – Crabs

4.1 The Scientific Committee noted the proposal by Russia to conduct research fishing under CM 24-01 in Subareas 88.2 and 88.3 (WG-FSA-18/32 Rev. 1). The Scientific Committee noted that although targeting deep-water crabs, as opposed to toothfish, the research evaluation format in Annex 9, Table 7, was a useful way to summarise the research plan and likelihood of success.

4.2 The Scientific Committee recommended that conducting research as structured under CM 24-01 is a good process to implement in the development of new fisheries, and that a pilot research program is an appropriate approach to collect information on distribution, species composition and abundance that could be used upon review to recommend future research or fishery data needs.

4.3 The Scientific Committee recommended that the crab research proceed following the recommendations of WG-FSA (Annex 9) in paragraphs 4.210 to 4.217 with the following requirements:

(i) a one-year pilot of a fixed effort survey with 25 sets in Subarea 88.2, and 20 sets in Subarea 88.3 with a total catch limit of 250 tonnes of crabs in each subarea and a maximum of 120 pots per line (including some sets with reduced number of pots to evaluate feasibility for future work)

(ii) coordinates for the 45 sets as set out in Appendix 2 of WG-FSA-18/32 Rev. 1

(iii) measure all crabs and retain representative samples of all catch to estimate maturity in both sexes (Annex 9, paragraph 4.212)

(iv) use benthic cameras to document and examine the impact of pots on benthic habitats (Annex 9, paragraph 4.213)

(v) all tagged and recaptured toothfish, or toothfish unsuitable to tag and release, shall be sampled for biological data as per CM 41-01, Annex 41-01/C, paragraph 2(viii)

(vi) catch and effort data be submitted according to CM 23-05 using the C5 form and SISO data collected using the e-POT(2013) form (Annex 9, paragraph 4.217)

(vii) the research is to be conducted after the fisheries in Subareas 88.1 and 88.2 have closed

(viii) a by-catch limit (retained catch) of 5 tonnes of toothfish should be applied to this survey, with only toothfish suitable for tagging to be tagged and released, following CM 41-01, Annex 41-01/C. Once 5 tonnes of toothfish by-catch is retained, research should cease.

4.4 The Scientific Committee requested the Commission to consider what conservation measures would be required to be identified in CM 24-05, Table 1, in respect of specific exemptions, noting that the proposal included a commitment to operate in compliance with all conservation measures relevant to exploratory toothfish fisheries.

4.5 Russia requested the Commission to consider whether the by-catch amount should be 5 tonnes total or 5 tonnes per each of Subareas 88.2 and 88.3 and what should be the source to allocate the by-catch from.

Non-target catch and ecosystem impacts of fishing operations

Fish and invertebrate by-catch

5.1 The Scientific Committee noted the discussions of WG-FSA on temporal, spatial and bathymetric trends in fish by-catch species composition and catch rates in Divisions 58.4.1 and 58.4.2 from 2012 to 2018 (WG-FSA-18/28; Annex 9, paragraphs 6.15 and 6.16), the spatial pattern of major by-catch fish species in Subarea 48.6 and Divisions 58.4.3a and 58.4.4b. The Scientific Committee noted that there would be enough information available in Subarea 48.6 to conduct estimates for the most common species listed in WG-FSA-18/70.

5.2 The Scientific Committee reviewed several reports on squaliform shark by-catch data from within the CCAMLR area, including from Division 58.5.1. Recognising that these shark species varied in their distribution range and that the Southern Ocean is likely to be at the southern limit of their ranges, the Scientific Committee noted that the effects of climate change may result in changes in their biogeography and spatial abundance over time. The Scientific Committee noted that studies on the biology and distribution of sharks could assist in identifying changes of their biogeography and of spatial abundance data over time.

5.3 The Scientific Committee recommended to:

(i) use catch information recorded as numbers in addition to weight which could potentially improve understanding as to the status and trends of shark species in the Convention Area

(ii) collate various identification guides on sharks to assist in species identification which could be made available by the Secretariat to all vessels and scientific observers

(iii) review historical records on sharks submitted to the Secretariat to identify errors and explore mechanisms to improve the quality of future data collection on sharks

(iv) exchange information with regional fisheries management organisations (RFMOs) adjacent to the Convention Area to facilitate the development of biogeographic analysis of present and assumed future distribution of sharks in the Convention Area and adjacent areas and to put shark by-catch in CCAMLR fisheries in context.

5.4 The Scientific Committee noted advice presented in CCAMLR-XXXVII/30 from the EU on the implementation of CM 32-18 on the conservation of sharks. This paper made recommendations on the use of existing data on shark by-catch, reviewing the current status of shark by-catch data reported by vessels and observers, identifying the type of assessments and indicators that could be appropriate for the different sharks caught as by-catch in CCAMLR fisheries, documentation of methods for collecting data on discards, assessment of the potential marketability of shark species from within the CCAMLR area, and reviewing compliance with CCAMLR conservation measures on shark species under CM 32-18.

5.5 The Scientific Committee noted that targeted fishing for sharks was prohibited within the Convention Area and, while there was no evidence of shark fishing within the Convention Area, there were reports of such activities in some adjacent RFMOs, specifically SIOFA. Noting the desire for increased cooperation (paragraph 10.32), the Scientific Committee highlighted the need to bring the attention of these RFMOs to the fact that directed fishing for sharks is not allowed within the CCAMLR Convention Area. The Scientific Committee recommended that this needs to be considered by the Commission as priority work.

5.6 The Observer from IUCN (Mr S. Sykora-Bodie) made the following statement:

> *'The IUCN appreciates the opportunity to participate in this year's Scientific Committee meeting and looks forward to the scientific advice to the Commission that is sure to result from these discussions.*
>
> *The IUCN would also like to express support for the EU's proposal to assess current sources of shark mortality and by-catch within the Convention Area. In recent decades, global populations have been decimated by overfishing with one recent study estimating current mortality at nearly 100 million sharks annually. The unintended effects of these removals could be catastrophic for the Southern Ocean and it is CCAMLR's responsibility to ensure the continued integrity and health of the marine ecosystems under its stewardship.'*

5.7 The Scientific Committee recommended that a second focused tagging program for *Amblyraja georgiana* be conducted in 2019/20 and 2020/21 in the Subarea 88.1 and SSRUs 882A–B region. This should be carried out for a minimum of a two-year period, during which the benefit of continuing the program as an ongoing measure would be evaluated. The proposed tagging rate will be for all live skates up to a maximum of 15 per line with the area of the program limited to the exploratory fishery in Subarea 88.1 and SSRUs 882A–B. The Scientific Committee also noted that specific advice for implementation of this program is contained in Annex 9, paragraph 6.36.

5.8 The Scientific Committee also noted discussion in WG-FSA-18 (Annex 9, paragraphs 6.37 to 6.42) on the genetics of the skates *A. georgiana* within Subarea 48.3, and an update on stock status of *A. georgiana* in Subarea 48.3. The genetic studies (WG-FSA-18/73) reported that species identification for *Amblyraja* could be limited to the generic *Amblyraja* spp. code (SRX), as genetic studies indicate that species location is more indicative of species differences than morphology, and highlighted that a low level of mixing of the *Amblyraja* populations between Subareas 48.3 and 48.4 may occur. The Scientific Committee noted that the Chapman biomass estimates and fishery exploitation rates for this species showed the overall trend of both biomass estimates and exploitation rate is stable across the time series (WG-FSA-18/27), indicating there is a low impact on this species from the *D. eleginoides* fishery in this area.

5.9 The Scientific Committee recalled the WG-EMM-18 discussion on the likelihood that crystal krill (*Euphausia crystallorophias*) will have been included in the reported *E. superba* catch. As some krill fishery operations occur in areas where datasets from scientific net hauls indicate the likelihood of co-existence of these two species, this underlined the importance of providing scientific observers with the appropriate materials needed to identify crystal krill in their routine observations.

5.10 The Scientific Committee noted that there are various other methods to detect crystal krill and other by-catch, such as the use of lipid or DNA markers, although these methods may not be practical to apply to many samples in a routine manner. The Scientific Committee noted that early research survey results from the early 1990s in Area 48 did not reveal the presence of crystal krill in catches using research gear. The current presence in some catches could be a result of changes in the distribution of the fishery with more effort in the Bransfield Strait region where more would be expected. The Scientific Committee noted that the synoptic survey planned for next year will include complete catch sorting, which should provide more up-to-date data on the presence or absence of krill species mixing.

5.11 The Scientific Committee noted discussions on fish by-catch within the krill fishery (Annex 9, paragraphs 6.43 to 6.46) which included advice from WG-FSA that it is currently not possible to provide an impact assessment for the krill fishery on finfish populations until previous concerns relating to reporting on continuous fishing system trawl vessels are addressed (Annex 9, paragraph 6.2).

5.12 The Scientific Committee recalled CCAMLR's approach to by-catch of (i) avoidance, (ii) mitigation, and (iii) the setting of sustainable by-catch limits if mortality is not preventable and recalled that Article II requires advice on related species and that conservation measures are in place for some non-target species. A number of these conservation measures relating to by-catch species may be based on outdated information or had been adopted as precautionary measures pending the availability of more information. The Scientific Committee encouraged Members to provide updates where new data exist.

5.13 The Scientific Committee discussed the application of region-specific by-catch limits and agreed that this may be a more appropriate method of fulfilling the requirements for managing by-catch under Article II rather having the limits based on a percentage of historic by-catch versus target species in a specific area as is currently the case in CM 33-03. Noting that there are some species for which a proper estimate would be problematic (e.g. species caught infrequently) there are still data-limited methods which are used in other management organisations which could be used for analysis. The Scientific Committee recognised the need to assess the risk to the population consistent with the principles of Article II but that does not necessarily involve calculating a biomass for every species. The Scientific Committee also noted that the SCAR *Biogeographic Atlas of the Southern Ocean* could contribute to such work in assessing the distribution of by-catch species.

General issues

5.14 The Scientific Committee noted discussions of WG-FSA on metadata analyses of target and by-catch reporting in its exploratory fisheries (WG-FSA-18/14; Annex 9, paragraphs 6.1 to 6.7), and a summary provided on the implementation of the by-catch move-on rules in the CCAMLR exploratory fisheries between 2010 and 2018 (WG-FSA-18/09; Annex 9, paragraphs 6.8 to 6.10). The Scientific Committee noted apparent inconsistencies in the way in which by-catch was recorded between vessels.

5.15 The Scientific Committee noted that it would be useful to further clarify instructions to vessels on how by-catch should be reported as recommended by the Commission in 2015 (CCAMLR-XXXIV, paragraphs 3.31 to 3.35) to address the apparent inconstancies in the way in which by-catch is recorded between vessels. The Scientific Committee recommended that this could be linked to any redevelopment of the C2 forms and associated development of guidelines for C2 form completion (paragraph 3.44).

5.16 The Scientific Committee further noted that, unless the inconsistencies in the reporting of by-catch between vessels in exploratory fisheries are addressed, progress on the development of methods for providing management advice on by-catch within exploratory fisheries will be compromised.

5.17 The Scientific Committee noted the ongoing discussions around by-catch, such as around by-catch limits in the krill fishery, regional risk assessments for non-target species, VME protection and management, or incidental mortalities of seabirds and marine mammals. It noted that in many cases, these items struggle to progress at pace as there are uncertainties around how consistent by-catch reporting is between vessels, and how changes in reporting requirements over time are reflected in collected data. It therefore recommended that the Commission implement the development of a work plan for progressing issues relating to by-catch.

Advice to the Commission

Incidental mortality of seabirds and marine mammals associated with fisheries

5.18 The Scientific Committee noted the update by the Secretariat on incidental mortality of seabirds and marine mammals in CCAMLR fisheries during 2017/18 (WG-FSA-18/13 Rev. 1). The paper summarised incidental mortality associated with fishing activities collected in scientific observer and vessel data during 2017/18 as received by the Secretariat up to 8 October 2018.

5.19 The Scientific Committee noted that for longline fisheries in which seabird mortalities have been reported, the extrapolated total of 87 birds killed is the lowest on record. The reduction has been most noticeable in the French EEZ fisheries (Subarea 58.6 and Division 58.5.1) where mortalities have shown a 95% reduction over the same time period. One marine mammal mortality was observed during longline fishing in Division 58.5.2; a southern elephant seal (*Mirounga leonina*) was recovered entangled in the main line (Table 2).

5.20 The Scientific Committee noted advice from WG-FSA that in future the information in WG-FSA-18/13 Rev. 1, Table 2, should include an additional category for observed mortality in addition to the extrapolated mortality and the observed mortality rate, as in some areas observers reported all seabird mortalities from each line.

5.21 The 11 krill vessels operating in Subareas 48.1, 48.2 and 48.3 reported one seabird mortality and 19 marine mammal mortalities. For some of these cruises, the observer data have yet to be received as the observers have not yet returned to their home port.

5.22 The 19 Antarctic fur seals (*Arctocephalus gazella*) caught in 2018 represent a sudden increase as only one mortality has been recorded since 2013. However, 18 of the 19 mortalities were reported from one vessel, indicating that this is likely to be a vessel-specific, rather than a fishery-wide issue. The Scientific Committee requested further detail on this incident when these become available.

5.23 Scientific Committee noted that the relevant conservation measures (CMs 51-01 to 51-03) contain the requirement for a marine mammal exclusion device and that the specification for the device is part of the requirement in CM 21-03, Annex 21-03/A. These devices have been successfully used for a number of years within the Convention Area and this particular result was unusual. Some suggested areas of investigation included assessing methods by which the device was fixed to the trawl and examining the hauling and shooting procedures.

5.24 Dr Zhao notified the Scientific Committee that a Chinese gear technologist is planning to employ underwater cameras and/or other means onboard the Chinese krill fishing vessel to observe interactions between marine mammals and fishing gear in the next fishing season with a planned report back on this to WG-FSA and the Scientific Committee next year. The Scientific Committee welcomed this initiative and noted that an analysis of the designs of marine mammal exclusion devices could provide a better understanding of the operation of such mitigation devices and procedures in relation to reported mortalities.

5.25 The Scientific Committee also noted that there are currently no by-catch limits for marine mammals or seabirds specified for the krill fishery. The Scientific Committee requested that the matter of by-catch limits in the krill fishery be considered by WG-EMM-19.

5.26 The Scientific Committee further noted that there was no requirement for marine mammal exclusion devices specified in CM 51-04, and asked the Commission to bring this conservation measure in line with CMs 51-01, 51-02 and 51-03.

5.27 The Scientific Committee noted a report (WG-FSA-18/57) detailing fishing effort and seabird interactions during the season extension trials in the longline fishery for *D. eleginoides* in Division 58.5.2. The Commission (CCAMLR-XXXIV, paragraph 5.68) had endorsed three trial season extensions for this division. Australia undertook to report annually on the results of all the trials. The Scientific Committee noted that the conditions set in WG-FSA-15/48 for the conclusion of the trial season extensions have now been met in all three trials and that a full analysis of all season extension trials, with complete data up until the end of the current fishing season, will be presented to WG-FSA-19.

5.28 The Scientific Committee noted that the proposal by Norway to trial the use of a third wire on krill trawl vessels had been approved by the Scientific Committee (SC-CAMLR-XXXV, paragraphs 4.10 and 4.11) for a limited time. The Scientific Committee noted that the time for this exemption had now expired and that any further trials would need to be notified anew.

5.29 The Scientific Committee welcomed a paper from the Secretariat to ACAP updating the conservation status, distribution and priorities for albatrosses and petrels in the CCAMLR area. The paper informed that thirteen ACAP species (out of 31 currently listed) are currently showing overall population declines. The population trends of a large proportion of 16 ACAP species with significant distribution in the CCAMLR area are still uncertain or showed declines during the last two decades, and two thirds of the total are listed by the IUCN as threatened. The Scientific Committee noted advice that the by-catch of seabirds in adjacent regions may undermine the success that CCAMLR has achieved to date, and the conservation status of those species that breed or forage in the Convention Area is dependent on efforts to minimise by-catch both within the CCAMLR area, and importantly outside of it, both in jurisdictional waters and the high seas (see also paragraphs 10.11 and 10.12).

Bottom fishing and vulnerable marine ecosystems

5.30 The Scientific Committee noted the discussions at WG-EMM-18 on the review of the proposal to add five sites in the western Antarctic Peninsula and three additional sites containing *Umbellula* seapens at the South Orkney Islands to the CCAMLR VME Registry.

5.31 The Scientific Committee welcomed the work on VMEs presented during WG-EMM-18 and noted the recommendation provided by the Working Group in order to include four of five sites (western Antarctic Peninsula) and three sites (South Orkney Islands) (as 1 n mile radius circles centred on the midpoint locations) to the CCAMLR VME Registry. The Scientific Committee welcomed the registration of the new VMEs and noted the importance of developing more work on VMEs.

5.32 The Observer from ASOC (Dr S. Lockhart) noted WG-EMM did not recommend (Annex 8, paragraph 6.9) one proposed VME based on a rare and unique community of cerianthids (tube anemones) because this taxon is not specifically listed in CCAMLR’s table of VME indicator taxa. ASOC considered that this is a contradiction of the 2009 on Workshop on Vulnerable Marine Ecosystems (WS-VME-09) report (SC-CAMLR-XXVIII, Annex 10, paragraph 3.5.7), which states that the vulnerability of such a population ‘is independent of the habitat-forming characteristics of the taxon’. ASOC also recognised that the same report states that ‘The Workshop agreed that the table is a living document that should be periodically reassessed and updated to incorporate the best available science’ (SC-CAMLR-XXVIII, Annex 10, paragraph 3.7). ASOC recognised the usefulness of the suggested approach by WG-EMM (Annex 8, paragraph 6.9). ASOC, noting the multiple VME-related issues raised by WG-EMM and WG-FSA (Annex 9, section 6 in both reports), called for an expert workshop comprised of original participants and additional specialists in key taxa. In this regard, ASOC urged that such a workshop would be the most effective way for CCAMLR to update its approach to identifying and designating VMEs.

5.33 The Scientific Committee noted that considering the different gears (including new gear such as crab pots) that are used in the Convention Area, further information on the effects of fishing on VMEs should be developed. Other issues, such as the potential for krill trawls to catch/damage benthic organisms, as it has been reported on some occasions, and also the development of buffers zones around VMEs, trigger levels and move-on-rules, should all be addressed during a future meeting.

5.34 The Scientific Committee noted that the development of a work plan addressing VME-related issues, including updated estimates to upgrade fishing footprint mapping, could be useful as well as defining key questions prior to setting out a detailed program for the work.

5.35 The Scientific Committee noted the discussions during WG-FSA-18 noting that conservation measures relating to VMEs (particularly CM 22-07) might need further consideration as it has not been reviewed for several years. It agreed that a review of the VME conservation measures should be considered in discussions of future work for the Scientific Committee.

5.36 The Scientific Committee endorsed the recommendation of WG-EMM-18 (Annex 8, paragraphs 6.8 and 6.12 on the addition of four sites (western Antarctic Peninsula) and three sites (South Orkney Islands) (as 1 n mile radius circles centred on the midpoint locations) to be added to the CCAMLR VME Registry.

Marine debris

5.37 The Scientific Committee considered the advice of WG-FSA regarding marine debris (Annex 9, paragraph 6.73) and endorsed the modification of the C1 data form to incorporate reporting of gear loss by trawl vessels. It noted that the Secretariat was clarifying the process for reporting gear loss, including the removal of 'other hooks lost' from the C2 form.

5.38 The Scientific Committee noted that there had been an overall decline in debris, as shown by monitoring undertaken since 1989, but that the monitoring in winter at Bird Island showed the second-highest level on record. The Scientific Committee also noted that CCAMLR's marine debris monitoring program was one of the longest marine debris datasets globally and one of the longest datasets within CCAMLR.

5.39 The Scientific Committee noted that four Members currently report marine debris monitoring data but that there were opportunities to engage with other organisations such as the CEP or the Council of Managers of National Antarctic Programs (COMNAP) and also recalled its discussions at its meeting in 2017, regarding potential links with other marine debris monitoring programs and researchers (SC-CAMLR-XXXVI, paragraph 4.11).

5.40 SCAR informed the Scientific Committee that a new SCAR Action Group on Plastics in Polar Environments (PLASTIC-AG) had been approved at the recent SCAR Open Science Conference in Davos, Switzerland, and that there was increased interest within SCAR to understand the issue of marine debris and that SCAR welcomed further discussion on this with CCAMLR Members.

5.41 The IAATO Observer informed the Scientific Committee that IAATO has been invited to take part in the SCAR PLASTIC-AG and also that IAATO vessels collect debris if found at visitor landing sites and report these data to the IAATO Secretariat. IAATO is currently liaising with the CCAMLR Secretariat to facilitate formal reporting of marine debris to CCAMLR.

5.42 ASOC introduced SC-CAMLR-XXXVII/BG/18 highlighting that microplastics have been detected in several different regions of the Antarctic, and have the potential to cause negative ecosystem effects, particularly if ingested by fish or krill. It suggests that, although microplastic pollution is a challenging problem, there are relatively simple measures that could minimise additional pollution entering the ocean; for example, through the filtration of laundry water, which some fishing vessels have already successfully introduced. SC-CAMLR-XXXVII/BG/18 suggested that all vessels and research stations should consider similar approaches to limit sources of microplastics and microfibers entering the environment. It also suggested that microplastic pollution research should be included in MPA research and monitoring plans.

5.43 The IUCN Observer noted that ASOC raised the issue of plastic pollution last year and thanked them for doing so. The IUCN Observer noted that since then, scientific studies have been completed and/or published by scientists from Australia, Italy, Japan, the USA and elsewhere, confirming the threat posed by microplastics to the Antarctic marine environment. The IUCN suggested that CCAMLR could:

(i) support SCAR's PLASTIC-AG as it begins to assess the abundance and impact of plastics in the Southern Ocean

(ii) endorse COLTO and IAATO's efforts to encourage their members to install onboard filtration systems to keep fibrous particulate matter and microbeads from being released into the surrounding marine environment

(iii) contact the Antarctic Treaty Secretariat to request that the Antarctic Treaty Consultative Parties (ATCPs) consider developing water filtration standards for laundry and wastewater disposal systems at research stations.

5.44 In SC-CAMLR-XXXVII/BG/29, ASOC urged CCAMLR to update its scientific approaches to marine debris and the protection of VMEs to be in line with the latest technologies and research, and generally encouraged CCAMLR to review other relevant conservation measures on a yearly or biennial basis to ensure that it can keep up with the latest scientific information and techniques.

Spatial management of impacts on the Antarctic ecosystem

Marine protected areas (MPAs)

6.1 The Scientific Committee noted that the WS-SM-18 was held in Cambridge, UK, from 2 to 6 July 2018, and convened by Dr Grant. Dr Grant thanked the Workshop participants for their constructive engagement, Dr M. Korczak-Abshire (Poland) for assisting with planning for the workshop, and the local organisers at the British Antarctic Survey for hosting the Workshop.

6.2 Mr L. Yang (China) expressed concern that the terms of reference drafted by Conveners for the WS-SM had been discussed before the Workshop but not agreed by consensus of the Scientific Committee. Mr Yang indicated that China would reserve its position on outcomes from WS-SM.

6.3 Dr Grant informed the Scientific Committee that the views of all Members were considered during development of the agenda for WS-SM, and that the agenda was limited by the technical nature of the Workshop, with policy issues omitted from consideration.

6.4 Most Members held the view that planning for WS-SM had been consistent with the Scientific Committee's Rules of Procedure and its usual business standards.

6.5 Further references to the report of WS-SM (Annex 7) occur throughout the following paragraphs, where they address specific topics considered by the Scientific Committee.

6.6 The Scientific Committee considered advice from WS-SM on progress towards the establishment of a representative system of MPAs in the Convention Area. It was noted that WS-SM advised:

(i) the existing set of CCAMLR MPAs and sub-Antarctic MPAs is not representative of all benthic and pelagic bioregions in the Southern Ocean (Annex 7, paragraph 2.10)

(ii) establishment of the East Antarctic MPA (EAMPA), Weddell Sea MPA (WSMPA) and D1MPA would substantially increase representativeness (Annex 7, paragraph 2.10)

(iii) the Commission had made the development of a representative system of MPAs a priority for the Scientific Committee in 2009, and had requested that progress towards this objective be provided (Annex 7, paragraph 2.12)

(iv) the Scientific Committee and Commission review Annex 7, Table 1, and regularly update it to continue to track progress (Annex 7, paragraph 2.12)

(v) the Scientific Committee continue to develop criteria to enable the assessment of CCAMLR's progress towards a representative system of MPAs and the other goals of CM 91-04 (Annex 7, paragraph 2.13).

6.7 Two Members noted that the advice of WS-SM on progress towards establishing a representative system of MPAs in the Convention Area could not be endorsed because, in their opinions:

(i) the provision of this advice was not included in the terms of reference for the Workshop

(ii) MPAs are tools and not objectives in their own right

(iii) determinations on the percentage of representativeness to be protected are usually policy issue rather than science issue

(iv) the many practical and policy issues associated with establishing a representative system of MPAs necessitates a pace allowing well weighted pragmatic approach to decision-making, with hasty approach being in fact detrimental to the purpose of achieving such a system.

6.8 All other Members noted that the advice of WS-SM should be endorsed. These Members commented that the advice from WS-SM:

(i) is clear and easy to interpret
(ii) directly addresses a request for information that was made by the Commission
(iii) is not policy advice
(iv) was not generated in haste
(v) advances MPA science generally.

6.9 A number of points regarding the development of MPAs in the Convention Area were raised in Russian paper SC-CAMLR-XXXVII/18, including the need for a unified approach to MPAs. The paper proposed that:

(i) baseline data should precede the establishment of an MPA and provide the possibility for development and justification of objectives, boundaries, monitoring and research plans, measurable criteria and indicators of the performance and efficiency of the MPA

(ii) the establishment of MPAs should be carried out on the basis of sound research

(iii) a unified approach and criteria for MPAs should be developed and this should be appended to CM 91-04. The Japanese checklist (CCAMLR-XXXIV/19) would be used as basis for this unified approach and criteria

(iv) scientific data relating to MPAs should be presented on the CCAMLR website as part of the proposal to establish an MPA

(v) baseline data and monitoring indicators relating to achieving the aims of MPAs should be described in a research and monitoring plan

(vi) a research and monitoring plan should be detailed based on reporting periods with regard to planned studies and the information to be obtained; information about who would conduct studies should be endorsed prior to each reporting period.

6.10 Mr Leonidchenko provided additional material on this issue, noting that the intention was to facilitate the process of the development of MPAs and research and monitoring plans in a consistent way.

6.11 Mr Yang expressed support for the proposal in SC-CAMLR-XXXVII/18, and highlighted the importance of baseline data in the assessment of the achievement of MPA's objectives and the need for elaboration of the guidelines on the development of MPA proposal.

6.12 The Scientific Committee noted that SC-CAMLR-XXXVII/18 raised generic issues across MPAs and was not specific to any particular MPA or proposal.

6.13 Two Members underlined that regular and robust monitoring was crucial to effective MPAs as it allowed to monitor changes in ecosystems and biodiversity and interaction with harvesting activities, adjusting conservation measures as necessary. They also underlined the volume of discussions related to the issue of RMPs and differences in approaches to this issue. They were of the view that it was useful for the Scientific Committee to come up with a common approach to development and implementation of RMPs. They suggested to launch an exercise to identify necessary basic elements that would be common for all RMPs despite the unique character of each MPA. With the goal to look for solutions and approaches that would make development and implementation of an RMP more efficient, integral and systematic process.

6.14 The Scientific Committee agreed that RMPs are an important component of all MPAs. However, there was not sufficient time in plenary to address these questions, including those identified in paragraph 6.13. The Scientific Committee encouraged Members to continue to communicate on this issue in the intersessional period, including to submit additional papers to the appropriate working group and/or the Scientific Committee.

6.15 ASOC introduced CCAMLR-XXXVII/BG/36. ASOC thanked the Members that had committed substantial resources to develop MPA proposals, and the scientific contributions of many other Members. ASOC considered that CCAMLR's progress in adopting an MPA network had been exceedingly slow, and that the list of obstacles to secure the adoption of new MPAs continuously expanded. Noting the consensus reached on the Ross Sea region MPA as an example, ASOC called on CCAMLR to make progress towards adopting a Southern Ocean representative system of MPAs by 2020. In the view of ASOC, this would be a significant contribution to meeting the requirements of Article II.3 of the Convention. Climate change added further urgency to MPA discussions. ASOC recommended that CCAMLR-XXXVII adopted the EAMPA and WSMPA proposals keeping their proposed boundaries intact; took further steps towards the adoption of the D1MPA, including the adoption of no-take zones in all critical conservation areas; and continued to develop and implement RMPs for current MPAs.

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

South Orkney Islands southern shelf (SOISS) MPA RMP

6.16 SC-CAMLR-XXXVII/09 presented a framework for developing a draft RMP to accompany the SOISS MPA. The framework is based on a draft initially proposed in 2014 (SC-CAMLR-XXXIII/11) and aims to harmonise the SOISS MPA RMP with the requirements of CM 91-04 before a review of the SOISS MPA scheduled for 2019. The framework also takes account of general principles from the RSRMPA RMP (SC-CAMLR-XXXVI, paragraphs 5.39 to 5.42) and the proposed WSMPA RMP (CCAMLR-XXXVII/29) as well as advice received from WS-SM.

6.17 The proponents of SC-CAMLR-XXXVII/09 proposed that during the 2019 intersessional period, the framework presented in the paper be developed into a draft RMP. This would be achieved by, in respect of the contents of the three tables presented in the framework, fully reporting on research and monitoring activities conducted in and around the SOISS MPA. The development of a draft RMP should also be advanced by populating a project list for the SOISS MPA RMP, and research questions included in the draft RMP could be refined with input received from the Scientific Committee and via the D1MPA planning process.

6.18 The Scientific Committee recalled that the SOISS MPA (CM 91-03) was the first MPA adopted by CCAMLR. It was designated before the general framework for the establishment of CCAMLR MPAs (CM 91-04), but Members have a strong desire to harmonise the SOISS MPA with CM 91-04.

6.19 Mr Yang thanked the proponents for this proposal and noted the lack of data is an important issue to address in the next review and future RMP. He further noted that the potential RMP for the SOISS MPA needs to focus on providing scientific data and information inside the boundary of the MPA in accordance and within the framework of CM 91-03, while other MPAs may have their own objectives and features and thus are not the business of the RMP of the SOISS MPA. He also noted that the baseline data provided in the 2019 review could be an important basis for developing the RMP, including the selection of indicators and so on.

6.20 The Scientific Committee recalled that it had previously requested that the RMP also consider areas outside the MPA as well as inside the MPA in developing the appropriate scientific basis for review of CM 91-03 (SC-CAMLR-XXXII, paragraph 5.2).

6.21 The Scientific Committee endorsed the advice of WS-SM that a summary of research and monitoring activities be developed in time for the next review of the SOISS MPA in 2019 (Annex 7, paragraph 4.24). It was also noted that WS-SM suggested the review in 2019 should aim to provide scientific advice on the extent to which the objectives of the SOISS MPA were being met (Annex 7, paragraph 4.21).

6.22 The Scientific Committee recommended that the framework proposed in SC-CAMLR-XXXVII/09 be expanded to include provision of baseline data on the SOISS MPA. It was further noted that the framework is also consistent with guidance to structure RMPs geographically (SC-CAMLR-XXXI, paragraph 5.58). Members were thus encouraged to draft an RMP and prepare for the 2019 review of the SOISS MPA by reporting against the content of the tables presented in the framework, including by reporting baseline data.

6.23 The Scientific Committee also recommended consideration of the following issues pertinent to the development of a draft RMP for the SOISS MPA:

(i) the baseline data relevant to the designation and review of the SOISS MPA, including whether data collected subsequent to adoption of the SOISS MPA could constitute baseline data for subsequent reviews of the SOISS MPA

(ii) the spatial scope of research and monitoring activities that are relevant to the SOISS MPA, including the relevance of such activities conducted in Subareas 48.1 and 48.5.

6.24 The Scientific Committee clarified that baseline data shall, in the context of RMPs, be considered to be all data used to justify designation of an MPA or that describe the state of the Antarctic marine ecosystem at the time an MPA enters into force.

Ross Sea region MPA (RSRMPA) RMP

6.25 The Scientific Committee noted that WS-SM discussed several issues related to the RSRMPA RMP, summarised in Annex 7, paragraphs 4.8 to 4.18 and 5.1 to 5.18. It was further noted that many of the issues discussed by WS-SM were taken forward in papers subsequently submitted to the Scientific Committee.

6.26 SC-CAMLR-XXXVII/11 and BG/13 presented candidate baseline data on seven indicator species in the Ross Sea region. These data were submitted for inclusion in the RSRMPA RMP, as endorsed by the Scientific Committee at its meeting in 2017. The baseline data provide benchmarks from which to assess change and evaluate the performance of the RSRMPA. The baseline data include zone-specific estimates of the mean densities of Antarctic krill, crystal krill, and larval and juvenile Antarctic silverfish (*Pleuragramma antarcticum*) in the RSRMPA; zone-specific estimates of the numbers of nesting pairs of Adélie penguins (*Pygoscelis adeliae*) and adult emperor penguins (*Aptenodytes forsteri*); and regionwide estimates of the numbers of Weddell seals and Type C killer whales (*Orcinus orca*).

6.27 Russia made the following statement:

'That the research and monitoring plan for the RSRMPA should include qualitative and quantitative characteristics of marine ecosystems and biodiversity, as well as the oceanographic and climatic history of the region. There are seven indicators presented for describing the status of ecosystems in the MPA. These proposed indicators require detailed discussion, which should provide clarity with respect to the following: (i) How will the selected indicators reflect the aims and objectives of MPAs in terms of biodiversity? (ii) What threatens each of the seven key species (Adélie penguins, emperor penguins, Antarctic and crystal krill, Antarctic silverfish, Weddell seals and Type C killer whales) and how the MPA will contribute to the conservation and protection of these species; (iii) how to assess the achievement of specific MPA aims based on the proposed seven indicators (number of pairs of penguins, number of killer whales and seals, density of krill and silverfish), if there no fishing in the MPA, and the impact of climate change is independent of the MPA. Toothfish species should be considered as additional ecosystem indictors and integrated monitoring indices should be developed relating to achieving the aims for the RSRMPA.'

6.28 The baseline data presented in SC-CAMLR-XXXVII/11 and BG/13 have been compiled into sets of files that have been submitted to and posted on the CCAMLR data portal. These files essentially comprise a geographic information system (GIS) that can be used to visualise the baseline data on maps of the RSRMPA (e.g. users can produce maps like those illustrated in SC-CAMLR-XXXVII/BG/13). These files also include complete metadata documentation of all the layers that can be mapped in the GIS; a set of files that provides statistics on the degree to which each zone of the RSRMPA covers habitats, ecosystem process areas, etc.; and relevant source documents for the baseline data. The files also incorporate the baseline data previously submitted to the Secretariat (e.g. the baseline data presented in WS-SM-18/01). Members can access the dataset at https://data.ccamlr.org/dataset/rsrmpa-baseline-data-v2.

6.29 The Scientific Committee welcomed the baseline data presented in SC-CAMLR-XXXVII/11 and noted that:

(i) provision of these data both highlighted the flexible nature of the RSRMPA RMP and was an expected outcome of the RMP

(ii) the baselines and associated indicators will increase understanding of the Antarctic marine ecosystem and facilitate assessment of changes in the system.

6.30 Some Members informed the Scientific Committee of ongoing or planned research and monitoring activities that will contribute to the RSRMPA RMP. These include efforts by Korean scientists who, since 2006, have collected and continue to collect data on Adélie penguins at Cape Hallett and an effort by an Australian research team to study functional relationships between baleen whales and krill in the Ross Sea region during the 2018/19 field season.

6.31 SC-CAMLR-XXXVII/BG/26 presented an inventory of research projects led by Italy, in the frame of PNRA (Italian Programme of Researches in Antarctica) that are relevant to the RSRMPA RMP. The inventory includes research to establish baseline environmental and ecological conditions in the Ross Sea region as well as process-based research to understand environmental and ecological processes and interactions. Italian research in the Ross Sea region addresses several specific objectives of the RSRMPA. The paper aimed to help researchers to identify existing PNRA data for retrospective analysis and to facilitate new collaborations by identifying Italian scientists who work in the Ross Sea region and their respective research expertise. The research identified in SC-CAMLR-XXXVII/BG/26 will be added to the project list for the RSRMPA RMP.

6.32 The Scientific Committee noted that the combination of Italian research projects identified in SC-CAMLR-XXXVII/BG/26 and New Zealand research projects identified in WS-SM-18/03 indicate that Members are making substantial efforts to address specific objective (i) of the RSRMPA ('to conserve natural ecological structure, dynamics and function throughout the Ross Sea region at all levels of biological organisation, by protecting habitats that are important to native mammals, birds, fishes and invertebrates'; CM 91-05), but less effort seems to be being spent addressing other objectives. In this regard, it was further noted that populating the project list for the RSRMPA RMP would help the Scientific Committee conduct a more complete gap analysis to assess whether research and monitoring efforts in the Ross Sea region are relevant to the specific objectives of the RSRMPA.

6.33 Dr Penhale welcomed China's plans to set up a long-term marine environmental and ecosystem monitoring system in the Terra Nova Bay polynya. This aim was detailed in China's

Comprehensive Environmental Evaluation (CEE) for construction of its new station on Inexpressible Island in Terra Nova Bay, as presented to the CEP in at its 2018 meeting. In its CEE, China stated that the new station will serve to promote multinational and multidisciplinary research collaborations in the Ross Sea region.

6.34 Mr Yang expressed the willingness of China to enhance international cooperation and contribute to the scientific knowledge base of the Antarctic community, and he also expressed the concern that the responsibility of making the RSRMPA RMP improved and adopted by the Commission, and called for the proponent of this MPA to lead this work.

6.35 The Scientific Committee noted that the provision of baseline data and Members' continued efforts to collect new data relevant to the RSRMPA, including efforts to submit information to the project list.

6.36 Dr Kasatkina introduced SC-CAMLR-XXXVII/19 and identified several concerns with the RSRMPA RMP and suggested approaches to address these concerns. The authors of the paper suggested that baseline data be clarified and organised into databases made available through the CCAMLR website, the RMP itself be annexed to CM 91-05 and be revised to specify requirements for implementing projects undertaken pursuant to the RMP (e.g. details regarding who, where and when projects will be undertaken).

6.37 The Scientific Committee recalled that the RSRMPA RMP is intended to be a living document that should be regularly reviewed and updated as appropriate (SC-CAMLR-XXXVI, paragraph 5.45). In this regard, it was noted that:

(i) as far as possible, additional baseline data on indicators of the status and structure of the Antarctic marine ecosystem should be added to the RMP, including data and indicators related to baleen whales, toothfish, zooplankton, phytoplankton, benthic communities and physical oceanographic conditions in the Ross Sea region

(ii) additional work should be undertaken to link baseline data and indicators to the specific objectives of the RSRMPA within the geographic locations listed in CM 91-05, Annex 91-05/B

(iii) where possible, baseline data should include information on productivity parameters (e.g. breeding success) and ongoing trends at the time the RSRMPA entered into force.

6.38 Mr Yang enquired when the timeframe for developing timelines for establishing baseline data, measurable criteria for evaluating the performance of the MPA and standardised data collection required by CM 91-05, Annex 91-05/C can be established.

Review of the scientific elements of proposals for new MPAs

Planning Domains 3 and 4 – Weddell Sea

6.39 The Scientific Committee considered discussions on the WSMPA proposal at the WS-SM (Annex 7, paragraphs 3.50 to 3.73), and in WG-FSA (Annex 9, paragraphs 8.1 to 8.4).

The Scientific Committee noted that several revisions to the proposal, including development of reference areas, had been made subsequent to WS-SM and these changes were described in two papers presented to the Scientific Committee.

6.40 The Scientific Committee considered SC-CAMLR-XXXVII/BG/14 Rev. 1, which described the revisions made to the WSMPA proposal since the proposal was first submitted to the Commission in 2016, and SC-CAMLR-XXXVII/BG/15, which provided technical detail on further analyses undertaken in response to recommendations from WG-EMM-17 and SC-CAMLR-XXXVI.

6.41 The Scientific Committee noted the following revisions to the proposal:

(i) closing the gap on the eastern coast of the Antarctic Peninsula: the 2018 WSMPA proposal now unifies what were previously two distinct geographical parts of the MPA

(ii) adjustment of the habitat of adult *D. mawsoni* in Subareas 48.5 and 48.6: the modelled habitat of toothfish now ranges between 550 m and 2 100 m depth and comprises the habitat of 90% of adult toothfish in these areas

(iii) editorial changes to the management plan and RMP: including new text to harmonise the WSMPA proposal with CMs 24-04 and 91-05, and changes to reflect the outcome of the WS-DmPH held in Berlin, Germany, in February 2018

(iv) establishment of scientific reference areas in Subarea 48.6: in response to advice from WG-SAM-18 (Annex 6, paragraphs 8.3 and 8.4) and WS-SM-18 (Annex 7, paragraph 3.63), the proponents developed a table to act as a decision-support tool for the establishment of reference areas, which WG-FSA-18 considered to be a valuable addition to the proposal (Annex 9, paragraph 8.3).

6.42 The Scientific Committee welcomed these revisions and acknowledged the scientific efforts of the proponents in further developing the MPA proposal. The Scientific Committee noted that the proponents had been responsive to the comments made at SC-CAMLR-XXXVI, WG-EMM-17, WS-DmPH-18, WG-SAM-18 and WS-SM-18, noting in particular the incorporation of reference areas into the WSMPA proposal, and the development of a table which provided a detailed analysis of parameters relating to the suitability of sectors of the Weddell Sea as reference areas (Table 3 of SC-CAMLR-XXXVII/BG/14 Rev. 1).

6.43 Mr Yang raised the issue what kind of advice the Scientific Committee will provide to the Commission with regard to the proposal, with reference to CCAMLR Resolution 31/XXVIII best available science. China requested the Scientific Committee to provide high-quality and clear advices on key issues developed on the basis of sound scientific information and analysis with regard to MPA proposals, such as conservation necessity, rationale of the MPA objectives, criteria and method to be used in the MPA to support its objectives and RMP including baseline data.

6.44 Mr Yang observed no robust evidence on fishing-induced decrease in the resilience of the ecosystem, and drew the attention of the Scientific Committee on the scientific rationale of the proposed MPA. For example, the scientific background paper for the proposal showed that the impacts of climate change and fishing activities in this area are very low, while the size of the MPA is huge and vast. The western part of the MPA is covered by year-round heavy sea-ice, but the MPA contains a big part of this area. The data for the proposed area is relatively poor, but there are strict limits on scientific research and monitoring, particularly, the krill data is very old and poor, the proposed MPA prohibited even the research fishing on krill.

6.45 Mr Yang observed that among a set of scientific issues regarding the WSMPA proposal, the key issue needing to be addressed urgently is the set of dual objectives system for the proposed MPA. These objectives are the core of the MPA, covering vast marine areas, but so far in the proposal they are overlapping and obscure due to the lack of scientific support. Mr Yang suggested the proponents first simplify the set of objectives, and further organise the available scientific data and information, focusing on the analysis of the rationale of each objective, particularly on:

(i) the similarity and differences characters and features of the subarea covered by the proposed MPA and the effect on the set of objectives

(ii) based on the characters and features of the subareas, what are the key components of the Antarctic marine living resources, biodiversity or ecosystem, ecological process, preferably in the form of food web

(iii) what is the status of the potential Antarctic marine living resources species and ecosystem components, with the support of identified baseline data organised in databases, to support the consideration of the proposed RMP

(iv) what is the threat on the potential Antarctic marine living resources and ecosystem components, analysis on the mechanism and extent of the threat

(v) the effectiveness of the current conservation measures, the necessity of the proposed management measure, the impact of the change of conservation measures, and its cost-effectiveness and alternatives

(vi) the SMART criteria to assess whether and the extent to which the objectives will be achieved, in accordance with the objectives and principles of the Convention

(vii) the indicator that can be monitored and evaluated to assess the effectiveness of the proposed management measures of the MPA

(viii) with regard to the reference area, the rationale for the size of the reference area, the feasibility to make comparison, the method to distinguish the climate change impact and the impact of harvesting activities, and the committed resources and effort we may have to support such research

(ix) the scientific uncertainties and further scientific effort needed to address the issues

(x) other issues or questions the Commission may ask.

6.46 Mr Yang appreciated that the proposal includes a RMP for the consideration by the Scientific Committee and the Commission and indicated that it is China's view that there are three key issues regarding the development of RMP for MPAs: (i) who will take primary responsibility for the development of the RMP, and how it will be developed and adopted;

(ii) what is the purpose or function of the RMP; (iii) what structure, components, elements a RMP should have to serve the purpose or function? Mr Yang suggested that the RMP should:

(i) function as a basis for evaluating whether and the extent to which the objectives are being achieved or relevant

(ii) be adopted and amended thereafter by the Commission, taking full consideration of the advice of the Scientific Committee

(iii) provide the SMART criteria to scientifically interpret and measure the objectives in accordance with Article II of the Convention, indicators corresponding to the management actions, and baseline data organised in databases, as a basis of the structured decision making process to facilitate the review and consideration of the Scientific Committee and the Commission, and to constitute a open, transparent and stable framework to allow Members to be involved in the management of MPAs on an equal basis (CCAMLR-XXXVII)

(iv) the RMP should encourage and provide guidance to related scientific research and monitoring, rather than limit the research on Antarctic marine living resources

(v) the RMP should integrate a set of method, standard, or procedures to guide data collection and analysis, to promote the understanding of the Antarctic marine living resources and ecosystem by all Members

(vi) the RMP should be stable for at least 10 years corresponding to the assessment and review procedure, and ensure the continuity of data flow

(vii) the implementation of the RMP should rely on the working groups of the Scientific Committee, rather than additional workshops

(viii) specify the minimum efforts and resources to support the implementation of the RMP need to be evaluated and specified, while cost-effectiveness be considered in the development and implementation of the RMP.

6.47 Mr Yang encouraged the proponent to streamline the scientific background paper and develop concrete RMP, to address the substantial issues mentioned above.

6.48 Dr Kasatkina noted the improvements in the proposal for an MPA in the Weddell Sea. However, some issues remain. She highlighted that there are populations of dominant fish species in the Weddell Sea: *D. mawsoni*; spiny icefish (*Chaenodraco wilsoni*); *P. antarctica*; Antarctic rockcod (*Trematomus eulepidotus*). Information on commercial potential of dominant fish species and krill for future rational use should be included into the MPA proposal. Dr Kasatkina noted that the revisions of the WSMPA proposal should provide clarifications of the MPA boundary as well as the boundary of reference areas taking into account the ice cover and accessibility. This revision requires new information on the commercial potential for dominant species in the MPA to designate areas for protection and fishing activity. This new information may be provided from research programs in the Weddell Sea.

6.49 The Scientific Committee recalled Resolution 31/XXVIII regarding the use of best available science and also that the development of a representative network of MPAs was a priority for the Scientific Committee. It also noted that some issues raised were matters for the Commission.

6.50 Most Members agreed that the proposal complied with CM 91-04, and reconfirmed their view that the proposal was based on the best available science and that this proposal would make an important contribution to the development of a representative network of MPAs in the Convention Area.

Planning Domain 1 (western Antarctic Peninsula and southern Scotia Sea)

6.51 The Delegations of Argentina and Chile presented a proposal on the establishment of a protected area in Planning Domain 1 (D1MPA). The proposed conservation measure is set out in CCAMLR-XXXVII/31, with background information on the MPA model and the rationale for changes in SC-CAMLR-XXVII/BG/07 and BG/08. The proposal is consistent with CM 91-04 and the recommendations and scientific conclusions discussed since 2012 by the Commission, Scientific Committee and its working groups, including those of WS-SM and the Domain 1 Expert Group e-group.

6.52 The proponents explained that the D1MPA model comprises three different management zones: General Protection Zone (GPZ), KFRZ and Special Fishery Management Zone (SFMZ). These incorporate the conservation of different objectives, the need for a better understanding of the krill fishery activity and the current fishery management strategy (CM 51-07).

6.53 The proponents also noted that scientific reference areas are a key tool for understanding the relative impacts of climate change and other human activities. Such information will be critical in monitoring the achievement of MPA objectives, particularly where protected species or habitats undergo change or are no longer present within a designated area. MPAs also provide the framework to focus research and monitoring efforts to observe climate trends. The D1MPA has assessed this issue by identifying potential reference areas for climate change (SC-CAMLR-XXXVII/BG/07 (Part A)) and by including this topic in the scientific RMP (CCAMLR-XXXVII/31, Annex C).

6.54 The Scientific Committee noted with appreciation the great amount of collaborative work undertaken by the proponents, taking into account the views of other Members and observers, particularly via the D1MPA Expert Group e-group. In particular, it reflected that much of this work has been led and undertaken by two recipients of CCAMLR scholarships, highlighting the significant value of this program to the work of the Scientific Committee.

6.55 The Scientific Committee agreed that the scientific basis for the proposal is well developed, with two Members' commentary on outstanding issues below, and that the proposed MPA model has addressed a broad range of objectives relating to the protection of representative habitats, ecosystem processes, important areas for species life cycles, rare and vulnerable benthic habitats, and the establishment of scientific reference areas.

6.56 The Scientific Committee reviewed advice from WS-SM on the development of reference areas in the context of the D1MPA proposal (Annex 7, paragraphs 3.10 to 3.40). It noted that the potential experimental approach for management of the krill fishery (SC-CAMLR-XXXVII/10), feedback management, the developing risk assessment for krill and the D1MPA proposal all contemplate the use of reference areas. It further noted that considerations of these initiatives and how to harmonise relevant aspects might be undertaken at the planned joint meeting of WG-EMM and SG-ASAM scheduled for 2019.

6.57 Most Members agreed that the proposal has been developed based on the best available science. Outstanding issues were raised by two Members in relation to the D1MPA proposal, including suggestions on the need for:

(i) further work on the design of reference areas and associated research questions, including consideration of a potential experimental approach, current krill catch levels, similar response to natural variation of the reference area with fishing area, and krill flux between areas

(ii) analysis of threats to the marine ecosystem in Domain 1, given existing management of human activities in the region

(iii) additional evidence that the proposed MPA could decrease the risks of krill fishing having a negative impact on the ecosystem

(iv) further consideration of how reference areas can be used to study the effects of climate change

(vi) further development of objectives, indicators and baseline data for research and monitoring, including within reference areas

(vii) development of indicators to assess the effectiveness of the MPA

(viii) the necessity of the inclusion of a KFRZ given the long existence of the krill fishery and scientific research in this region.

6.58 The Scientific Committee also considered a paper on evaluating MPA scenarios in Planning Domain 1 using a dynamic food-web model (SC-CAMLR-XXXVII/BG/04), noting that the outcomes from this work had been incorporated into the updated D1MPA proposal.

6.59 The Scientific Committee noted that outstanding issues relating to the development of management provisions were for consideration by the Commission.

Planning Domains 4, 5 and 6 (sub-Antarctic areas of the Atlantic and Indian Ocean)

6.60 The Scientific Committee considered SC-CAMLR-XXXVII/07 proposing an expert group on 'pelagic spatial planning of the sub-Antarctic areas of Planning Domains 4, 5 and 6' ($PS^2$456).

6.61 The Scientific Committee welcomed the progression of work in this region, recalling also the discussions on this topic from the WS-SM (Annex 7, paragraphs 3.74 to 3.81). It agreed that an expert group was not required at this stage, but that an e-group could be used to facilitate the further development of scientific activities with regard to pelagic spatial planning in the sub-Antarctic areas of the Atlantic and Indian Ocean of Planning Domains 4, 5 and 6.

6.62 Dr Lowther encouraged interested Members to participate in this work via the e-group. A scientific workshop will be held in Cape Town, South Africa, during May 2019 to be confirmed through the e-group, and will report back to the Scientific Committee and its working groups.

IUU fishing in the Convention Area

7.1 The Scientific Committee noted that an update from the Secretariat on IUU fishing activity and trends in 2017/18 (CCAMLR-XXXVII/12) contained no reports of IUU vessel sightings in the Convention Area in 2017/18. However, this paper reported the condition of fishing gear recovered in Subarea 88.1 in November 2017 which indicated that this gear had been likely deployed within five days of the recovery and thus fishing had occurred immediately prior to the start of the fishing season.

7.2 The Scientific Committee agreed that fishing prior to the start of the fishing season would negatively affect both the ability to manage the fishery sustainably and impact on the collection of data required for the assessment for this fishery. The Scientific Committee requested that this event be reviewed by SCIC. The Scientific Committee observed that there were also COMM CIRCs related to this matter which may provide additional information to inform any investigation.

7.3 The Scientific Committee noted that data from catches on retrieved IUU gear can provide important information on the nature and impact of IUU fishing activities. However, the Scientific Committee recognised that uncertainty about how to report any catch from retrieved IUU gear and any potential consequent reduction in a catch limit could be a potential disincentive for authorised vessels to recover IUU fishing gear.

7.4 The Scientific Committee agreed that while such IUU catches were already incorporated into the removals used in CCAMLR stock assessments, further clarification and advice was required from the Commission on managing and reporting catch associated with IUU fishing, including the procedures and mechanism by which authorised vessels retrieving IUU gear would record and report this process and quantify any associated catch. The Scientific Committee noted advice from the Secretariat that there were existing instructions in place under SISO to manage such events for observers and welcomed offers to assist in preparing similar instructions for Members for use by vessel crew.

7.5 The Scientific Committee noted that analyses of IUU fishing data from activities in Division 58.4.1 during the 2013/14 season and Division 58.4.3b during the 2014/15 season had been conducted following a request from SC-CAMLR-XXXVI (SC-CAMLR-XXXVI, Annex 7, paragraph 2.16). These analyses were based on data from Division 58.4.1 provided by Spain following Operation Sparrow II and data from Division 58.4.3b collected by a non-governmental organisation vessel from five recovered IUU gillnets.

7.6 The analyses showed that the daily catch rates of IUU vessels using gillnets were similar to those from authorised fishing vessels using longlines, although total removals by IUU vessels during the 2013/14 season were much higher than those of an authorised vessel fishing in the same season in Division 58.4.1. The Scientific Committee recognised that IUU removals may have impacted on research in this area.

7.7 The Scientific Committee recommended that the similarity in daily catch rates between IUU vessels and authorised vessels could enable estimation of total IUU removals across the Convention Area using sightings of IUU vessels and that a workplan be developed with the objective of providing such estimates.

7.8 Noting the reported proximity of the FV *Tronio* to one of the IUU vessels for a number of days, the Scientific Committee requested that SCIC evaluate whether authorised vessels are an effective deterrent to IUU vessels.

CCAMLR Scheme of International Scientific Observation

8.1 SC-CAMLR-XXXVII/15 presented information on Russian training for SISO observers, including topics on toothfish, krill and crab fisheries. The Scientific Committee thanked Russia for the observer training workshop information and noted the utility of sharing training practices and resources between Members to further improve observer performance.

8.2 The Scientific Committee requested WG-FSA develop procedures to assist Members to voluntarily exchange information on training, documentation and procedures used by SISO observers as a means to encourage collaboration and information sharing between Members to further improve activities carried out by SISO observers. The Scientific Committee noted that the CCAMLR Observer Training Program Accreditation Scheme (COTPAS) provided a framework to facilitate this exchange.

8.3 The Scientific Committee endorsed the changes to the krill observer logbook recommended by WG-EMM (Annex 8, paragraphs 2.14, 3.15 and 3.16).

8.4 The Scientific Committee endorsed the recommendations from WG-FSA (Annex 9, paragraph 5.4) to guide the Secretariat-led intersessional development of the revised CCAMLR observer manual.

8.5 The Scientific Committee recommended the completion of a tagging information survey by observers in 2018/19, which will be coordinated by the Secretariat through contact with observer technical coordinators and observers (paragraph 3.42).

8.6 The Scientific Committee noted the many resources that Mr N. Gasco (France) has developed for observers and acknowledged his efforts and willingness to share these resources with CCAMLR Members.

8.7 The Scientific Committee thanked all SISO observers deployed in 2017/18 and recalled that all observer names are chronicled on the CCAMLR website (www.ccamlr.org/node/87040) in recognition of their contribution to the work of the Scientific Committee.

Climate change

9.1 CCAMLR-XXXVII/01 references CCAMLR Resolution 30/XXVIII which recognises global climate change as one of the greatest challenges facing the Southern Ocean. The resolution also urges increased consideration of climate change impacts in the Southern Ocean to better inform CCAMLR management decisions. This working paper proposed a mechanism to communicate the relevance of climate change impacts in papers submitted to the Scientific Committee and the Commission in the form of scientifically based summary statements. Such statements could include the nature and implications of any known and potential climate change impacts (for example ocean acidification, ocean warming, regional decline of sea-ice) identified during the preparation of the paper, as well as recommended steps that could be taken to address any issues arising. These statements would assist the Commission in addressing climate change impact as it develops management provisions.

9.2 The Scientific Committee noted that the physical impacts of climate change are already evident, including changes in climate indices such as the Southern Annular Mode, now in a positive state, with associated changes in air temperature, ice shelves, and sea-ice extent and duration in some regions. The Scientific Committee recognised that implications of climate change are important for the Southern Ocean and for marine ecosystems and ecosystem components, including harvested species. Highlighting these changes to policymakers is vital if the impacts of climate change are to be properly taken into account by CCAMLR's management. The Scientific Committee reaffirmed that climate change consequences and impacts on ecosystems are important to consider and that future scientific studies on this topic should be encouraged.

9.3 Many Members supported the recommendation to include climate change implication statements in appropriate Scientific Committee papers, where relevant. This was viewed as an important communication tool to highlight these papers to the Commission.

9.4 Some Members stressed the fact the potential implications of climate change should be based on sound scientific analysis of time-series data and not a limited number of observations, therefore they cannot support the paper's more general recommendation, so no consensus was reached.

9.5 The ICED–CCAMLR Projections Workshop (SC-CAMLR-XXXVII/BG/16) brought together a range of ecologists, physical and ecological modelers and fisheries scientists to examine questions posed by WG-EMM to consider the potential impacts of climate change on Antarctic krill in Area 48 to address the questions of direct relevance to CCAMLR. The key outcomes of the workshop for SC-CAMLR included:

(i) Area 48 is a region of high natural variability and scenarios of future changes in physical, chemical and ecological drivers are highly uncertain. Global climate models do not currently resolve key ocean and sea-ice processes at scales relevant to predictions for Area 48

(ii) sea-ice and SST projections over the next few decades are highly uncertain, and current Coupled Model Intercomparison Project Phase 5 (CMIP5) models indicate that signals of change will not be distinguishable from model variability until after ~2050

(iii) the position of the Polar Front is highly constrained and is not expected to change by 2100

(iv) under a high emissions scenario, the warming and loss of sea-ice is expected to result in a reduction in the abundance and biomass of krill in northern areas of the Scotia Sea but an increase in abundance to the south around the Antarctic Peninsula and Weddell Sea. However, the resilience and adaptive capacity of krill to withstand such changes is poorly determined

(v) existing models and approaches developed for Area 48 to assess potential impacts and risks of fishing on krill and the dependent predators are a useful basis for developing models that can incorporate the implications of climate change in a precautionary approach into CCAMLR management

(vi) CCAMLR would benefit from investment in the development of high-resolution physical biological models and improved models of krill recruitment processes, underpinned by mechanistic understanding to resolve recruitment processes during the winter and the role of sea-ice.

9.6 The Scientific Committee welcomed SC-CAMLR-XXXVII/BG/16 and thanked ICED for its efforts in this successful joint endeavour. It recognised the value of collaboration with ICED, first envisioned at WG-EMM in 2017. The Scientific Committee highlighted the importance of the interdisciplinary approach provided by the participation of both biological and physical scientists and looks forward to future collaboration with ICED and other such organisations incorporating the implications of climate change in its management advice.

9.7 In SC-CAMLR-XXXVII/BG/11, Oceanites reported its continued efforts to distinguish the direct and interactive effects of climate change, fishing, tourism and other human activities on the Antarctic Peninsula ecosystem. This work will involve the Mapping Application for Penguin Populations and Projected Dynamics (MAPPPD) penguin database and be guided forward through industry (Aker BioMarine) and stakeholder (IAATO) partnerships.

9.8 ASOC introduced CCAMLR-XXXVII/BG/26 and noted that CCAMLR Members had acknowledged the threat posed by climate change but had not yet adopted a comprehensive approach to responding to the issue in the Convention Area. Recent scientific analyses indicated that the consequences of not addressing climate change were extremely serious for Antarctica and the rest of the world, but that strong action now could prevent some of the most negative effects. ASOC recommended that CCAMLR improve collaboration with other international organisations in order to incorporate climate change considerations into decisions and actions, implement an overarching climate change strategy and work program, and designate a network of MPAs.

9.9 The Scientific Committee noted the importance of collaboration with other organisations and initiatives including SCAR, Integrating Climate and Ecosystem Dynamics in the Southern Ocean (ICED), Southern Ocean Observing System (SOOS), and Marine Ecosystem Assessment for the Southern Ocean (MEASO), which have programs and expertise relevant to the Scientific Committee's work in the area of climate change impacts. In particular, such collaborations can bring an interdisciplinary approach to addressing critical scientific issues of interest to CCAMLR.

Cooperation with other organisations

Cooperation within the Antarctic Treaty System

CEP

10.1 The CEP Observer to SC-CAMLR (Dr Penhale) informed the Scientific Committee that the 21st meeting of the CEP was held from 13 to 15 May 2018 in Buenos Aires, Argentina.

Two topics of mutual interest to both the CEP and SC-CAMLR were presented in the CEP 2018 Annual Report to the Scientific Committee (SC-CAMLR-XXXVII/BG/03). Under the climate change topic, progress has been made in updating the CEP Climate Change Response Work Plan (CCRWP). This document refers to the work of SC-CAMLR, along with SCAR, the World Meteorological Organization (WMO) and other relevant bodies. A joint SCAR/CEP workshop on further developing the Antarctic protected area system was agreed. This workshop is to be hosted by the Czech Republic just prior to the 2019 CEP meeting in Prague. The workshop will include topics related to climate change as put forward in the CEP Five-year Work Plan and the CCRWP.

10.2 Under the topic of spatial management and area protection, New Zealand will convene an informal intersessional contact group (ICG) which will address topics related to the harmonisation of marine protection initiatives across the Antarctic Treaty System. In particular, the ICG will focus on the connectivity between land and ocean, and complementary measures that could be undertaken by Parties with respect to MPAs.

10.3 Dr Welsford presented potential opportunities for engagement with other organisations, such as CEP or COMNAP as mentioned in the report of WG-FSA. This included the CCAMLR marine debris program (Annex 9, paragraph 6.77) as well as ongoing work with the Secretariats of SIOFA and SPRFMO to operationalise the respective memorandums of understanding (MoUs) (Annex 9, paragraphs 4.222 to 4.225).

SCAR

10.4 The SCAR Observer (Dr A. Terauds) presented the SCAR Annual Report 2017/18 (SC-CAMLR-XXXVII/BG/27) and noted that SCAR and CCAMLR have a long history of cooperation and that representatives of the two organisations continue to meet regularly to maintain and develop the relationship by identifying current areas of mutual interest.

10.5 SC-CAMLR-XXXVII/BG/27 contained a diverse range on recent research outputs, activities and initiatives of interest to CCAMLR. The research topics range across a range of taxa and environments and included: predicted impacts of climate change on benthic and pelagic taxa, including the impacts of ocean acidification; a continent-wide analysis of Adélie penguin trends, which assessed the suitability of this species as an indicator species for ecosystem health; and a paper on future scenarios for Antarctica and the Southern Ocean, which highlights that decisions made in the next decade will be fundamental in driving conservation trajectories over the next 50 years. Three key areas of recent research were detailed as focus issues: (i) a global study on the speciation on marine finfish; (ii) dramatic changes in seabird populations across the Southern Ocean and (iii) the use of a multi-species, model-based approach to quantify and map the distribution of demersal fish assemblages. SCAR also reported on outcomes from the recent SCAR Open Science Conference in Davos, Switzerland, earlier this year including the approval of the SCAR Krill Action Group and three new Programme Planning Groups for potential new SCAR Scientific Research Programmes, including one entitled Integrated Science to Support Antarctic and Southern Ocean Conservation (Ant-ICON), which aims to focus on science that is of direct relevance to policy makers, including those within CCAMLR.

Reports of observers from other international organisations

SCOR

10.6 The SCOR Observer (Dr L. Newman) introduced SC-CAMLR-XXXVII/BG/31 and made a presentation on the recent activities and products developed under SOOS relevant to the work of CCAMLR. The information provided contained, inter alia, key data, coordination products and upcoming activities of relevance to the Scientific Committee. The SCOR Observer also updated the Scientific Committee on progress and invited collaboration towards delivery of SOOS networks and tools that would benefit both communities. Dr Newman highlighted the work of the Regional SOOS Working Groups and encouraged CCAMLR delegates to communicate with, and be involved in, these coordination networks.

10.7 Dr Van de Putte presented the recommendations of the report of a joint one-day SOOS–CCAMLR workshop (SC-CAMLR-XXXVII/BG/19) held in order to identify mechanisms and opportunities for improved communication, collaboration and cooperation between both communities. These recommendations would require a closer collaboration between the SOOS International Project Office, the CCAMLR Secretariat and the CCAMLR DSAG.

10.8 The workshop report in SC-CAMLR-XXXVII/BG/19 contained four recommendations:

(i) the CCAMLR Secretariat to work with SOOS to enable the inclusion of fisheries notifications information into DueSouth

(ii) SOOS International Project Office (IPO) and CCAMLR Secretariat to work together in developing and publishing metadata records according to international data management standards such as used by the Antarctic Master Directory for all data held by the CCAMLR Secretariat, even where the data themselves cannot be published. SOOS IPO and CCAMLR Secretariat to work together to explore ways to publish publicly available fisheries catch data through SOOSmap and options for derived data products from CEMP that could be published to the broader science community

(iii) SOOS, CCAMLR DSAG and CCAMLR Secretariat to work together to identify ‘orphan’ datasets of value to the international community, and to identify ways to ensure this data is discoverable

(iv) CCAMLR Secretariat to communicate with Members to develop an inventory of National Antarctic Data Centres, available CCAMLR-relevant datasets and their accessibility. Support from the SCAR standing committee of Antarctic Data Managers will be important in this effort.

10.9 The Scientific Committee recognised the productive discussions held during this workshop and recommended the endorsement of the four recommendations.

10.10 The Scientific Committee noted the importance to pursue collaboration with international organisations such as SOOS and SCAR. It recognised the value in developing specific biotic environmental and biology data in the Indian Ocean sector. The Scientific Committee noted the work in the past of the International Polar Year and the Census of Antarctic Marine Life and ongoing work at the regional level towards open access to data and knowledge relevant to CCAMLR.

ACAP

10.11 The ACAP Observer (Dr M. Favero) thanked CCAMLR for the invitation to attend the Scientific Committee meeting and presented SC-CAMLR-XXXVII/BG/10. ACAP appreciated the work done by the Scientific Committee in maintaining an effective implementation of conservation measures concerning seabirds. The Observer noted that the 2018 season had seen the lowest seabird mortality from by-catch on record exemplifying that CCAMLR has been, and still is, considered by ACAP as a model in these matters, to be followed by other fora. Many albatross and petrel species listed in Annex 1 of ACAP and present in the CAMLR Convention Area are also distributed in adjacent waters where fisheries by-catch still occurs, both in jurisdictional waters and high-seas areas managed by RFMOs. This by-catch may undermine the success of CCAMLR by preventing the improvement of the conservation status of species in the area, and highlights the importance of coordinating actions with other organisations. ACAP continues its work in these areas to promote the adoption and implementation of seabird conservation measures, as well as to better understand the nature and magnitude of by-catch. The ACAP Secretariat reaffirmed its commitment to working with the CCAMLR Scientific Committee and the Secretariat to assist in seabird by-catch matters and relevant interactions with other international bodies.

10.12 The Scientific Committee welcomed the ongoing cooperation with ACAP and thanked Dr Favero for his contribution, noting that this is his last year as Executive Secretary.

ARK

10.13 The observer from ARK (Mr P.E. Skogrand) presented SC-CAMLR-XXXVII/BG/30 and made the following statement:

> *'ARK would like to thank for the opportunity to attend the 2018 meeting of the Scientific Committee. ARK now has seven companies in its membership. 10 of the 12 krill fishing vessels notified for the fishery in 2018/19 are from ARK member companies. Over 90% of the 2017/18 krill catch was landed by ARK companies.*
>
> *ARK has committed to participate in the multinational synoptic krill survey in Area 48 in 2019. ARK has decided to use one vessel to cover the entire effort from ARK in the survey. The* Cabo de Hornos *will dedicate 58 vessel days, including steaming, to the survey effort from ARK, and will have scientific equipment installed to fulfil this task.*
>
> *ARK has supported the conduct of annual acoustic transects for CCAMLR and has made completion of these a condition for membership of ARK. In the 2017/18 season several transects were completed and the data are in the process of being submitted to CCAMLR Secretariat.*
>
> *With the Industry Commitment, ARK has from 1 January 2019 committed to avoid krill harvesting from October to March in waters up to 40 km away from the coast in Subarea 48.1.*
>
> *The voluntary restrictions are based on scientific data on foraging range and breeding season of different penguin colonies in 48.1. These voluntary restrictions will as well as*

being a precautionary industry effort provide an opportunity for scientific research to collect information on the interactions of the krill fishery with predators in the area.

Important to note also that the ARK Commitment's seasonal closure will evolve into a permanent closure from 2020. The size of the restricted area and its limits will be decided after an independent review in 2019. For the record, the ARK Commitment is not intended to interfere with other ongoing discussions on management of the krill fishery in development, such as feedback management, risk assessment and the Domain 1 MPA process, but rather to offer support to the mentioned processes.

ARK is considering holding a meeting with CCAMLR scientists during the 2018/19 season where issues such as the voluntary restrictions can be explored in more detail. We would like to understand the level of interest in holding such a meeting at the Scientific Committee, acknowledging of course the considerable workload on the Committee in general.

As Members in this meeting have stressed the importance of strengthening krill management and harmonising the different initiatives related to krill management and conservation, ARK is looking forward to further engaging in this work, providing operational insight and perspectives into how the future sustainable management of krill may look like.

We see the workshop convened by the UK and USA as the first opportunity to engage on this issue. We understand the workshop is being proposed to take place at the Marine Biology Institute in Concarneau, France, on the week of June 10 prior to the WG-EMM meeting. We note that Pew and WWF have offered financial support for the cost of the workshop and ARK is also pleased to let Members know that we will join with our fellow Observers to support this workshop.

Lastly, ARK is delighted to announce the appointment of Javier Arata as its new Executive Officer who will be the main contact point for all CCAMLR Members wanting to interact with ARK. This appointment will strengthen ARK's capacity to drive and support its objectives and to increase its responsiveness to the needs of CCAMLR. ARK is grateful for the opportunity to observe during the 2018 annual meeting of the Scientific Committee and looks forward to working with CCAMLR scientists in the intersessional period.'

10.14 The Scientific Committee thanked ARK for the information provided and also welcomed Dr J. Arata as the new Executive Officer.

10.15 The Scientific Committee noted ARKs willingness to contribute to the proposed workshop on the harmonisation of krill management (paragraph 16.3), including by helping provide financial support for the workshop. It also noted the major contribution from ARK to the planned 2019 synoptic survey. Finally, the Scientific Committee noted how ARK is behaving in a responsible manner through its commitment to spatial management, including through spatial measures to support the D1MPA.

10.16 The Scientific Committee noted the commitment from ARK members to also adhere to international regulations for the safety of fishing vessels.

10.17 Mr Leonidchenko noted that the practice of voluntary self-restrictions followed by ARK was a good example of responsible industry and noted that voluntary ARK restrictions are binding only to ARK members.

10.18 Mr Leonidchenko underlined that such practice cannot be considered as being equal or as establishing process for creation of MPAs within CCAMLR.

10.19 The Scientific Committee recognised the importance of the proposal of a joint workshop in conjunction with WG-EMM, and considered it very timely. The Scientific Committee also noted that ARK is being involved in the 2019 synoptic survey, pointing out voluntary restrictions as a good example of the responsible industry.

ASOC

10.20 The Observer from ASOC (Mr C. Johnson) introduced SC-CAMLR-XXXVII/BG/40, and highlighted some of the contributions made by ASOC and its member organisations relevant to the work of the Scientific Committee. This included participation in the Antarctic Wildlife Research Fund and collaboration with the Hogwarts Running Club, both of which funded Antarctic ecosystem research. ASOC presented scientific work of its member organisations Greenpeace, Pew and WWF relevant to the work of the Scientific Committee. Greenpeace has conducted an expedition to Antarctica that identified four new VMEs and took microplastic samples, results of which were added to the database produced by SCAR PLASTIC-AG. Pew has funded research on a variety of topics relevant to SC-CAMLR's identified priorities, including on the effect of rising sea temperatures on krill and on the development of a decision support tool that can inform CCAMLR's goal of advancing ecosystem-based management for the krill fishery. WWF has released a science report coproduced with the University of California, Santa Cruz, that highlights emerging whale conservation issues, such as how krill fishing overlaps with key whale feeding areas and the impacts of climate change, and has also developed Wildcrowd, a new citizen science app co-funded by Apple for Antarctic tourism to provide species presence data to monitor ocean habitats. ASOC hoped that these and other projects it had undertaken would support CCAMLR's ability to obtain critical information needed to meet the objectives of the Convention.

IAATO

10.21 The Observer from IAATO (Ms A. Lynnes) summarised a background paper on its organisation (SC-CAMLR-XXXVI/BG/27) and noted that IAATO's interest in attending CCAMLR is driven by its belief that the long-term management and conservation of Antarctica and the Southern Ocean is reliant upon on coordination across all stakeholders; IAATO members represents over 95% of tourism activity in Antarctica, united by a vision that through self-regulation, Antarctic tourism is safe and causes no more than a minor or transitory impact on the environment; members work together to develop good practices for operational procedures, membership requirements and guidelines within the framework of the Antarctic Treaty System; IAATO has maintained a comprehensive database on its activities to inform management decisions for the past 27 years, commissioning independent analyses as required. IAATO annually reports its activities and trends to ATCM, which it has been attending as an invited expert body since 1994.

10.22 IAATO welcomed the desire of the Antarctic Treaty community for an increased flow of information between the ATCM and CCAMLR and highlighted its willingness to engage in discussions about the responsible management of human activities in Antarctica, in particular on marine spatial management and protection by providing specific, relevant information as required and requested.

10.23 IAATO supports programs of research, monitoring and hydrographic surveying in order to further its mission and promote the advancement of Antarctic science. The IAATO fleet of 'vessels of opportunity' also offers a valuable additional resource to research.

10.24 The Scientific Committee welcomed IAATO as an Observer and noted that IAATO is being very active in providing logistic and scientific platforms.

Oceanites

10.25 The Observer from Oceanites (Mr R. Naveen) introduced SC-CAMLR-XXXVII/BG/11, which reported on the excellent progress over the past year in its 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:

(i) successful 24th consecutive field season of the Antarctic Site Inventory, which monitors penguin and seabird population changes over the entire Antarctic Peninsula

(ii) continued use and application of the MAPPPD database of raw penguin population data, now comprising 3 630 records from 110 sources of on-the-ground colony counts and satellite photo analyses

(iii) the second annual State of Antarctic Penguins Report summarising the population size and trends of Antarctica's five penguin species, continent-wide and in key CCAMLR regions. These species total at least 6.1 million breeding pairs nesting at 661 or more sites across the entire Antarctic continent

(iv) an interactive reference tool showing locations, species composition and counts at all penguin colonies in CCAMLR Subarea 48.1, and the spatial extent of various suggested no-fishing buffer zones around penguin colonies that will assist discussion of potential management possibilities in the Antarctic Peninsula

(v) Oceanites' climate analyses, which, ultimately, are expected to include an analysis of fishing data vis-à-vis the MAPPPD penguin database, and are guided forward through industry (Aker BioMarine) and stakeholder (IAATO) partnerships.

10.26 Oceanites looked 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.

10.27 The Scientific Committee noted the usefulness of the repository that includes known counts, literature and updated surveys.

COLTO

10.28 The Observer from COLTO (Mr R. Arangio) informed the Scientific Committee that, once again, COLTO was delighted to be able to promote collaboration between the fishing industry and science by sponsoring the CCAMLR tag-return lottery. He announced the winners of the tag lottery for the 2017/18 fishing season, which had been randomly drawn by the Secretariat from tag returns in new and exploratory fisheries:

(i) first place went to the Korean-flagged vessel *Kostar*, returning a tag from an Antarctic toothfish tagged in Subarea 88.1 on 25 December 2017, which had been at liberty for 1 814 days. The fish was originally tagged on 6 January 2013, in the same subarea, only 30 km away.

(ii) second place went to the Spanish-flagged vessel *Tronio*, returning a tag from an Antarctic toothfish tagged in Division 58.4.1 on 29 January 2018, which had been at liberty for 372 days. This fish was originally tagged on 22 January 2017, in the same subarea, 368 km away.

(iii) third place went to the New Zealand flagged vessel *San Aspiring*, returning a tag from an Antarctic toothfish tagged in Subarea 88.1on 2 January 2018, which had been at liberty for 747 days. This fish was originally tagged on 17 December 2015, in the same subarea, only 17 km away.

10.29 COLTO reiterated its support for the tagging program in CCAMLR fisheries, thanked the crews of vessels for their efforts in the tag and release programs, and congratulated the winners.

10.30 The Scientific Committee thanked COLTO for continuing this very useful initiative.

10.31 Australia, on behalf of SPRFMO, noted that the SPRFMO Secretariat values its Arrangement with CCAMLR and is optimistic that the CAMLR Commission and the SPRFMO Commission will support its continuation. SPRFMO's 6th Scientific Committee Meeting (SC6), held in September 2018, strongly encouraged renewing and progressing the Arrangement with CCAMLR and suggested including an item addressing observer program knowledge exchange. This would include aligning the observer programs, exchanging information and encouraging good practices. SPRFMO therefore requested that the CCAMLR Scientific Committee consider including observer program knowledge exchange as an item in the Arrangement. Pending CCAMLR's agreement, SPRFMO intends to take a draft Arrangement proposal including the observer program knowledge exchange to the 7th Meeting of the SPRFMO Commission in January 2019. At this point, SPRFMO will also make a decision on renewing the Arrangement. SPRFMO remains committed to continued cooperation with CCAMLR Members.

10.32 The Scientific Committee welcomed the arrangements for cooperation with RFMOs in areas adjacent to the CCAMLR area (CCAMLR-XXXVI/10 Rev. 1) and the update from the Secretariat that there is ongoing discussion between the relative Secretariats towards the operationalisation of the respective MOUs.

Budget for 2018/19 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 Scientific Committee welcomed the decision by SCAF to make funding of A$50 000 available for one convener of a Scientific Committee working group for their activities in 2019 and 2020.

11.3 The Scientific Committee welcomed the decision by SCAF to make funding of A$13 000 available for attendance of scientists from CCAMLR Members to the SKAG meeting.

Advice to SCIC

12.1 On behalf of the Scientific Committee, the Chair transmitted the Scientific Committee's advice to SCIC. SCIC requested advice from the Scientific Committee Chair on scientific observer safety, late gear removal impacts, IUU fishing data and the discrepancy between CDS and C2 data.

12.2 The Scientific Committee noted that SCIC had discussed discrepancies between C2 and CDS data (CCAMLR-XXXVII/BG/14) in Subarea 48.2, which is a closed area in which research is being conducted under CM 24-01, and requested the Scientific Committee review the information on catches and *Dissostichus* catch documents (DCDs) available from the vessels conducting research in the area (Table 3).

12.3 The Scientific Committee noted that the catch data reported in the C2 form can be divided by the product conversion factor and compared with the product weight provided in the verified landings weight in an individual DCD. The Scientific Committee noted that for some vessels the DCD landings exceeded the reported catch by 30% and this was unlikely to be accounted for solely by variability in conversion factors, therefore this discrepancy indicated a higher than expected level of uncertainty in the actual level of removals in this subarea.

12.4 The Scientific Committee agreed that for the provision of advice consistent with Article II an accurate understanding of the catch is fundamental, particularly when using CPUE and the expectation of tags available for recapture that are used in the estimation of biomass in the research in this subarea. Therefore, it would be expected that a discrepancy of 30% would impact the advice provided by the Scientific Committee.

12.5 The Scientific Committee welcomed the offer by Ukraine to undertake an investigation of the circumstances surrounding catch reporting on its vessels and to deliver a detailed analysis to the intersessional meetings of the Scientific Committee in 2019.

12.6 The Scientific Committee requested SCIC evaluate whether the close proximity of authorised vessels is an effective deterrent to IUU vessels (paragraph 7.8).

Scientific Committee activities

Priorities for work of the Scientific Committee and its working groups

13.1 The Scientific Committee considered priority intersessional work for its subsidiary bodies, and noted that in addressing the work plan, considerable discussion was required to efficiently coordinate the increasing workload of the Scientific Committee and its working groups.

13.2 The Scientific Committee 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 CM 51-07. This priority may be addressed by having SG-ASAM and WG-EMM meet in consecutive weeks with a joint meeting to address those items of mutual interest.

13.3 Some Members noted that WG-EMM-18 had taken place over one week and suggested that there was not adequate time for the working group to achieve the objectives set out in the terms of reference.

13.4 The Scientific Committee discussed whether WG-SAM could meet biannually to address the provision of advice on stock assessments for WG-FSA and review of the use of the tag-select approach in the development of Chapman-based estimates of toothfish biomass.

13.5 Many Members supported a recommendation to develop some of the priorities of the Scientific Committee into multi-year work plans to balance the workload.

13.6 The Scientific Committee considered the discussion at WG-FSA-18 (Annex 9, paragraphs 4.24 and 4.25) on reviewing research proposals for research fisheries and noted that a considerable amount of time is given to review these proposals by both WG-SAM and WG-FSA, and suggested that WG-SAM focus on the objectives as set out in the terms of reference, with the research proposals to be primarily reviewed by WG-FSA.

13.7 The Scientific Committee agreed that a clear workplan for intersessional working groups would require further deliberation by the Scientific Committee Bureau and conveners. A draft work plan, including any associated workshops, should be circulated via SC CIRC with a request for comment by Members. The Scientific Committee further noted that any workplans must be developed in accordance with the Scientific Committee's five-year strategic plan.

13.8 The Scientific Committee noted that workshops have been an effective method for addressing focus topics and provide flexibility for responding to priorities. The Scientific Committee noted the value of issue-specific workshops and external expert collaboration within working groups. The Scientific Committee also considered providing better opportunities for invited experts to participate (rather than bringing them to working groups with a much broader range of topics being considered).

13.9 The Scientific Committee noted that the use of conveners' reports as output from workshops may allow more flexibility in reporting and increased the opportunities for scientists to engage during workshops. However, some concern was expressed over the status of conveners' reports, noting that they are not formally adopted and may not reflect the positions of all participants.

13.10 The Scientific Committee noted that the process by which workshops are established needs to be more streamlined, with the expectations for outputs clarified.

13.11 The Scientific Committee considered suggestions for several workshops to take place intersessionally, including:

(i) joint industry and scientific workshop supported by COLTO, focusing on tagging, e-monitoring and redeveloping C2 data forms to include catch and effort reporting

(ii) VME workshop considering the development of VME-related conservation measures and identification of new VME taxa

(iii) workshop on the management of krill resources in Subareas 48.1 and 48.2.

13.12 The Scientific Committee considered that hosting multiple workshops in parallel, either during or in the margins of WG-EMM, may be the most efficient use of time for all participants.

13.13 France requested that all interested parties correspond with Dr Eléaume regarding the development and organisation of any workshops wishing to take place during the mid-year meetings, following the development of the WG-EMM 2019 work plan.

Term of appointments for conveners

13.14 The Chair of the Scientific Committee presented SC-CAMLR-XXXVII/13 recommending a more structured approach to the appointment of working group conveners with the introduction of fixed-term appointments. Many Members supported the recommendation and noted that mechanisms to provide financial support for conveners should be further considered.

13.15 The Scientific Committee encouraged the introduction of the role of junior convener to participate at working groups as a mechanism to strengthen the pool of potential future conveners.

Second Performance Review

13.16 The Scientific Committee considered SC-CAMLR-XXXVII/11 outlining a framework for addressing specific recommendations as outlined in the Second Performance Review Report (PR2 Report) (CCAMLR-XXXVI/01). The Scientific Committee agreed that the Scientific Committee Bureau be tasked with working intersessionally to develop a process to address the recommendations of the PR2 Report, as they relate to the Scientific Committee, for consideration at SC-CAMLR-XXXVIII. The Scientific Committee noted that discussions on the development of this work should be open to all Members and identified that an e-group would be the appropriate mechanism for these intersessional discussions.

CCAMLR Scientific Scholarships Scheme

13.17 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, and thanked the current recipients attending the Scientific Committee, Ms E. Seyboth of Brazil, Ms A. Capurro of Argentina and Mr Y. Ying of China, as well as Dr D. Di Blasi of Italy who had attended WG-FSA-18, for their work at the CCAMLR meetings.

13.18 The Scientific Committee noted the research by the recipient of the 2018 CCAMLR scholarship, Dr Di Blasi, on non-extractive work on *D. mawsoni* using baited underwater cameras through sea-ice in the Ross Sea. The Scientific Committee encouraged future feedback to its working groups on the results, as non-extractive sampling is of particular interest in monitoring within an MPA.

13.19 The Scientific Committee expressed its disappointment in receiving no applications for the CCAMLR scholarship scheme this past year and considered mechanisms by which to promote the scholarship scheme to attract wider interest.

13.20 Scientific Committee agreed to hold an additional call for scholarship applications with a deadline for applications by March 2019 so that any potential recipient may have suitable time to organise for attendance at the mid-year working group meetings. The applications would be reviewed by correspondence by the CCAMLR Scientific Scholarships review panel and the outcomes communicated by SC CIRC from the Senior Vice-Chair (as chair of the review panel). The Scientific Committee encouraged Members and Observers to utilise their outreach to communicate this call for scholarship applications.

Invitation of experts and observers to meetings of working groups

13.21 The Scientific Committee agreed that all Observers invited to the 2018 meeting would be invited to participate in SC-CAMLR-XXXVIII.

Next meeting

13.22 The next meeting of the Scientific Committee will be held at the CCAMLR Headquarters building (181 Macquarie Street) in Hobart, Australia from 21 to 25 October 2019.

Secretariat supported activities

14.1 The Scientific Committee noted the Secretariat's proposed 2019–2022 Strategic Plan (CCAMLR-XXXVII/06) and welcomed this initiative. The Scientific Committee welcomed the development of the theme-based approach in the Strategic Plan and, in particular, the importance of providing scientific support to the work of the Scientific Committee.

14.2 The Scientific Committee welcomed the proposed Secretariat Staffing and Salary Strategy (CCAMLR-XXXVII/21 Rev. 1), including its intent to strengthen the Secretariat's Data Management, Fisheries Management and Scientific functions and Human Resources capabilities.

14.3 The Scientific Committee noted the Secretariat's proposals arising from the feedback from Members following the consultation on Secretariat catch and effort monitoring (CCAMLR-XXXVII/BG/22) and welcomed, in particular, the future efforts towards the development of the CCAMLR data warehouse, facilitated by a strengthened Data Management staffing support.

Election of Vice-Chair

15.1 Mr R. Sarralde Vizuete's (Spain) term as Vice-Chair ended with this meeting and the Scientific Committee sought nominations for a new Junior Vice-Chair. Dr G. Zhu (China) was unanimously elected to the position for a term of two regular meetings (2019 and 2020). A very warm welcome was extended to the incoming Junior Vice-Chair who thanked the Committee for this honour.

15.2 The Scientific Committee thanked Mr Sarralde Vizuete for his excellent contribution to the work of the Scientific Committee, his professionalism and positive attitude.

Other business

Nomenclature of CCAMLR meetings and new CCAMLR brochure

16.1 The Scientific Committee noted the Secretariat's plans to establish a new nomenclature for CCAMLR meetings (CCAMLR-XXXVII/15) and welcomed this initiative.

16.2 The Scientific Committee noted the Secretariat's plan to produce a new CCAMLR brochure (CCAMLR-XXXVII/16) and welcomed this initiative as it will increase the transparency of CCAMLR activities and benefit CCAMLR through its outreach to the general public and academia.

Workshop on krill fishery management for Subareas 48.1 and 48.2

16.3 The Scientific Committee noted and welcomed the future workshop on krill fishery management for Subareas 48.1 and 48.2 (SC-CAMLR-XXXVII/24). Co-convened by Drs Watters and Trathan, the workshop aims to address the requirements of CM 51-07 while collaboratively harmonising krill fishery management approaches.

Notifications of future scientific surveys

16.4 The Scientific Committee noted the future scientific survey to be conducted by Germany (SC-CAMLR-XXXVII/BG/02), aiming to contribute to the development of a *D. mawsoni* population hypothesis for Area 48.

16.5 The Scientific Committee noted the future scientific survey to be conducted by Australia, aiming to contribute to the understanding of the linkages between biogeochemical processes, krill and whales in Division 58.4.1 and Subarea 88.1.

16.6 The Scientific Committee noted the future scientific survey to be conducted by Japan, aiming to estimate krill biomass and to collect oceanographic observations in Division 58.4.1, an area which was surveyed 23 years ago by Australia.

16.7 The Scientific Committee noted the continuation of the scientific survey conducted by Korea to estimate penguin abundance, and silverfish and krill biomass in the Ross Sea area.

16.8 The Scientific Committee noted the future scientific survey to be conducted by Argentina in the Antarctic Peninsula area, aiming to improve the understanding of the early life stages of Euphausiids in relation to bathymetry and oceanographic processes.

CEMP Fund

16.9 The Scientific Committee requested that the Secretariat CEMP Fund Committee provide an SC CIRC updating the status of the Fund and the procedures for submitting applications to the Fund.

16.10 Dr Trathan reported that he had been a recent recipient of support from the CEMP Fund and that the project had now been completed. The project concerned the identification of preferred penguin foraging habitats in relation to the distribution of the krill fishery and had resulted in the publication of two papers that included multiple authors from different CCAMLR Members (Warwick-Evans et al., 2018; Trathan et al., 2018), as well as other work that is currently under review. Other work will also be submitted to WG-EMM-19.

Adoption of the report

17.1 The report of the Thirty-seventh meeting of the Scientific Committee was adopted.

Close of the meeting

18.1 At the close of the meeting, Dr Belchier thanked all participants for their patience, stamina and contributions throughout the week. He acknowledged that it had been a challenging meeting at times, but that the report provided a good reflection of the discussions. He thanked the Secretariat for their provision of technical and nutritional support throughout the week.

18.2 On behalf of the Scientific Committee, Drs Watters and Zhao thanked Dr Belchier for his painstaking and skilful chairing of the Scientific Committee. They acknowledged that even though the meeting had extended late into the night, he had remained admirably calm and this had allowed the Scientific Committee to reach agreement on important scientific issues.

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Table 1: Catch limit (in tonnes) advice from the Scientific Committee for 2018/19 (the catch limits for Antarctic krill are included for completeness but were not considered during the Scientific Committee meeting). 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.

Subarea/ division	SSRU	Area	Species	Catch limit 2018/19	Additional information	Conservation measure containing catch limit
48.1		481_1 and 481_2	*D. mawsoni*	40		No CM
48.3		Total A (0%) B (30%) C (70%)	*D. eleginoides*	2 600 0 780 1 820		CM 41-02
48.3			*C. gunnari*	3 269		CM 42-01
48.4			*D. eleginoides*	26		CM 41-03
48.4			*D. mawsoni*	37		
58.5.2			*D. eleginoides*	3 525		CM 41-08
58.5.2			*C. gunnari*	443		CM 42-02
48.2	n/a	N and S	*D. mawsoni*	75	Ukraine research proposal	No CM
	n/a	E	*D. mawsoni* and *D. eleginoides*	23	UK research program	No CM
48.4	n/a	S	*D. mawsoni* and *D. eleginoides*	18	UK research program	No CM
48.6	n/a	486_2	*D. mawsoni*	175	Japan, Spain and South Africa joint research proposal	CM 41-04
48.6	n/a	486_3	*D. mawsoni*	32	Japan, Spain and South Africa joint research proposal	CM 41-04
48.6	n/a	486_4	*D. mawsoni*	144	Japan, Spain and South Africa joint research proposal	CM 41-04
48.6	n/a	486_5	*D. mawsoni*	274	Japan, Spain and South Africa joint research proposal	CM 41-04
58.4.1	C	5841_1	*D. mawsoni*	115*	Australia, France, Japan, Republic of Korea and Spain joint research proposal	CM 41-11
58.4.1	C	5841_2	*D. mawsoni*	116*	Australia, France, Japan, Republic of Korea and Spain joint research proposal	CM 41-11
58.4.1	E	5841_3	*D. mawsoni*	149*	Australia, France, Japan, Republic of Korea and Spain joint research proposal	CM 41-11

(continued)

Table 1 (continued)

Subarea/ division	SSRU	Area	Species	Catch limit 2018/19	Additional information	Conservation measure containing catch limit
58.4.1	E	5841_4	*D. mawsoni*	19*	Australia, France, Japan, Republic of Korea and Spain joint research proposal	CM 41-11
58.4.1	G	5841_5	*D. mawsoni*	50*	Australia, France, Japan, Republic of Korea and Spain joint research proposal	CM 41-11
58.4.1	G	5841_6	*D. mawsoni*	130*	Australia, France, Japan, Republic of Korea and Spain joint research proposal	CM 41-11
58.4.2	E	5842_1	*D. mawsoni*	50*	Australia, France, Japan, Republic of Korea and Spain joint research proposal	CM 41-05
58.4.4b	n/a	5844b_1	*D. eleginoides*	19	France and Japan joint research proposal	No CM
58.4.4b	n/a	5844b_2	*D. eleginoides*	22	France and Japan joint research proposal	No CM
58.4.3a	n/a	5843a_1	*D. eleginoides*	30*	Japan research proposal	CM 41-06
88.1	All SSRUs in 88.1 and SSRUs 882A–B	Total	*D. mawsoni*	3 157		CM 41-09
		N70	*D. mawsoni*	587		CM 41-09
		S70	*D. mawsoni*	2 041		CM 41-09
		SRZ	*D. mawsoni*	464		CM 41-09
		Shelf survey	*D. mawsoni*	65		CM 41-09
88.1, 88.2	SRZ		*D. mawsoni*	*	Russian proposal	
88.2	D, E, F, G	882_1	*D. mawsoni*	240		CM 41-10
88.2	C, D, E, F, G	882_2	*D. mawsoni*	240		CM 41-10
88.2	C, D, E, F, G	882_3	*D. mawsoni*	160		CM 41-10
88.2	C, D, E, F, G	882_4	*D. mawsoni*	160		CM 41-10
88.2	H		*D. mawsoni*	200		CM 41-10

(continued)

Table 1 (continued)

Subarea/ division	SSRU	Area	Species	Catch limit 2018/19	Additional information	Conservation measure containing catch limit
88.3	n/a	883_1	*D. mawsoni*	20	New Zealand and Republic of Korea joint research proposal	No CM
88.3	n/a	883_2	*D. mawsoni*	25	New Zealand and Republic of Korea joint research proposal	No CM
88.3	n/a	883_3	*D. mawsoni*	50	New Zealand and Republic of Korea joint research proposal	No CM
88.3	n/a	883_4	*D. mawsoni*	50	New Zealand and Republic of Korea joint research proposal	No CM
88.3	n/a	883_5	*D. mawsoni*	10	New Zealand and Republic of Korea joint research proposal	No CM
88.3	n/a	883_6	*D. mawsoni*	30	New Zealand and Republic of Korea joint research proposal	No CM
88.3	n/a	883_7	*D. mawsoni*	30	New Zealand and Republic of Korea joint research proposal	No CM
88.3	n/a	883_8	*D. mawsoni*	10	New Zealand and Republic of Korea joint research proposal	No CM
88.3	n/a	883_9	*D. mawsoni*	10	New Zealand and Republic of Korea joint research proposal	No CM
88.3	n/a	883_10	*D. mawsoni*	10	New Zealand and Republic of Korea joint research proposal	No CM
58.4.1	n/a	W	*E. superba*	277 000		CM 51-02
58.4.1	n/a	E	*E. superba*	163 000		CM 51-02
58.4.2	n/a	W	*E. superba*	260 000		CM 51-03
58.4.2	n/a	E	*E. superba*	192 000		CM 51-03
48.1	n/a		*E. superba*	155 000		CM 51-07
48.2	n/a		*E. superba*	279 000		CM 51-07
48.3	n/a		*E. superba*	279 000		CM 51-07
48.4	n/a		*E. superba*	93 000		CM 51-07
88.2			Crabs	250*	Russian research proposal	No CM
88.3			Crabs	250*	Russian research proposal	No CM

* The Scientific Committee did not reach consensus on these catch limits and referred these matters to the Commission for resolution.

Table 2: Numbers of incidental mortalities of seabirds and marine mammals (IMAF) in 2017/18 received through vessel and observer data. Data source Obs. tally period is the haul observation period conducted by observers, and the mortalities recorded during this period are used to calculate the extrapolated total (scaled by the percentage of hooks observed) for seabird mortalities. Obs. total is the total number of mortalities reported by observers (includes incidental mortalities reported from outside the haul observation/tally period). Catch and effort are summary catch and effort data reported at 1, 5 or 10 day intervals depending on the fishery. C1 and C2 data are haul by haul vessel data reported to the Secretariat at monthly intervals. Subareas and divisions[1] that are marked with an asterisk have incomplete datasets and fields marked with a dash have no fishing activity present, or data is not submitted to the Secretariat.

		Data source	Subarea				Division		Total
			48.1*	48.2*	48.3*	58.6 (French EEZ)	58.5.1 (French EEZ)	58.5.2*	
Longline									
	Seabirds	Obs. tally period	-	0	15	4	9	0	28
		Obs. total	-	0	25	-	-	0	25
		Extrapolated total	-	0	35	16	36	0	87
		Catch and effort	-	0	25	-	-	1	26
		C2	-	0	25	-	-	1	26
	Marine mammals	Vessel	-	0	0	-	-	1	1
		Observer	-	0	0	0	0	1	1
Finfish trawl									
	Seabirds	Observer	-	-	0	-	-	0	0
		Catch and effort	-	-	0	-	-	0	0
		C1	-	-	0	-	-	0	0
	Marine mammals	Vessel	-	-	0	-	-	0	0
		Observer	-	-	0	-	-	0	0
Krill trawl									
	Seabirds	Observer	0	1	0	-	-	-	1
		Catch and effort	1	1	0	-	-	-	2
		C1	1	1	0	-	-	-	2
	Marine mammals	Vessel	0	0	0	-	-	-	0
		Observer	0	0	19	-	-	-	19

1 Subareas and divisions not listed in this table had no reported mortalities during 2017/18 or no fishing activities were undertaken.

Table 3: Reconciliation of the verified weight landed on the e-CDS (DCD sum) with fine-scale catch and effort data (Catch product sum) for catches in Subarea 48.2 for 2018 and 2017 by vessel. A positive difference value represents more catch reported in the e-CDS than the fine-scale catch and effort data. A negative difference value represents more catch reported in the fine-scale catch and effort data than the e-CDS. TOA – *Dissostichus mawsoni*; TOP – *D. eleginoides*.

2018	Vessel name	Species code	Vessel Flag	DCD sum (kg)	Catch product sum (kg)	Difference (kg)	Difference (%)
	Argos Froyanes	TOA	United Kingdom	700	787	–87	–12.44
	Simeiz	TOA	Ukraine	37 200	32 723	4 477	12.04
	Simeiz	TOP	Ukraine	1 382	1 431	–49	–3.55
	San Aspiring	TOA	New Zealand	2 296	2 296	0	0
	San Aspiring	TOP	New Zealand	347	358	–11	–3.19
	Total			41 925	37 595	4 330	10.33
2017							
	Argos Froyanes	TOA	United Kingdom	4 949	5 153	–203	–4.11
	Argos Froyanes	TOP	United Kingdom	262	262	-	0.00
	Simeiz	TOA	Ukraine	40 580	30 889	9 691	23.88
	Simeiz	TOP	Ukraine	4 000	3 739	261	6.51
	San Aspiring	TOA	New Zealand	1 261	1 261	-	0.00
	Total			51 052	41 303	9 749	19.10

Annex 1

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Ms Silvia Martinez
Dr Marc Orlando
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Mr Philippe Tanguy
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Annex 2

List of Documents

List of Documents

SC-CAMLR-XXXVII/01	Report of the Co-conveners of the CCAMLR Workshop for the Development of a *Dissostichus mawsoni* Population Hypothesis for Area 48 (19 to 21 February 2018, Berlin, Germany) Workshop Co-conveners (C. Darby (UK) and C. Jones (USA))
SC-CAMLR-XXXVII/02 Rev. 1	Summary Report of the CCAMLR Independent Stock Assessment Review for Toothfish (Norwich, United Kingdom, 18 to 22 June 2018)
SC-CAMLR-XXXVII/03	Report of the Working Group on Ecosystem Monitoring and Management (Cambridge, United Kingdom, 9 to 13 July 2018)
SC-CAMLR-XXXVII/04	Report of the Working Group on Fish Stock Assessment (Hobart, Australia, 8 to 19 October 2018)
SC-CAMLR-XXXVII/05	Report of the Working Group on Statistics, Assessments and Modelling (Norwich, United Kingdom, 25 to 29 June 2018)
SC-CAMLR-XXXVII/06	Report of the Meeting of the Subgroup on Acoustic Survey and Analysis Methods (Punta Arenas, Chile, 30 April to 4 May 2018)
SC-CAMLR-XXXVII/07	The Expert Group on “pelagic spatial planning of the subantarctic areas of Planning Domains 4, 5 and 6” (PS^2456) A. Makhado, P. Koubbi, A.D. Lowther, F. D’Ovidio, R. Reisinger, P. Pistorious, R. Crawford, P. Trathan and S. Grant
SC-CAMLR-XXXVII/08	Report of the Meeting of the Workshop on Spatial Management (Cambridge, United Kingdom, 2 to 6 July 2018)
SC-CAMLR-XXXVII/09	Draft Research and Monitoring Plan for the South Orkney Islands southern Shelf Marine Protected Area (MPA Planning Domain 1, Subarea 48.2) Delegation of the European Union
SC-CAMLR-XXXVII/10	Advancing management and conservation through the use of an experimental approach for the Antarctic krill fishery P.N. Trathan and O.R. Godø

SC-CAMLR-XXXVII/11	Candidate baseline data for ecosystem indicators in the Ross Sea region. Part A: Brief presentation of data Delegation of the USA
SC-CAMLR-XXXVII/12	International synoptic krill survey in Area 48, 2019; update of transect design based on proposed modifications developed during WG-EMM 2018 Delegation of Norway
SC-CAMLR-XXXVII/13	Terms of appointment for the Conveners of the working groups of the Scientific Committee Chair of the Scientific Committee
SC-CAMLR-XXXVII/14 Rev. 2	Long-term changes in the length composition of Patagonian toothfish (*Dissostichus eleginoides*) in longline catches in waters around South Georgia N.N. Kukharev and A.F. Petrov
SC-CAMLR-XXXVII/15	Information about a Workshop for Training CCAMLR Scientific Observers and Inspectors Delegation of the Russian Federation
SC-CAMLR-XXXVII/16	Methodical Aspects of a Large-scale International Krill Survey in 2019: Comments and Proposals Delegation of the Russian Federation
SC-CAMLR-XXXVII/17	Vacant
SC-CAMLR-XXXVII/18	Comments and Proposals Regarding the Development of MPAs for Spatial Management in the CCAMLR Convention Area Delegation of the Russian Federation
SC-CAMLR-XXXVII/19	Comments and Proposals regarding the Ross Sea region MPA Research and Monitoring Plan Delegation of the Russian Federation
SC-CAMLR-XXXVII/20	Procedure established by the CCAMLR Secretariat to monitor catch and effort: comments Delegation of the Russian Federation
SC-CAMLR-XXXVII/21	Vacant
SC-CAMLR-XXXVII/22	Comments and proposals on the development of a population hypothesis for Antarctic toothfish *D. mawsoni* in Area 48 Delegation of the Russian Federation

SC-CAMLR-XXXVII/23	Report of the first SCAR Krill Action Group (SKAG) meeting (Cambridge, United Kingdom, 16 July 2018)
SC-CAMLR-XXXVII/24	Invitation to participate in a workshop on krill fishery management for Subareas 48.1 and 48.2 G. Watters and P. Trathan
SC-CAMLR-XXXVII/BG/01 Rev. 4	Catches of target species in the Convention Area Secretariat
SC-CAMLR-XXXVII/BG/02	Information on the marine scientific research expeditions with RV *Polarstern* in the 2018/19 season Delegation of Germany
SC-CAMLR-XXXVII/BG/03	Committee for Environmental Protection: 2018 Annual Report to the Scientific Committee of CCAMLR CEP Observer to SC-CAMLR, Dr P. Penhale (USA)
SC-CAMLR-XXXVII/BG/04	Evaluating MPA scenarios in Planning Domain 1 using a dynamic food-web model Delegation of the USA
SC-CAMLR-XXXVII/BG/05	Features of chronology and breeding success of *Pygoscelis papua* and *Pygoscelis adeliae* penguins in the Wilhelm Archipelago (CCAMLR Subarea 48.1) I.V. Dykyy, G.P. Milinevsky, O.L. Savitsky, D.G. Lutsenko, P.B. Khoetsky, M.F. Veselsky, V.M. Smagol, A.O. Dzhulay, J.V. Tsaryk, K.M. Nazaruk, A.T. Zatushevsky, A.O. Simon and M.A. Telipska *Український антарктичний журнал уаж* (Ukrainian Antarctic Journal), 16 (2018): 209–225
SC-CAMLR-XXXVII/BG/06	Pygoscelis penguin census in the Vernadsky Antarctic station area V.M. Smagol, A.O. Dzhulay, I.V. Dykyy, G.P. Milinevsky and E.O. Dykyy
SC-CAMLR-XXXVII/BG/07	Updated background paper (2018) on the Domain 1 MPA. Part A: Domain 1 MPA Model Delegations of Argentina and Chile
SC-CAMLR-XXXVII/BG/08	Updated background paper (2018) on the Domain 1 MPA. Part B: rationale of changes Delegations of Argentina and Chile

SC-CAMLR-XXXVII/BG/09	Report from the SC-CAMLR Observer (Australia) to the First Meeting of the Southern Indian Ocean Fisheries Agreement (SIOFA) Stock Assessment Working Group (SAWG) (St Denis, Reunion, 15 to 18 March 2018) SC-CAMLR Observer (Australia)
SC-CAMLR-XXXVII/BG/10	Update on the conservation status, distribution and priorities for albatrosses and petrels in the CCAMLR area Submitted by the ACAP Secretariat
SC-CAMLR-XXXVII/BG/11	Antarctic Site Inventory / MAPPPD / State of Antarctic Penguins 2018 Report / Buffer Zone Reference Tool / Climate Analyses: 2018 Report to CCAMLR by Oceanites, Inc. Submitted by Oceanites, Inc.
SC-CAMLR-XXXVII/BG/12	Preliminary evaluation of two feedback management strategies for the krill fishery in Subareas 48.1–48.3 Delegation of the USA
SC-CAMLR-XXXVII/BG/13	Candidate baseline data for ecosystem indicators in the Ross Sea region. Part B: Discussion of the data Delegation of the USA
SC-CAMLR-XXXVII/BG/14 Rev. 1	Informing the Scientific Committee about the revisions of the WSMPA proposal Delegation of Germany
SC-CAMLR-XXXVII/BG/15	Scientific background document in support of the development of a CCAMLR MPA in the Weddell Sea (Antarctica) – Version 2018 – Reflection on the recommendations by WG-EMM-17 and SC-CAMLR-XXXVI Delegation of Germany
SC-CAMLR-XXXVII/BG/16	Integrating Climate and Ecosystem Dynamics in the Southern Ocean (ICED) programme: Report of the ICED–CCAMLR Projections Workshop, 5 to 7 April 2018 E. Murphy, N. Johnston, S. Corney and K. Reid
SC-CAMLR-XXXVII/BG/17	Precautionary, ecosystem-based management for the Antarctic krill fishery: a work in progress Submitted by ASOC
SC-CAMLR-XXXVII/BG/18	Responding to the emerging threat of microplastics in the Southern Ocean Submitted by ASOC and COLTO

SC-CAMLR-XXXVII/BG/19	Delivering enhanced data access through CCAMLR–SOOS collaboration Delegations of the USA, Belgium and SOOS
SC-CAMLR-XXXVII/BG/20	CEMP cameras data validation experiment at the Galindez Island gentoo colonies A. Dzhulay, V. Smagol, G. Milinevsky, I. Dykyy, A. Simon, M. Telipska, E. Dykyy, L. Pshenichnov and A. Grytsai
SC-CAMLR-XXXVII/BG/21	Marine debris and entanglements at Bird Island and King Edward Point, South Georgia, Signy Island, South Orkneys and Goudier Island, Antarctic Peninsula 2017/18 C. Waluda
SC-CAMLR-XXXVII/BG/22	Marine Ecosystem Assessment for the Southern Ocean (MEASO) A. Constable, J. Melbourne-Thomas, R. Trebilco and M. Brasier
SC-CAMLR-XXXVII/BG/23	Efficiency of the multi-year research programs for the *Dissostichus* species exploratory fishery: comments on the multi-Member research in the East Antarctic (Division 58.4.1) Delegation of the Russian Federation
SC-CAMLR-XXXVII/BG/24	Approach to the study of the ecosystem effect in the krill fishery Delegation of the Russian Federation
SC-CAMLR-XXXVII/BG/25	On multi-year variability of the Patagonian toothfish (Dissostichus eleginoides) size composition in longline catches in the South Georgia maritime zone (full version) N.N. Kukharev and A.F. Petrov
SC-CAMLR-XXXVII/BG/26	List of Italian research projects that contribute to the Research and Monitoring Plan for the Ross Sea region Marine Protected Area Delegation of Italy
SC-CAMLR-XXXVII/BG/27	The Scientific Committee on Antarctic Research (SCAR) Annual Report 2017/18 Submitted by SCAR
SC-CAMLR-XXXVII/BG/28	CCAMLR research and exploratory fishing: commercial fishing disguised as scientific research Submitted by ASOC

SC-CAMLR-XXXVII/BG/29	Is CCAMLR science keeping up? Submitted by ASOC
SC-CAMLR-XXXVII/BG/30	ARK Report to SC-CAMLR-XXXVII Submitted by ARK
SC-CAMLR-XXXVII/BG/31	Networks and tools to enhance collaboration and coordination of observational activities Submitted by SOOS

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Other Documents

CCAMLR-XXXVII/01	Climate change implications statements Delegations of Australia, Norway and the United Kingdom
CCAMLR-XXXVII/06	CCAMLR Secretariat Strategic Plan 2019–2022 Executive Secretary
CCAMLR-XXXVII/10	Cooperation with other organisations: Arrangements with International Organisations CCAMLR Secretariat
CCAMLR-XXXVII/11	Second performance review – progress report CCAMLR Secretariat
CCAMLR-XXXVII/15	Nomenclature of CCAMLR meetings CCAMLR Secretariat
CCAMLR-XXXVII/16	New CCAMLR Brochure CCAMLR Secretariat
CCAMLR-XXXVII/21 Rev. 1	CCAMLR Staffing and Salary Strategy (2019–2022) Executive Secretary
CCAMLR-XXXVII/30	EU working paper on the implementation of CM 32-18 on the conservation of sharks Delegation of the European Union
CCAMLR-XXXVII/31	Proposal on a conservation measure establishing a marine protected area in the Domain 1 (Western Antarctic Peninsula and South Scotia Arc) Delegations of Argentina and Chile

CCAMLR-XXXVII/BG/22	Consultation on Secretariat catch and effort monitoring: Secretariat proposals arising from the feedback from Members CCAMLR Secretariat
CCAMLR-XXXVII/BG/26	CCAMLR and climate change: the need for urgent action Submitted by ASOC
CCAMLR-XXXVII/BG/27	An introduction to the International Association of Antarctica Tour Operators (IAATO) Submitted by IAATO
CCAMLR-XXXVII/BG/36	Fulfilling CCAMLR's commitment to create a representative system of Marine Protected Areas Submitted by ASOC
CCAMLR-XXXVII/BG/40	ASOC Report to CCAMLR Submitted by ASOC
WG-FSA-18/11 Rev. 1	Implementation of the CCAMLR Scheme of International Scientific Observation during 2017/18 CCAMLR Secretariat

Annex 3

Agenda for the Thirty-seventh Meeting of the Scientific Committee

**Agenda for the Thirty-seventh 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 2018/19

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 Vice-Chair

16. Other business

17. Adoption of report of the Thirty-seventh Meeting

18. Close of meeting.

Annex 4

Report of the Meeting of the Subgroup
on Acoustic Survey and Analysis Methods
(Punta Arenas, Chile, 30 April to 4 May 2018)

Contents

Report of the Subgroup on
Acoustic Survey and Analysis Methods
(Punta Arenas, Chile, 30 April to 4 May 2018)

Introduction

1.1 The 2018 meeting of the Subgroup on Acoustic Survey and Analysis Methods (SG-ASAM) was held at the Laboratorio Jorge Berguño, Chilean Antarctic Institute (Instituto Antártico Chileno – INACH), Punta Arenas, Chile, from 30 April to 4 May 2018. The Convener, Dr X. Zhao (China), welcomed the participants (Appendix A) and noted that this meeting venue was the closest to the Antarctic in which the Subgroup had ever met.

1.2 In welcoming participants to the meeting, Dr Marcelo Leppe (National Director INACH) noted the increasing awareness of Southern Ocean issues both in Chile and globally. He highlighted that the hosting of a CCAMLR meeting sent a very positive signal to the Chilean Government on the important role of INACH and Punta Arenas in Chile's engagement in CCAMLR.

1.3 The Science Manager, Dr K. Reid, thanked Dr Leppe for his kind hosting of the subgroup meeting and noted that meeting in a venue named after Ambassador Jorge Berguño Barnes, who made such a long and distinguished contribution to Antarctic affairs, exemplified the strong tradition of Chile's engagement in CCAMLR.

1.4 The meeting's provisional agenda was discussed, and the Subgroup adopted the proposed agenda without any changes (Appendix B).

1.5 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.

1.6 This report was prepared by S. Fielding (United Kingdom), G. Macaulay (Norway), E. Niklitschek (Chile), K. Reid (CCAMLR 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'.

Monitoring echosounder performance

Echosounder calibration using seabed as reference target

2.1 Mr Wang presented SG-ASAM-18/06 that described the potential to use maximum seabed backscattering to evaluate echosounder performance. Acoustic data (around 300 pings) were collected using a Simrad EK60 echosounder (38, 70 and 120 kHz) on board the Chinese krill fishing vessel *Fu Rong Hai* while drifting around a hydrographic station in the Bransfield Strait in March 2015, January 2016 and February 2018. Analysis of the 38 kHz and the 120 kHz data showed that the largest interannual variation of the mean of the maximum ping-by-ping seabed backscattering (S_v) was less than 1.0 dB, with a difference of 0.78 dB at 38 kHz and

0.35 dB at 120 kHz respectively. ANOVA analysis indicated that there was no significant difference in the distribution of maximum seabed backscattering among years at both frequencies.

2.2 The Subgroup recalled that the issue of using seabed as a reference target to evaluate echosounder performance had been investigated by SG-ASAM previously, but that the effort was mostly focused on the use of mean seabed echo integration. The Subgroup noted that the geographic location used for the three years in SG-ASAM-18/06 were not exactly the same due to the drifting nature of the vessel, and this may introduce additional uncertainty for direct comparison. The Subgroup suggested that such exercises be carried out at a calibration site in the future to enable concurrent collection of seabed signal with standard sphere calibration while maintaining the vessel in the same location.

2.3 To demonstrate the potential of this suggested approach, the Subgroup compared variation on maximum seabed S_v distribution among three consecutive years (November 2015, December 2016, January 2018) using data collected during standard sphere calibration onboard RV *James Clark Ross* in Stromness Bay. Changes to the transducer gain based on the mean value of maximum seabed S_v showed high consistency with the standard sphere calibration result at 120 kHz, but were significantly different at 38 kHz with the largest difference over 1.5 dB in 2016.

2.4 Dr Macaulay introduced an experiment by the Norwegian Institute of Marine Research (IMR) that indicated seabed integration along a fixed line can be used as an alternative calibration method to estimate transducer gain with 0.5 dB accuracy. He suggested that seabed integration was sensitive to the seabed type and bottom features and was also frequency dependent. He highlighted that it would be useful to know the bottom type along the reference stretch presented in SG-ASAM-18/06 as this might explain the variation in backscattering.

2.5 Dr K. Amakasu (Japan) drew the attention of the Subgroup to a paper (Furusawa, 2011) that described the echo integration theory for seabed echoes. The echo integration of seabed echoes is performed by setting an integration layer so as to include seabed echoes to get 'bottom Sv'. The theory is an effective tool to check the performance of scientific echosounders.

2.6 The Subgroup emphasised that the standard sphere calibration still represents the benchmark method for calibration of echosounders which had also been addressed in previous meetings (SG-ASAM 2014, 2015, 2017). However, the Subgroup continued to agree that using the seabed had substantial potential as a reference target to evaluate general performance of an echosounder, including cross-checking for different frequencies of the same echosounder. The Subgroup encouraged further development, including comparing data from the seabed at a fixed location versus transect, grid dimension in seabed integration, seabed type etc.

Internal test of echosounder performance

2.7 The Subgroup agreed that regular evaluation of the echosounder performance is an important aspect for acoustic surveys, and this is especially true if an echosounder was not calibrated using the standard sphere method. The Subgroup recalled that general functionality of a split-beam transducer can be checked by examining the single target distribution in the acoustic beam of the echosounder (SC-CAMLR-XXXIII, Annex 4, paragraph 2.26). Mr Wang presented an example of data examined using this technique and the Subgroup noted that it could be used both during a survey, and/or post-survey data analysis, to identify where an echosounder performance may have changed.

Methods for the collection and analysis of krill acoustic data from fishing vessels

3.1 In 2017, SG-ASAM agreed that there are several potential advantages of the swarm-based method compared to the dB difference method for the identification of krill when applied to data collected from fishing vessels and recommended that the swarm-based method be used when analysing acoustic data collected by fishing vessels (SC-CAMLR-XXXVI, Annex 4, paragraphs 3.2 and 3.3). The Subgroup recalled that the swarm-based method:

(i) is not dependent on data from a specific set of acoustic frequencies which is required when setting the dB difference window for krill identification following the CCAMLR protocol

(ii) reduces the risk of integrating noise-contaminated segments of the data

(iii) provides potentially interesting information about swarm dynamics and swarm characteristics which would not be available from standard interval integration

(iv) potentially reduces data processing time.

3.2 The Subgroup recognised that some misunderstanding had arisen because of the terminology used by different authors to describe different components of the analytical process, specifically, the terms gridded or interval method inherited from SG-ASAM-17/02. The Subgroup clarified that the distinction between the two methods that have been recommended by SG-ASAM was in the target identification method used to discriminate between krill and other targets, such that:

(i) the swarm-based target identification approach that uses the Shoal Analysis and Patch Estimation System (SHAPES) algorithm, parameterised according to SC-CAMLR-XXXVI, Annex 4, Table 1, to identify 'krill' targets in acoustic data

(ii) the dB-window target identification method using two or more frequencies subtracted from each other, parameterised by a knowledge of the krill length frequency and an acoustic scattering model or empirical measurements (e.g. Madureira et al., 1993).

3.3 The Subgroup agreed that the distinction between the target identification methods provided a useful means for distinguishing the swarm-based and dB-window-based approaches as used in the papers submitted to, and in the report of, the Subgroup. However, a more comprehensive review and clarification of the terminologies is needed to reflect the development of acoustic techniques considered by SG-ASAM.

3.4 The Subgroup noted that although the Echoview template agreed at SG-ASAM-17 (SC-CAMLR-XXXVI, Annex 4, Appendix D, available from https://github.com/AustralianAntarcticDivision/EchoviewR/tree/master/inst/extdata) has the potential to apply 'dB differencing' for 120 kHz – 38 kHz, the default settings of a –20 to 20 dB difference range is so wide as to be functionally equivalent to not using a dB-window to identify krill. The dB difference option is retained in the template to enable future research to be carried out on the sensitivity of swarm-based approaches to krill length-frequency data.

3.5 SG-ASAM-18/04 provided a comparison of the swarm-based and dB-window target identification methods using uncalibrated acoustic data collected by the Chinese fishing vessel *Furong Hai* over four years from 2013 to 2017. Interval echo-integration units of 250 m × 1 n mile were used to sum the nautical area scattering coefficient (NASC) attributed to krill for both identification methods. High correlation was observed between the two techniques (Pearson correlation $r > 0.9$) across all years. Similar cumulative distribution patterns were observed (over the range of observed NASC values), and there were no significant differences between distributions of NASC values identified using the two identification techniques. Overall, the paper showed good agreement between the swarm-based identification method and the dB-window target identification method.

3.6 The Subgroup welcomed the comparison of a swarm-based approach applied to fishery vessel data and thanked Dr X. Yu (China) who undertook further analyses during the meeting and presented these in SG-ASAM-18/04 Rev. 1. The Subgroup noted that:

(i) differences between methods within a year were lower than the interannual variability

(ii) the distributions of normalised differences in NASC values between the two methods were symmetrically distributed around zero

(iii) data were highly correlated and linearly related and the regression line for three of the four years had a slope of ~1

(iv) the slope of the regression in 2016 was 1.27 and the cumulative NASC values calculated along transects indicated that this difference between the two methods arises from a small number of strong swarm targets.

3.7 Based on the analysis presented in SG-ASAM-18/04 Rev. 1, the Subgroup agreed that this reinforces the agreement from SG-ASAM-17 that the swarm-based approach is a suitable technique to investigate variability in krill density and/or distribution.

3.8 The Subgroup agreed that further analysis to improve the comparison between methodologies should include:

(i) conducting a detailed scrutiny of the data and echograms from 2016 in order to identify issues causing observed discrepancies and allow for some additional learning about the comparative performance of both methodologies

(ii) using a geometric regression rather than a predictive regression since both methods estimate krill density with error

(iii) pairwise comparison of means, along with, or instead of, Kruskal-Wallis comparison of distributions

(iv) applying an identification dB-window to swarm-based analysis, as in SG-ASAM-17/02, to evaluate the potential inclusion of other schooling organisms prevalent in some of the Antarctic (e.g. lanternfish (*Electrona carlsbergi*), mackerel icefish (*Champsocephalus gunnari*) and Antarctic silverfish (*Pleuragramma antarctica*)) (see paragraph 3.4)

(v) echo-integration by region (swarms) was suggested for further consideration as it would produce biologically meaningful information (swarm density) and should not affect transect-based (Jolly and Hampton, 1990) abundance estimates.

3.9 SG-ASAM-18/01 examined the efficacy of different frequencies used with a two- and three-frequency dB window identification method to identify Antarctic krill (*Euphausia superba*) (e.g. Madureira et al., 1993), whilst determining krill density always using the 120 kHz. Data from three surveys were used and different dB windows were applied to each survey based on length-frequency data from RMT8 nets. A Bland Altman analysis was used to show that only a combination of 120 and 70 kHz data ($S_{v120-70}$) shows agreement (low bias) compared to the dB window using 120 and 38 kHz, and likewise only a combination of 200, 120 and 70 kHz is comparable to the dB window using 200, 120 and 38 kHz.

3.10 The Subgroup noted that choosing frequency pairings with similar scattering (e.g. Rayleigh or Geometric) appeared to have poorer identification performance compared with pairs chosen from each scattering type and noted that the results presented in SG-ASAM-18/01 indicated that the transition from Geometric to Rayleigh scattering occurred somewhere between 70 and 120 kHz for the size range of Antarctic krill. The Subgroup noted that there was strong agreement between methods, except those using the 70–38 kHz dB window at the 500 m integration bin scale, but identified that mean values for each transect within each survey showed a poorer agreement during cruise JR15002 than the other two surveys and occasionally some large discrepancies between techniques. It was noted that the size range of krill was considerably different during JR15002 compared with the other two cruises.

3.11 The Subgroup considered how changes in the distribution of krill length frequencies, krill material properties and orientation could influence the krill identification windows both between surveys and within a survey. This included trying different dB windows, not based on in situ krill length frequencies, to compare efficacies of different 'sized' zooplankton windows as well as using simulated data to aid the understanding of complex interactions that involve decisions on the use of different dB windows, krill length-frequency distributions as well as krill material properties.

3.12 The Subgroup noted that despite comparable results at a 500 m integration bin level for the 120 kHz–70 kHz frequency combination, compared with 120 kHz–38 kHz, there was sufficient discrepancy at the transect level to warrant further investigation into the causes. The Subgroup noted that further work is required before accepting that the krill density estimates made using different frequency pairs between vessels or surveys were comparable.

Analysis of data collected from fishing vessels

4.1 SG-ASAM-18/08 provided an analysis of the density and biomass of krill around the South Shetland Islands conducted on the krill fishing vessels *Kwang Ja Ho* in April 2016 and *Sejong* in March 2017. This paper included density and biomass estimates using the dB window method and the swarm-based procedure developed at SG-ASAM-17 (SC-CAMLR-XXXVI, Annex 4, paragraph 2.6). For the survey in 2016 the mean density of krill was 7.34 g m^{-2} using the dB window method and 13.99 g m^{-2} using the swarm-based method.

4.2 The Subgroup noted that in SG-ASAM-17/04 the mean density of krill in the survey in April 2016 was 13.37 g m^{-2} using the dB window method. However, in SG-ASAM-18/08 the mean density from the same survey was 7.34 g m^{-2} using the dB window method. The Subgroup agreed that it was essential to understand the reason for this change in the value of density from the same survey before evaluating the comparison of the results from the dB window method and the swarm-based method for the same survey.

4.3 Following discussion of potential analytical issues, the authors of SG-ASAM-18/08 welcomed the offer from Dr M. Cox (Australia) to assist with a reanalysis of the data the using the dB window method and the swarm-based method.

Survey methods

2019 Krill Synoptic Survey of Area 48

5.1 SG-ASAM-18/07 outlined the proposal for a Norwegian-led Krill Synoptic Survey of Area 48, comprising a multinational acoustic trawl survey with confirmed contributions from both research and fishing vessels. The proposed survey design closely follows the CCAMLR 2000 Krill Synoptic Survey of Area 48. The proposal included the formation of a Survey Coordination Group to further plan the survey, data processing and data management. Advice was requested from SG-ASAM on the contents of a survey operation manual, a plan for processing workflow, including priority outputs, a timeline for delivery of results and suggestions for the use of existing CCAMLR data protocols and data management tools.

5.2 The Subgroup welcomed the formation of a Survey Coordination Group led by Norway, and recommended that the Survey Coordination Group conduct a pre-survey meeting to facilitate vessel coordination, procedure standardisation and coordination of survey activities, including a plan for carrying out the analysis of the survey data, along with a timeline of expected analysis products. The Subgroup also encouraged the Survey Coordination Group to use the existing CCAMLR e-group for the Area 48 krill survey 2019 (https://groups.ccamlr.org/mnrg2016) for planning and coordination of the survey.

5.3 The Subgroup recommended that the Survey Coordination Group should contain at least one person from each Member participating in the survey.

Acoustic activities

5.4 Dr Skaret presented the acoustic data collection protocol for the 2019 large-scale survey that was developed during the SG-ASAM meeting (Appendix D). This protocol prescribes, in detail, the acoustic configuration and data collection procedures, and was endorsed by the Subgroup as appropriate for ensuring the collection of usable acoustic survey data.

5.5 The Subgroup recommended that all participating survey vessels have a suitable echosounder that operates at 38 kHz and 120 kHz.

5.6 The Subgroup recommended that a minimum acoustic performance be specified for vessels to participate in the survey and welcomed the offer from IMR to request the required passive or active acoustic data from each vessel (see Appendix D) and carry out this assessment prior to the survey. The Subgroup recommended that a noise level that allows the detection of targets of -76 dB at 250 m is an appropriate minimum acceptable level. The Subgroup also recommended that the analysis of candidate vessels be made available for discussion at WG-EMM-18.

5.7 The Subgroup noted that the noise level analysis could also be used to optimise the survey speed of the vessels so as to collect high-quality acoustic data, or the survey design could be modified to minimise the effect of this on the survey data.

5.8 The Subgroup recommended that an acoustician be on board all vessels, to ensure that the survey procedures are followed and data of sufficient quality are collected.

5.9 The Subgroup noted that other forms of echosounder performance checks, such as inter-calibration between vessels and seabed calibration methods (see paragraphs 2.1 to 2.7) are desirable.

5.10 The Subgroup noted that during the CCAMLR-2000 Survey acoustic transects were only conducted during daylight hours. Dr Macaulay stated that the current intention is to conduct acoustic surveying both during the day and at night.

Sampling activities

5.11 The Subgroup emphasised the importance of specifying standardised krill measurement protocols for use in acoustic biomass estimation and that this should be based on the CCAMLR-2000 Survey RMT 8 protocol. The Subgroup noted that although the nets proposed for use in the survey differed between vessels, this was unlikely to significantly bias the resultant krill length distributions.

Other items

5.12 The Subgroup recommended that the Survey Coordination Group prepare a survey manual for presentation at WG-EMM. The manual should include acoustic procedures (Appendix D), survey design, analysis procedures and contingencies for different levels of available vessel effort. Attention should be given to the fact that the distribution of the fishery has changed since 2000 and that the survey coverage could be changed to cover where the fishery occurs today. The Subgroup noted the potential for inclusion of the US AMLR transects (including in Bransfield Strait) in the 2019 survey.

5.13 The Subgroup recommended the development of contingency plans that could include how to adjust to unexpected loss or delay of vessel and/or survey time. Consideration should be given to whether delayed survey effort is better redirected to repeating already completed transects. In the case of reduced survey effort, consideration should be given to redirecting effort to transects in the areas of krill fishery operation such as the US AMLR transects in Subarea 48.1 and the Norwegian survey transects in Subarea 48.2.

5.14 The Subgroup also noted the following items for consideration in planning the survey:

(i) the survey design would only be 'synoptic' if all the vessels participated at the same time. The Subgroup recalled that the CCAMLR-2000 Survey was undertaken within a one-month period (mid-January to mid-February) and the vessels operated simultaneously

(ii) the benefit of carrying out the initial processing and analysis of the data on a vessel-specific basis so that potential vessel bias can be identified and isolated

(iii) the vessels participating in the survey should be allocated transects to complete, rather than a fixed number of days of survey effort

(iv) the survey should include oceanographic observations from all survey areas

(v) data management would need to be given further consideration by the Survey Coordination Group and that this consideration should include the Secretariat and the Data Management Group.

5.15 SG-ASAM-18/09 provided a description of the acoustic data collection on the South African research vessel, SA *Agulhas II*, which has been proposed as a vessel that will contribute to the 2019 survey. The Subgroup agreed that the echograms in SG-ASAM-18/09 indicated that the 38 and 120 kHz echosounders on that vessel would meet the minimum acoustic performance criteria for acoustic surveys of Antarctic krill (see paragraph 5.6).

Japanese krill survey

5.16 SG-ASAM-18/03 described a revised outline of the dedicated krill survey in Division 58.4.1, planned for the 2018/19 season. The Subgroup noted that the plans included operation of an ADCP (Ocean Surveyor (OS) 38 kHz, RD Instruments) at 38 kHz and an echosounder for depth sounding (ES60 12 kHz, Simrad), with the potential for interference with the 38 kHz survey echosounder. Dr K. Abe (Japan) reported that he conducted an experiment in the western North Pacific in January 2018 to investigate whether such an interference could be avoided by using the K-sync synchronisation system and he found that it could be avoided with appropriate settings. In the experiment, the bottom detecting function of an EK80 was turned off (assuming that the Japanese Antarctic survey would mainly be conducted in deep water). No interference was observed in the water column from 0 to 500 m if the transmission interval of the EK80 was forced to 2 seconds while the transmission interval of the OS38 and ES60 was forced to 4 seconds. Although OS38 pings were observed at depth ranges greater than 700 m in the echograms of EK80 38 and 70 kHz, it would not affect the krill biomass estimation because only data from 0 to 500 m are used for the estimation. Nevertheless, Dr Abe cautioned that a seabed artefact due to the self-echo (double reflection of bottom) of the EK80 38 kHz appeared on the echogram when the bottom depth was around 1 500 m if the transmission cycle of the EK80 was forced to 2 seconds. In such cases, it would be necessary to change the transmission cycle in the field to accommodate the problem.

5.17 SG-ASAM-18/02 contained more detailed information on the dedicated krill survey in Division 58.4.1, planned for the 2018/19 season. This included information on planned supporting and analysis activities, including measurement of krill density and sound speed contrast, plans for collection of broadband data (see details under Item 6), and the use of the CCAMLR-2000 Survey protocol for data analysis

Other business

Broadband acoustics

6.1 SG-ASAM-18/05 outlined a proposal to investigate the utility of broadband signals for Antarctic krill acoustic surveys during the krill survey in Division 58.4.1 during 2018/19 on the Japanese research vessel *Kaiyo-maru*. Echo sampling by a Simrad EK80 echosounder in frequency modulation (FM) mode (broadband pulses) will be simultaneously performed during targeted RMT1+8 tows. Spectra of volume backscattering strengths will be calculated from the sampled echoes and their characteristics will be investigated in order to improve current krill identification methods. Also, the potential for the acoustic inference of orientation and length distributions of in situ krill will be investigated using the measured spectra and theoretical acoustic scattering models.

6.2 In response to a question about the possibility of collecting broadband acoustic data to infer orientation during krill surveys, Dr Amakasu noted that each broadband channel must be pinged sequentially to avoid cross-channel interference, so the acoustically sampled volumes are inappropriately different among four broadband channels at survey speeds. Furthermore, as there was a requirement to use single-frequency signals during the transects during the survey described in SG-ASAM-18/02, broadband data collection would only be performed during targeted RMT1+8 tows.

6.3 The Subgroup recognised the importance of the work on orientation inference from broadband data given the role of the orientation angle distribution of krill in biomass estimation and looked forward to receiving the results of the investigation at a future meeting.

6.4 Dr Macaulay provided an update on developments in the use of broadband acoustics in fisheries research from the ICES Working Group on Fisheries Acoustics Science and Technology (WGFAST) held in March 2018. This included details of the papers presented and a notification of the ICES training course on ‘Principles and Methods of Broadband/Wideband Technologies: Application to fisheries acoustics’ to be held in 2019. Of particular note to SG-ASAM was ongoing work to reconcile differences observed during inter-comparison measurements of single frequency data from EK60 and EK80 echosounders.

6.5 The Subgroup thanked Dr Macaulay and agreed that it was important to keep abreast of developments in this area noting that broadband acoustics, while it would be unlikely to be used during acoustic biomass surveys, is likely to provide important ancillary information to improve the interpretation of the identification and biomass conversion parameters used in those surveys.

Autonomous acoustic data collection

6.6 The Subgroup noted a proposal from Norwegian scientists to deploy autonomous acoustics data collection ‘Sailbuoys’ in conjunction with the research from the Norwegian vessel *Kronprins Haakon* in 2019. These devices are equipped with an EK-80 echosounder (333 kHz) and an acoustic modem for communication with moored instrumentation.

6.7 The Subgroup noted the potential advantages of the development of such autonomous data collection systems and looked forward to seeing the results from the first deployment in the Antarctic region.

Analysis of acoustic data from fishing vessels during un-designed surveys

6.8 The Subgroup noted a research proposal from Mr J. Canseco (Chile) to evaluate biomass estimates from non-designed surveys. The aim of the study is to compare density estimates using acoustic data of krill from krill fishing vessels during routine fishing operations with spatially contemporaneous estimates from the proposed large-scale survey in 2019. In order to do so there was a need to access raw acoustic data from those vessels fishing for krill during the period of the large-scale survey.

6.9 The Subgroup encouraged the development of collaborations between Chilean scientists, including acousticians and scientific observers, working on Chilean krill fishing vessels in the development of this project.

6.10 The Subgroup noted that the notifications of intention to fish for krill (Conservation Measure (CM) 21-03) includes information on which vessels are proposing to fish for krill and also details of the echosounder equipment on board those vessels and that this would provide a means to identify potential collaborators.

Advice to the Scientific Committee and Future Work

7.1 The Subgroup noted that progress had been made on some of the important elements of future work identified by SG-ASAM-17 (SC-CAMLR-XXXVI, Annex 4, paragraphs 6.1 and 6.7), including the comparison of the swarm-based approach with the dB window method, nonetheless all of those future work topics identified by SG-ASAM-17 remained relevant to the work of the Subgroup.

7.2 Areas of additional future work identified by the Subgroup in this meeting include:

(i) review and clarification of the terminologies is needed to reflect the development of acoustic techniques considered by SG-ASAM (paragraph 3.3)

(ii) specific analysis to improve the comparison between swarm-based and dB window methodologies (paragraph 3.8)

(iii) reanalysis of data from Korean surveys the using the dB difference window and the swarm-based method (paragraph 4.3).

7.3 The Subgroup suggested that a joint survey analysis workshop be held for the Norwegian-led and Japanese surveys that will be conducted in 2019 to ensure consistency in acoustic analysis procedures and result production. The Subgroup encouraged the participants of the krill surveys in Division 58.4.1 and Area 48 to collaborate more broadly and look for opportunities to combine data and make comparative studies of these two contrasting areas.

7.4 The Subgroup noted the proposal for a joint workshop between SG-ASAM, WG-EMM, WG-SAM on Acoustic survey methods and design to facilitate feedback management (FBM) in 2019 (SC-CAMLR-XXXVI/BG/40) according to the priorities of the Scientific Committee. Noting the proposed workshop to analyse acoustic survey data from Norwegian and Japanese surveys conducted in 2019, the Subgroup requested the Scientific Committee consider whether this would be instead of or in addition to the regular meeting of SG-ASAM.

7.5 The Subgroup noted that if the proposed workshop to analyse acoustic survey data was held prior to the joint workshop between SG-ASAM, WG-EMM, WG-SAM then the presentation of the preliminary results from these surveys could make an important contribution to the consideration of the acoustic survey methods and design to facilitate FBM.

Remote participation

7.6 Dr Fielding expressed her thanks to the Subgroup for facilitating her remote participation in the meeting via Skype, although she acknowledged that it was not the same as actually being in the meeting.

7.7 The Subgroup noted that this had been very successful in the case of one person joining the meeting remotely but identified that additional facilities would need to be considered if remote participation in working group meetings was to the rolled out more broadly.

Adoption of the report

8.1 The report of the meeting was adopted.

Close of the meeting

9.1 At the close of the meeting Dr Zhao thanked all participants for their productive and positive contributions to the work of SG-ASAM. Dr Zhao also thanked Dr Cardenas and his team at INACH for creating such a warm atmosphere for the meeting. He also thanked the Secretariat for their efficient support to the meeting.

9.2 Dr Zhao also thanked Dr Fielding for her remote contribution to the meeting especially given differences in time zones and looked forward to her participation in person at future meetings.

9.3 On behalf of the Subgroup Dr Reid thanked Dr Zhao for his guidance, patience and technical expertise in convening the meeting recognising that this had ensured the effective engagement of all participants.

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Appendix A

List of Participants

Subgroup on Acoustic Survey and Analysis Methods
(Punta Arenas, Chile, 30 April to 4 May 2018)

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Appendix B

Agenda

Subgroup on Acoustic Survey and Analysis Methods
(Punta Arenas, Chile, 30 April to 4 May 2018)

1. Opening of the meeting
2. Calibration of echosounders
3. Methods for the collection and analysis of krill acoustic data from fishing vessels
4. Analysis of data collected from fishing vessels
5. Survey methods
6. Other business
7. Advice to the Scientific Committee
8. Adoption of the report and close of the meeting.

Appendix C

List of Documents

Subgroup on Acoustic Survey and Analysis Methods
(Punta Arenas, Chile, 30 April to 4 May 2018)

SG-ASAM-18/01	Comparing two and three frequency dB window identification techniques for estimating Antarctic krill density S. Fielding
SG-ASAM-18/02	An outline of narrowband echosounder survey methods to estimate biomass of Antarctic krill in CCAMLR Division 58.4.1 during 2018/19 season by the Japanese survey vessel, *Kaiyo-maru* K. Abe, K. Amakasu, R. Matsukura, T. Mukai and H. Murase
SG-ASAM-18/03	Revised outline of the dedicated krill survey for CCAMLR Division 58.4.1 during 2018/19 season by the Japanese survey vessel, *Kaiyo-maru* H. Murase, K. Abe, R. Matsukura, H. Sasaki and T. Ichii
SG-ASAM-18/04 Rev. 1	Comparison of NASC values calculated by swarm-based and grid-based acoustic data processing methods for Antarctic krill density estimation X. Yu, X. Wang and X. Zhao
SG-ASAM-18/05	A plan for Antarctic krill survey with a scientific broadband echosounder onboard R/V *Kaiyo-maru* in the CCAMLR Division 58.4.1 during 2018/19 season K. Amakasu, K. Abe, R. Matsukura, T. Mukai and H. Murase
SG-ASAM-18/06	Evaluation on the performance of echosounder on a fishing vessel using maximum seabed backscattering X. Wang, X. Yu and X. Zhao
SG-ASAM-18/07	Multinational large-scale krill synoptic survey in CCAMLR Area 48 in 2019 – survey plan and protocol for consideration by SG-ASAM 2018 B.A. Krafft, O.A. Bergstad, T. Knutsen, G. Skaret and G. Macauley
SG-ASAM-18/08	Estimating density and biomass of Antarctic krill (*Euphausia superba*) around South Shetland using the 2-dB difference method S. Choi, K. Lee and D. An
SG-ASAM-18/09	Preliminary results on the distribution and abundance of Antarctic krill (*Euphausia superba*) in the Weddell Sea, Southern Ocean F.W. Shabangu

Appendix D

The 2019 large scale krill survey of Area 48

Acoustic sampling protocols

1. The following protocols are set for the purpose of standardising acoustic data collection and archival from multiple ships during the multinational effort to synoptically survey the entirety of Area 48 during the austral summer of 2018/19. Methods for data analysis are not considered here, rather the primary objective of these protocols is to make the data collections as comprehensive and uniform as possible across all research platforms. Whenever possible, exact equipment, software and settings have been specified. In the cases where exact matches are not possible, pertinent comparative information has been specified.

Echosounder

2. The following echosounder models are acceptable to use:

(i) Simrad EK60, software version ER60 2.4.3

(ii) Simrad EK80, software version EK80 1.12.1 (a more recent version will be available before the survey and this will most likely be recommended)

(iii) EK80/ES80 software be used to control the GPT instead, as this avoids the triangle wave error present in ES70 data. However, it is acknowledged that moving to EK80/ES80 software requires a more powerful computer to run the software and that this may not be feasible.

Transducers

3. Preferred transducer models have 7° conical beamwidths that allow approximately equivalent insonified volumes.

38 kHz: Simrad split-beam (e.g. ES38-7, ES38B)
70 kHz: Simrad split-beam (ES70-7C)
120 kHz: Simrad split-beam (e.g. ES120-7, ES120-7C)
200 kHz: Simrad split-beam (e.g. ES200-7, ES200-7C).

4. Single-beam transducers at the same frequencies are acceptable if there is at least one split-beam transducer co-located with the single-beam transducer to allow for efficient calibration of the single-beam transducer.

5. Transducers with beamwidths other than 7° may be acceptable. However, using a standard 7° conical beam width would ensure approximately equivalent insonified volumes. This will be advantageous for employing multi-frequency methods for swarm delineation.

6. Mounting configuration should be documented by scaled technical diagrams, suitable for positioning them on both the alongship and athwartships axes. Record should be made of blister, or trunk dimensions and location on hull; acoustic window material and acoustic properties; and the transducer depths, dimensions and relative locations.

7. The transducers should be mounted as close to each other as possible.

Settings

8. Echosounder settings files should be agreed upon and used by all survey participants for the survey, calibration and noise measurement operations; only settings determined by individual system calibrations might differ (e.g. gain, Sa correction, beam angles, transducer depth).

9. Before the initial calibration experiments, critical system-specific settings should be updated following Table 2 in this appendix and specifications and should not be changed. Compliance with the prescribed settings should be checked daily.

10. Particularly notable settings:

(i) For EK80/ES80: use single-frequency pulses (CW not FM).

(ii) For EK80/ES80 the pulse slope must be set to ‘Fast’.

(iii) A pulse repetition rate of 2.0 seconds will be used for survey and noise measurements. Faster rates (0.5 seconds) should be appropriate for calibration.

(iv) Pulse durations of 1.024 ms will be transmitted at all three frequencies.

(v) The transducer depths will be set to the nominal mounting depths for each transducer.

(vi) A mean sound speed and mean absorption coefficient will be provided; all echosounders will be set using these values. Note a CTD prior to calibration will be used to set these values during calibration, but the mean values should be used for the survey and noise measurements.

(vii) Data for each ping and frequency will be recorded at 0–1 100 m for EK60 and ES70 and for EK80/ES80 within the following ranges:

(a) 38 kHz: 0–1100 m
(b) 70 kHz: 0–1100 m
(c) 120 kHz: 0–500 m
(d) 200 kHz: 0–300 m.

(viii) Echosounder time should be reset to correspond with logging PC/GPS time at the start of each day’s survey at a minimum – or synchronised to the ship’s GPS network clock using appropriate software.

(ix) Echosounder computer time must be within 5 seconds of the GPS time.

(x) Time must be entered in UTC, which needs to be used as the only time for all logging and sampling procedures aboard. The use of UTC should be cross-checked among the acoustic, biological and oceanographic components of the cruise.

(xi) The log menu/distance will be set only once to 0.0 n miles at the end of the initial calibration.

Data logging

(i) Data must be logged continuously in .raw format into dedicated hard drives.

(ii) A daily backup must be carried out (e.g. on to a second external hard drive or network server).

(iii) Data discs can be provided by IMR, on request.

System calibration: standard sphere calibrations

(i) Ideally, system calibrations will be performed at all frequencies immediately before and after the survey in appropriate locations. However, a single calibration at appropriate sites within the study area in the survey period is required. Suitable locations should be free from strong freshwater input. Good examples of suitable locations within the study area include Rosita Harbour and Stromness Bay, South Georgia; Scotia Bay, South Orkney; and Admiralty Bay, King George Island.

(ii) Sphere calibration must follow ICES CRR 326 standard procedures (Demer et al., 2015). Some particular issues to be highlighted:

(a) if at all possible, the transducer faces must be cleaned of debris and bio-fouling prior to the initial calibration

(b) during the entirety of both pre- and post-survey calibration experiments, all acoustic data will be logged in .raw files

(c) record must be made of the calibration: date; time; location; sea state (swell, wind, currents, ice); water temperature profile; salinity profile; sound speed profile; bottom depth; calibration apparatus; and ship's mooring configuration

(d) the 38.1 mm WC sphere must be used as the standard target. If possible, spheres will be purchased from a single production batch and provided to all parties by the Norwegian Institute of Marine Research (IMR)

(e) a calibration rig can be borrowed from another nation or the Association of Responsible Krill harvesting companies (ARK)

(f) theoretical TS = f (bandwidth and sound speed) will be provided (Table 1) for the EK60 and ES70. For the EK80, the sphere material properties are entered into the EK80 calibration program

(g) the calibration parameters should be estimated using the echosounder software of either the ER60 (for EK60 and ES60) or the EK80 (for ES70 and EK80)

(h) it is recommended to update calibration parameters before running the survey.

System check

11. Echosounder operation checks must be carried out daily. These checks are to include:

(i) examination of the spatial distribution of single target detections to check for abnormal distributions

(ii) for the ES80/EK80, use of the BITE view to monitor the transducer impedance

(iii) inspection of the background noise level as reported by the echosounder software.

12. If feasible, the use of the seabed echo amplitude as an echosounder operation check is encouraged.

Pre-cruise characterisation of system noise

13. A pre-cruise background noise characterisation is required before the cruise in order to establish a baseline noise level and identify the speed at which appropriate quality data is collected. In order to do this, data are required to be collected in passive or active mode, using prescribed settings (Table 2) in water depth greater than 50 m (in passive mode) or greater than 300 m (in active mode). Data collected should cover a range of speeds. Ideally, 15 minutes per 6 knots, 7 knots, 8 knots, 9 knots, 10 knots, 11 knots and 12 knots.

Survey operations

14. Whenever possible, survey at a constant speed of 10 knots (or as instructed from pre-cruise characterisation of system noise – see above); acoustic noise perceived by each of the echosounder frequencies will be routinely monitored and speed adjusted if needed to reduce noise or increasing speed to maintain schedule as needed (provided noise level is acceptable).

Necessary preliminary investigations

15. Bench test echosounder using chosen settings and logging options.

Metadata logging

16. Metadata must be logged according to ICES (2016), trawl metadata will be recorded as part of the trawl station work and catch recording. Logging of environmental data should follow Table 3. Acoustic metadata is automatically recorded by the echosounders.

17. A survey log must be kept. This log must include these items:

(i) start and stop times and positions of transects

(ii) times and positions of other survey activities (e.g. trawls, oceanographic stations, calibrations)

(iii) other items of note that are relevant to the survey, such as diversion of vessel from transects, reasons for doing so, equipment problems, etc.

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Table 1: Calibration sphere target strength values
Sphere diameter = 38.1 mm
Sphere density = 14900 kg m^{-3}
Sphere compressional sound speed = 6864 m s^{-1}
Sphere shear sound speed = 4161.2 m s^{-1}
Water density = 1025.3288 kg m^{-3}
Pulse duration = 1.024 ms

Sound speed (m/s)	Sphere TS at 38 kHz	Sphere TS at 70 kHz	Sphere TS at 120 kHz	Sphere TS at 200 kHz
1450	–42.01	–40.56	–39.84	–39.44
1455	–42.06	–40.65	–39.76	–39.48
1460	–42.11	–40.74	–39.69	–39.50
1465	–42.16	–40.83	–39.63	–39.50
1470	–42.20	–40.92	–39.58	–39.48
1475	–42.23	–41.01	–39.54	–39.44
1480	–42.26	–41.09	–39.52	–39.38
1485	–42.29	–41.18	–39.5	–39.30
1490	–42.31	–41.25	–39.51	–39.22
1495	–42.32	–41.33	–39.52	–39.13
1500	–42.33	–41.39	–39.55	–39.04
1505	–42.33	–41.45	–39.59	–38.96
1510	–42.33	–41.50	–39.63	–38.90
1515	–42.33	–41.54	–39.69	–38.85
1520	–42.32	–41.57	–39.76	–38.81

Table 2: Echosounder settings

Parameter	Value	Comment
Pulse duration	1.024 ms	
Transmit power	38 kHz: 2 000 W	
	70 kHz: 750 W	
	120 kHz: 250 W	
	200 kHz: 150 W	The selectable values differ slightly between the EK60/ES70 and EK80/ES80. Choose the closest value that is equal to or less than the given values.
Pulse slope	Fast	Only applicable to ES80/EK80 systems.
Ping interval	2.0 s	
Vessel speed	8–10 knots	Subject to sufficiently low noise levels.
Sound speed	1 456 m s^{-1}	Obtained from Table 1 of Demer (2004), derived from Scotia Sea measurements.
Absorption coefficient	38 kHz: 10.4 dB km^{-1}	
	70 kHz: 18.9 dB km^{-1}	
	120 kHz: 27.7 dB km^{-1}	
	200 kHz: 41.3 dB km^{-1}	Obtained from Table 1 of Demer (2004), derived from Scotia Sea measurements. 70 kHz value derived from weighted harmonic mean temperature and salinity values from the same table.
Data recording depth	38 kHz: 1 100 m	
	70 kHz: 1 100 m	
	120 kHz: 500 m	
	200 kHz: 300 m	For EK60/ES70 systems use 1 100 m for all frequencies.
Pulse type	CW	Only applicable to ES80/EK80 systems.

Table 3: Environmental data to be recorded

These are to be collected four times daily (00:00, 06:00, 12:00, 18:00 UTC) as per the WMO Voluntary Observing Ships Scheme, following guidelines provided in the US National Weather Service Observing Handbook No. 1 (2010).

Wind speed	
Wind direction	
Sea state	
Ice conditions	
Ice cover	
Cloud cover	
Air temperature	
Dew point	

Annex 5

CCAMLR Independent Stock Assessment Review for Toothfish
(Norwich, United Kingdom, 18 to 22 June 2018)

Convener's report by C. Reiss

Contents

CCAMLR Independent Stock Assessment Review for Toothfish
(Norwich, United Kingdom, 18 to 22 June 2018)
Convener's report by C. Reiss

Overview

1. The purpose of this summary is to provide key ideas and findings from the CCAMLR Independent Stock Assessment Review in order 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 (SAs) relative to international best practices, and to suggest improvements to the assessment methods where appropriate. Given the number and diversity of assessments across two species (Patagonian toothfish – *Dissostichus eleginoides* and Antarctic toothfish – *D. mawsoni*) and multiple areas (Subareas 48.3, 48.4, 88.1 and small-scale research units (SSRUs) 882A–B and Division 58.4.2), the review is necessarily broad. The review panel (RP) and principal SA scientists familiar with each of the four CCAMLR SAs met at the University of East Anglia, Norwich, UK, from 18 to 22 June 2018 (Agenda and schedule – Appendix A). The RP consisted of Dr N. Cadigan (Canada), Dr M.-P. Etienne (France) and Dr M. Maunder (Inter-American Tropical Tuna Commission) and was convened by Dr C. Reiss (USA) (Review panel and attendees – Appendix B). Prior to the review, the RP was provided with approximately 120 documents from the four CCAMLR assessments to review. The CCAMLR assessment scientists (Dr T. Earl (UK), Dr S. Mormede (New Zealand) and Dr P. Ziegler (Australia)) were asked to develop summary documents to guide the expert group and presentations (www.ccamlr.org/node/104099) to explain how data, modelling and assumptions of the reviewed SAs were developed. In addition, these assessment scientists and other CCAMLR experts provided background documents for reference. The number of documents provided to the RP demonstrated the continued development of the SAs and highlighted the commitment of CCAMLR to a detailed assessment review.

General findings

2. An important first point agreed by the experts was that a more standardised format be developed by CCAMLR for the presentation of details of the various 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-year period). The RP also felt that this review effort was timely, but that in future, external reviews should focus on fewer issues and cover topics in more detail.

3. The RP concluded that 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. 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. CCAMLR's approach with tagging studies makes it a leader in this area, and this knowledge is of interest to the broader SA community. Where possible, scientists from

Members should contribute to this in other international SA fora (NSAW, CAPAM, ICES, etc.). Additionally, changes to the CASAL modelling framework, that will implement many of the smaller changes and investigations suggested throughout this review document, are noteworthy and will be useful.

4. The RP further concluded that overall, CCAMLR SA scientists applied assumptions in the SAs in a precautionary manner, when there is uncertainty in parameters and assumptions. The RP, given its understanding of the CCAMLR approach to management, considered management of these fisheries consistent with CCAMLR's approach. Additionally, in most instances examined, appropriate practices are being followed and the assessments continue to adapt to new standards. 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.

5. Among the many considerations provided to CCAMLR by the RP in the following sections, two are worth noting. The presence of longline and trawl surveys that catch younger fish in the populations is an important component of data collected by CCAMLR Members conducting assessments. The RP concluded that these surveys were important to the assessments because they provide data to inform the assessments and also to monitor recruitment strength. Such surveys provide an early detection of recruitment failure and are an added measure of precaution for the long-term management of toothfish in accordance with Article II of the Convention. Where possible, such surveys should be continued and optimised to ensure recruitment variability can be detected.

6. The review also demonstrated that geographic variability of these toothfish fisheries and the restricted movement and complex spatial patterns of habitat use of toothfish makes interpretation of fishery, survey and tagging information more complicated. This creates an impetus to increase scientific effort to model the spatial aspects of the fisheries and the fish and include this in the SA process. The RP was presented with many instances where the assessment scientists considered spatial structure in fishing and population dynamics indicating a high level of understanding of the importance of this component to the assessment of these fisheries in the future. The RP considered assessing these stocks in a manner cognisant of the impact of spatial processes on vital rates, fishing mortality and parameter estimation to be a critical element of the long-term precautionary management of Southern Ocean resources.

7. CCAMLR, through its Members' national research programs, is encouraged to support this research priority (spatial modelling, field experiments and laboratory analysis).

Review of findings based on terms of reference

8. The terms of reference (Appendix C) revolved around two general themes and five groups of questions and this summary is organised around these:

(i) data inputs, modelling assumptions and parameter choice

(ii) modelling implementation and practices: discussion and recommendations regarding –

(a) improvements to modelling

(b) improvements to data

(c) evaluation of the utility of alternative models and structures that could be explored.

9. The detailed comments by the RP to each of the terms of reference follow this summary.

1. Evaluations of adequacy of the data inputs, modelling approaches and methods

10. In most instances examined, appropriate practices are being followed and the assessments continue to adapt to new standards.

1.1 Review the data, observations (survey, catch-per-unit-effort (CPUE), tag, age, length), treatment and processing of observations

Stock hypotheses

11. Appropriate boundaries to define the stock to be assessed are critical to proper fisheries management. The complex life history of toothfish has required considerable study to appropriately define stock boundaries for assessments. The RP did not discuss the many types of studies that contribute to the understanding of the spatial extent of these stocks, or that describe their physical life history. However, a number of assessments described the proposed stock hypotheses, and described ideas for future work. **The RP suggested that appropriate experts be consulted and a review be planned if these assessments or CCAMLR require evaluation of the hypotheses.**

Surveys/indices of abundance

12. Indices of relative abundance are a main component of most contemporary SAs. The toothfish assessments are different in that they have multiyear tagging programs and therefore the relative indices of abundance are less important. However, a variety of indices of abundance are available from both surveys and commercial catch-per-unit-effort (CPUE) and their use varies among the assessments.

13. For example, a random stratified trawl survey designed for icefish is conducted in Subarea 48.3, but is not used in the assessment because its index and length composition are highly variable and the assessment model does not fit these data well. CPUE data is used in this assessment, which is broken into two periods (1998–2003 and 2004–2017), based on the availability of data on the presence of cetaceans. A CPUE index is available for Subarea 48.4, but is not used in the SA.

14. A randomised stratified longline survey is conducted in Subarea 88.1 and SSRUs 882A–B and is used in the assessment. However, the relative index is down weighted so that it has little influence on the results and therefore it is the age composition data that is providing information on the recruitment strength. The use of the survey age composition data is important because the commercial fishery age composition data is highly variable and does not provide information on recruitment strength. **Consideration should be given to restricting the data**

from the survey to be more representative of recruitment. For example, the data could be limited to young/small fish or the areas occupied by juveniles. The survey requires a catch limit and issues arise when catch rates are high such that the catch limit would be reached before the survey is completed, requiring modification of the survey design. This is undesirable and may bias the results. **Consideration should be given to designing the 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.**

15. A random stratified trawl survey is available for Division 58.5.2. Historically, this survey information has been included as a set of relative indices at age or length, but in the current assessment the information is included as an overall index of relative abundance and proportions (i.e. compositions) at age or length. This change caused a moderate change in the SA results and it is not clear what caused the change, but it may be related to differences in the implied data-weighting given to the index and composition data versus the relative indices at age or length. Longline CPUE is also available.

16. The moderate influence of the method to include the survey data into the Division 58.5.2 assessment highlights the need to further investigate the methods. Inclusion of age-specific indices is the traditional approach when using virtual population analysis (VPA) assessments and implies a completely free, but time invariant, selectivity curve as represented by the catchability parameters. This approach also allows for convenient data weighting by estimating the standard deviation of the likelihood function for each age-specific index. However, it ignores the correlation among ages in survey indices and has to separate the periods when only length data is available from those that have age data. Also, for a long-lived species or for length composition data, there will be a large number of indices or the compositions would have to be grouped into a smaller number of categories. The approach used in contemporary statistical catch-at-age models is to fit to an aggregated index of relative abundance and age (length, or both) composition data and estimate a selectivity curve based on a functional form. The selectivity curve could be made more flexible to better represent the assumptions used in a traditional VPA. The appropriate weighting of the composition data is more complicated (e.g. should the Francis method should be used), and the correlations are not taken into account using the commonly used multinomial likelihood. A more appropriate approach might be to fit the index-at-age data using a multivariate likelihood function and the empirical variance–covariance matrix. However, this only accounts for the observation error and does not account for the unmodelled process variation and model misspecification which should be addressed. In addition, an appropriate multivariate likelihood function may not be available in the assessment software.

17. The index of abundance from Subarea 88.1 and SSRUs 882A–B longline survey of juveniles was down weighted so that essentially only the composition data informed the model parameter estimates (e.g. the annual year-class strengths). This suggested that even if the sampling for CPUE is too variable (a few large catch sets or tows influencing the index) or too narrow in its spatial extent, the composition data might be stable and useful in informing the annual year-class strength, therefore it should still be considered for use in the assessment model even if the index of abundance is not.

18. It is important for the index of relative abundance to be based on a complete coverage of the available toothfish habitat. Indices of abundance based on the fishery CPUE may be limited in their spatial coverage. The approach used in Subarea 48.3 of supplementing the fishery CPUE with sets taken in areas not covered by the normal fishery operation is a good way of improving the fishery CPUE-based index of relative abundance.

19. The tagging data provides a substantial amount of information on absolute abundance in additional to other population and fishing processes. Therefore, the need for indices of relative abundance on adult toothfish is reduced. This suggests that focusing surveys on providing information on juveniles might be important for both improving SAs and providing early information on weak recruitment.

Growth and age composition data and computation

Data sources

20. Length and age data are fundamental building blocks for many SAs and are used to build age–length keys (ALK) and to estimate growth functions, to calculate other age- and length-specific life history traits (mortality, maturity and biomass) and are thus critically important to correctly specify or model in assessments. The age data is used in ALKs to construct catch-at-age from catch-at-length and to estimate the von Bertalanffy (VB) growth curves used in the assessments. The VB curve is used to generate age at release for the tagging data outside the assessment model, and inside the SA model to calculate expected length for fitting length composition data and recaptures at length, and calculating biomass from numbers at age. This section details the available data to inform length and age composition, and is divided into four subsections: (1) describes the available data; (2) how the relationship between age and length is modelled in the SAs; (3) estimation of the VB curve in the assessments; (4) conversion of age to weight to calculate biomass.

21. All assessments currently collect information on the age of fish in the catch using length-binned sampling to ensure better coverage of the age range. In some assessments the use of length-bin sampling is recent but also coupled with random sampling of the lengths in the catch.

22. In all CCAMLR subareas, fish from these length-binned samples are aged, although some laboratory methods differ between assessments. Laboratory ageing practices seemed appropriate using standard methods (multiple readers, reference collections, occasional interlaboratory comparisons) which is reviewed during routine SAs. However, in some cases just a single experienced reader has been used. **The RP suggested that, where possible, increasing the number of readers to a minimum of two experienced readers, within laboratories, would be beneficial.**

Linking length and age

23. ALKs are used to transform the length composition of the catch into catch at age. These observations are then used in the integrated models as part of the likelihood fit function. ALKs are derived for each year, for each assessment, and for fleet categories. However, in Subarea 48.4, the ALK from Subarea 48.3 is used because the total catch is small in this area. Additionally, in Subarea 88 the ALK is derived from a part of the fishery, but is also split by sex and by geographic area (slope/shelf and North) to account for possible spatial and sexual variability in growth.

24. Because ALKs are constructed annually, the assessments can account for any temporal changes in the ALKs. **Some members of the RP suggested that the nonparametric**

estimation of ALKs might introduce unnecessary noise in the catch-at-age composition so the assessment scientist might consider smoothing the data. However, this additional variability may not have much impact on the SA models because selectivity functions are assumed to be constant within fleets in these assessments. Nevertheless, it would be interesting to investigate how smoothing the ALK matrix (by applying a kernel or use some sort of spline function) would affect the SA.

25. In cases when few data are available in a given year, some assessments have used two years of data to construct their ALKs which implicitly assumes the ALK is constant between years. In these cases the assessment scientist might consider conducting studies on the effect of removing data from the corresponding years.

Growth curve

26. The relationship between length and age in all four assessments is modelled using a VB growth curve. It is used in a number of ways in the CASAL models including, (i) to convert expected number at ages to expected number at length, and the latter are involved in the likelihoods, (ii) to allocate total catch to different age classes, (iii) to compute ALKs when no aged fish are available (e.g. the first years of a fishery), and (iv) to convert length of tagged fish to age at time of release and recapture.

27. The different assessments use different approaches to construct the VB growth models based on specific differences in fisheries in their areas. For example, in Division 58.5.2, the SA uses all available age–length data up to 2017 because only the most recent data have older fish and inclusion of those recent years greatly improves the quality of the estimation. Similarly, in Subareas 88.1 and SSRUs 882A–B, because of the spatial differences in size and sex, a VB curve is estimated for each by sex and by area (six estimates). In cases where the VB model has not been updated, the SA scientists should consider updating the estimation of these VBs on a regular basis. In addition, the assessment should investigate whether any temporal changes are occurring in the VB relationship.

28. The use of commercial catch and the length-stratified design used to sample ages often leads to biased estimation of the VB model because of fishery and sampling selectivity. The SA scientists in some assessments use the Candy et al. (2007) method to account for sampling bias and selectivity. **The RP suggested that all SAs implement this or some other method to account for these potential biases. One member of the RP suggested that the SA scientists explore the use of a hierarchical model to share information between stocks of Patagonian toothfish to examine the impacts on the VB curve fit.**

29. Some SAs exhibit quite variable VB curves depending on the years selected to fit the curve. This high variability may have several sources, including spatial structure in the sex and maturity and the distribution of the stock. Therefore, depending on the spatial location of the catch, the targeted local population changes and this may produce different curves. In such cases the RP recommended that this variability be further investigated. **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 suggested that this be investigated occasionally to ensure that no biases occur.**

30. Because changing the VB can affect the calculated virgin biomass, and thus the depletion estimates, **the RP suggested that the SA scientists explore whether the fitted VB in these cases is sufficiently precautionary. The RP also suggested 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. In the VB estimation, the L_∞ parameter is influenced by data from younger fish as well as older fish, and this is especially a problem when there are many young fish in the sampling set. **The RP recommended that sensitivity analyses be used to assess the impact of the different choices of the growth model on SA results and on biological reference points.**

31. In the four SAs reviewed, CASAL computes spawning biomass from numbers at age. Going from number at age to spawning biomass requires several transformations, including using the maturity function to convert from number at age to mature number at age, and the VB growth curve and a weight–length relationship to convert from mature number at age to spawning biomass. The assessment should investigate how uncertainty at each step impacts the overall uncertainty of the virgin biomass.

Tagging data and analyses

32. In this section, issues related to how information from recaptures of tagged fish by the fishery was used in the SAs are considered, and in particular the methodologies for including recapture information in the CASAL assessment models. The RP concluded that these tagging programs were designed well overall given the practical limitations, and the tagging information greatly contributes to improving the reliability of the toothfish SAs. Tagging data is essential for the toothfish stocks due to the conservative management that limits contrast in the fishery and survey time series and reduces the information about absolute abundance in the indices of relative abundance.

Spatial overlap

33. An important issue identified by the stock experts and further explored during the review meeting involved the spatial overlap in the locations where the tagged fish were released and where the commercial fishery, which recaptured the tagged fish, operated in subsequent years. This issue is accentuated due to the limited movement of toothfish (incomplete mixing). In an idealised and optimal tagging study, complete mixing between tagged and untagged fish would occur due to movement, or fish would be tagged in proportion to abundance. The toothfish tagging programs were designed to spread out tagging effort spatially by having a per-tonne (usually 1-per-tonne) tagging requirement. This insures that fish are tagged throughout the spatial range of the fishery, but not necessarily the stock. The RP concluded this was a good design element of the tagging program.

34. A problem identified by the RP with the tagging program was that the spatial range of the fishery could vary substantially and change systematically with time (i.e. years). Combined with the apparent low mobility of toothfish, this means that in subsequent years the spatial distribution of tagged fish may not overlap well with the spatial distribution of the fishery, and this will be a source of uncertainty and probable bias. This is a problem given that fishery harvest rates vary spatially. In this case, poor spatial overlap in tagging and the fishery could

result in biased estimates of stock size, but the magnitude and direction of the bias will depend on the spatial differences in harvest rates in areas where tagged fish densities are high compared to areas where tagged fish densities are lower (including zero):

(i) The overlap issue was identified as a problem for the Division 58.5.2 stock and therefore it was decided to limit the data used for the assessment model estimation to 2012–2015. In these years, the spatial overlap between tagging and fishing in subsequent years was considered to be good. The substantial tagging information collected during 2003–2011 was not used for model estimation, because of poorer spatial overlap. The RP concluded that this was appropriate, but fine-scale spatial models may allow for the appropriate use of the earlier data.

(ii) The RP concluded that this was not an important issue for the Subarea 48.3 and Subarea 48.4 stocks because of the generally good overlap between the tagging locations and the fishery. Fish were also tagged outside the area of the fishery to extend the spatial coverage of tagging.

(iii) This was identified as an issue for the Subarea 88.1 and SSRUs 882A–B stock because of the variable spatial distribution of the fishery from year to year. The RP concluded that this was a source of uncertainty in the assessment, but did not consider that this is a source of bias.

35. **The RP recommended further investigation of the fine-scale spatial model used in the restricted spatial regression (RSR) to deal with interannual variation in the spatial distribution of the fishery and the incomplete overlap between releases and recaptures should be considered.**

Growth of tagged fish

36. The SA models used size-structured tag-release and recapture data. Data were aggregated in 10 cm length bins. All assessment models calculated the expected tag catch per length bin using a stochastic (i.e. with between-individual variability) VB model derived from size-at-age data. The VB growth curve was used to calculate tag release numbers-at-age. The VB model was the same for all years and was sex-specific only for the Subarea 88.1 and SSRUs 882A–B stock. Using a single VB model will not be appropriate if the growth rates in the stocks have changed over years. The RP was not provided with an analysis of changes in growth rates for the Division 58.5.2, Subarea 48.4 and the Subarea 88.1 and SSRUs 882A–B stocks. Annual size-at-age information was provided for the Subarea 48.3 stock but information on the statistical significance of annual differences in VB growth function was not provided. The statistical significance of the difference in male/female VB curves was also not provided. **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 recommended that more flexible growth curves be investigated.**

37. **The RP recommended 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.** Using annual ALKs will account for potential spatio–temporal changes in the distribution of size-at-age. Such changes can be a source of uncertainty and potential bias if the change is systematic over time.

38. The Subarea 88.1 and SSRUs 882A–B and Division 58.5.2 stocks used a tagging growth retardation effect. The potential for growth retardation seemed reasonable to the RP; however, little information on this effect was provided.

Data weighting

39. A binomial log-likelihood term is used by CASAL to include tagging information in the model estimation. This log-likelihood term can be weighted. In these assessments the weighting was calculated based on Poisson over-dispersion of the mean length of recaptured fish observed versus expected. It was not clear to the RP if this specific procedure was appropriate, but the RP agreed that accounting for over-dispersion of tagging data is important in the estimation of the assessment model. This over-dispersion factor was calculated only once based on the unweighted model configuration. Weighting was calculated by year of release, and then an average weight was calculated, although the averaging procedure for averaging varied by stock. **The RP recommended 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.

Tag loss

40. All fish in the tagging experiments for the four stocks were double tagged. The capture rates of fish with only one tag give information on tag loss rates. The individual loss rate of a single tag can be used to infer the cumulative rate at which a fish will lose both tags and thereby be undetected if caught in toothfish fisheries. This was approximated as a single-tag shedding rate that varied with age at liberty as an input to CASAL because this software package does not directly accommodate data from double-tagged fish. An issue is that the retention rate of at least one tag is a concave function of age that must be approximated as a convex function in CASAL. The RP concluded that the assessment procedures for accounting for tag loss was appropriate but could be slightly improved.

41. The description of the tag loss rate estimation for Subarea 88.1 and SSRUs 882A–B was in a document (WG-SAM-11/18) but the RP did not have time to fully discuss the application of this method for these areas. This was also not described for the stocks in Subarea 48.3 and Subarea 48.4. The RP noted that the tag-retention analysis for Division 58.5.2 was updated. For the Division 58.5.2 stock, tag loss rates were found to be different for longline and trawl fisheries, and also to be different for three time periods (2003–2006, 2007–2011, 2012–2015). The RP suggested that it is timely to update this analysis for the stocks in Subareas 48.3, 48.4, 88.1 and SSRUs 882A–B 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.

42. A small increase in tag loss rates was used in the Division 58.5.2 SA to account for a small amount of emigration of tagged fish out of the stock area. The RP concluded that this procedure was appropriate because the movement rates were low. If movement rates were higher, a different procedure may be necessary.

Initial tagging mortality

43. Little information was available to assess initial tagging mortality. This was emphasised in the Division 58.5.2 stock presentation. Two studies were cited that suggested initial tagging mortality was less than 10%. As a precautionary measure, the assessments all assumed that initial tagging mortality was 10%.

44. Analyses for Subarea 88.1 and SSRUs 882A–B indicated that this mortality rate could vary greatly for different vessels, depending on the protocols used. A procedure was outlined for Subarea 88.1 and SSRUs 882A–B to adjust tagging mortality rates for some vessels. **The RP encouraged future research on the estimation of initial tagging mortality rates, and factors that may cause this to vary.** This could include the use of on-board tank studies of several weeks to provide minimum short-term tagging mortality information.

45. A modelling approach based on a reference set of vessels may be useful to estimate tagging mortality for other vessels. An alternative approach is to limit tagging data used in the assessment model to vessels believed to have low tagging mortality.

Tag detection

46. Tag detection was considered to be very good for the Subareas 48.3 and 48.4 and Division 58.5.2 stocks. This was because all fish were handled by fishers and trained observers involved in the tagging program. However, in Subarea 88.1 and SSRUs 882A–B information was presented that indicated that tag detection could be very different for some vessels in some years. Similar to tagging mortality, the RP encouraged future research on the estimation of tag detection rates, and factors that may cause this to vary.

47. **The RP recommended that implementation of good tagging protocols (release and recapture) be encouraged for all vessels involved in these fisheries.** Over-estimation of tagging mortality rates and under-estimation of detection rates will lead to under-estimation of exploitation rates. Misidentifying or unmodelled trends in tagging mortality and detection rates could also cause bias in estimation of natural mortality rates, particularly if the trends are not accurately accounted for in the SA model.

Emigration

48. Across all stocks, tagging information indicated that toothfish were usually not recaptured far from their release location, but occasionally this did occur. Emigration was accounted for in Subarea 48.3 and Division 58.5.2. An exploratory spatial model for Subarea 88.1 and SSRUs 882A–B was briefly presented.

Time at liberty truncation

49. Tagging data was limited to recapture years-at-liberty less than four for the 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 the Subarea 88.1 and SSRUs 882A–B

assessments. It was not clear to the RP why this year range differed. Part of the motivation for limiting this data was to reduce bias related to ontogenetic movements of fish as they get older, but another motivation was to reduce bias due to the mis-specification of the double tag loss rate in CASAL. However, this could be confounded with mis-specifying natural mortality (M). **The RP recommended further investigation of this issue.**

1.2 Review whether modelling assumptions, model structure, priors and penalties are appropriate (including assessment of both biological and fishery components)

Selectivity/fleet structure

50. Correct specification of the selectivity curve is important when developing SA models, and particularly when fitting to composition data. In general, fishery fleets are defined in assessment models to ensure that selectivities are as time invariant as possible. This requires determining groups of catch that have similar composition data. For example, fisheries are often defined by gear type and area.

51. Toothfish show ontogenetic movement from shelf areas to slope areas as they age over time. In Subarea 88.1 and SSRUs 882A–B they also appear to move from the slope to the northern area as they age. Therefore, the longline fishery is broken into fisheries by depth with each fishery having a separately estimated selectivity curve. Separating the catch into fishery fleets also facilitates the possibility of having an asymptotic selectivity for one fleet, which helps stabilise the model. The Subarea 48.4 assessment assumes asymptotic selectivity, but the other assessments estimate dome-shaped selectivities for all fisheries. Further, separation of the fisheries by depth or space might allow for the use of asymptotic selectivity.

52. The availability of tagging data may facilitate the estimation of dome-shaped selectivity for all fisheries. It also may allow the estimation of the dome-shaped selectivity simultaneously with natural mortality, which are typically confounded. Simulation analysis could be used to investigate the confounding.

53. Selectivity as represented in SA models includes both contact selectivity and availability. Availability is impacted by the spatial distribution of the fishing effort relative to the spatial distribution of the stock and its composition. Temporal changes in the spatial distribution of the fleet can translate into temporal changes in selectivity. 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–B and temporal changes in selectivity should be considered.

Natural mortality

54. Natural mortality is fixed at an assumed value in all the assessments and is not dependent on sex, age, or time. Component likelihood profiles were conducted for three of the stocks to determine what information is in the data about natural mortality. Much of the information about natural mortality comes from the tagging data as expected. The survey data for juveniles also has information about natural mortality indicating that natural mortality could be estimated

for both juveniles and adults, since the tagging data is mainly on adults and there is no fishery on juveniles. Since composition data was collected from when the fishery was initiated (virgin conditions), this also provides information on the value of the natural mortality rate.

55. Estimates of natural mortality rates may be confounded with other parameters such as dome-shaped selectivity, the initial tagging mortality, reporting rate and tag loss rates. Double-tagging experiments are used to estimate tag loss rates eliminating this confounding. Constructing the fishery fleets so that one is asymptotic would eliminate confounding with the declining limb of the dome-shaped selectivity. The multiple years of recaptures used in the model might eliminate the confounding with initial tag loss since it only occurs in the first year. Only the use of recapture vessels with reliable reporting rates that are close to one would eliminate the confounding with this parameter. Area differences in growth rates suggest that natural mortality may differ among stocks.

56. **The RP recommended 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.**

The recruitment standard deviation

57. The recruitment standard deviation is used in several ways in the assessment. It is used to define the distribution of recruitments used in projections and for penalising the estimated year-class strengths. These two uses can and do have different values in the toothfish assessments. In general, the standard deviation for the projections is set to represent the real variation in recruitment while the standard deviation for the penalty is set higher to provide a lower constraint on the recruitment variation. The projection can also be conducted by sampling the historically estimated year-class strengths.

58. The commonly used approach that models recruitment as a lognormal deviate requires the use of a lognormal bias correction factor to ensure that the stock-recruitment relationship represents the mean rather than the median. Although CASAL uses a lognormal penalty, it does not use this bias correction factor and defines a set of years over which the average is defined and rescales the year-class strengths for this period to average one. It should be noted that this also determines the period representing the recruitment used to determine the initial conditions, as adjusted by the stock-recruitment relationship. **The RP recommended that consideration should be given to adjusting the penalty for years in which there is incomplete information about year-class strength.**

Steepness

59. The same value (0.75) for steepness of the stock-recruitment relationship values is used in all the assessments and is precautionary. The short time series and the lack of contrast in the biomass due to the precautionary biomass target reference points make it unlikely that steepness can be estimated in the model. Steepness could be taken from estimates for related species, but it is debatable if there are any reliable estimates of steepness due to bias in estimating this parameter.

Sex structure

60. Including sex structure in SA models can be important if one or more of the population dynamics or fishing processes differ among the sexes. The processes that often differ are growth, natural mortality and selectivity. Selectivity in fisheries models is a combination of contact selectivity and availability. Sex-specific differences in spatial distribution can influence availability and thus affect the selectivity. Biomass-based reference points are typically represented by female spawning biomass and their calculation may require a sex-structured model to be accurately represented.

61. The Ross Sea assessment is sex structured, while the other assessments are not. The Ross Sea assessment had differences in growth and selectivity between the sexes, but did not have differences in natural mortality. The differences in growth were small and were greatest at older ages as typically seen for fish species. However, it was not clear if the differences were statistically significant at old ages because there is little data for old ages and the VB growth curve is too inflexible and is controlled by data on young fish. There were patterns in the spatial distribution of sex structure with the northern area comprised of a higher proportion of males. The northern area also had a greater variability in the sex structure even within neighbouring spatial cells. It is not clear what causes this variability, but it may be due to differences in the season or the year in which the spatial cell was fished.

62. The ability to conduct a sex-structured model is also dependent on the data that is available. For example, composition data by sex is needed to estimate sex-specific selectivity curves, otherwise assumptions have to be made. It is not clear what data is available by sex. For example, the tag release and recapture data may not be available by sex.

63. The RP noted that there is an inconsistency in the use of sex-structured models and it is not clear if a sex-structured model is necessary. **The RP suggested that the SA scientists conduct a more thorough evaluation on the necessity of sex-structured models.** 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.

2. Implementation

2.1 Have the statistical modelling and the resulting inferences on stock status and dynamics been implemented using best practice methods, including how these are implemented using CASAL

64. The current CASAL modelling framework has been used successfully in the SAs reviewed here. Some limitations in the modelling framework with respect to properly accounting for double tagging, and some selectivity functions were noted (e.g. temporal variation). However, developers of CASAL have indicated that the current version will be replaced by CASAL2.0 that will address the issues noted. CASAL2.0 will be employed over the next two review cycles alongside the current versions to ensure that modelling results are comparable.

2.2 Are industry best practices to modelling methods, estimation and data weighting, Markov Chain Monte Carlo (MCMCs) and diagnostics used appropriately?

65. The RP noted that CCAMLR and its SA scientists are using appropriate practices in the assessments reviewed here. The use of data weighting procedures is also useful. However, the reliance on tagging data for these assessments and the less developed nature of data weighting for tagging data in integrated assessments was noted. The CCAMLR assessment scientists could usefully lead the field in the development of this data weighting issue given the importance of tagging data to the assessments.

66. A standard set of diagnostic plots across the assessments covering important and sensitive parameters is encouraged to be included in each SA. The RP recognised the enormity in the number of diagnostics that can be produced, and thus a standard set across assessments could provide for greater transparency and comparability (e.g. standard format for likelihood component plots, prior/posterior distribution on key parameters as well as Gelman Rubin diagnostic of convergence).

Data weighting

67. The assessments all use data weighting approaches based on those commonly used in contemporary fisheries assessments. Tagging data is not commonly integrated in SA methods and therefore the data weighting procedures for this type of data are not fully developed. **The RP recommended 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 to account for correlations in the recaptures.

3.1 Improvements to modelling

68. Comment on, and suggested work by, the SA scientists is provided throughout the report. The reader is encouraged to read the various sections.

3.2 Improvements to data and research

69. Comment on, and suggested work by, the SA scientists is provided throughout the report. The reader is encouraged to read the various sections.

4. The utility of alternative models and structures that could be explored for the assessment of CCAMLR stocks and provide input to the evaluation process

70. The RP briefly discussed the value of developing alternative models and structures, and felt that over the short term, the most critical development would be to emphasise the spatial modelling given the observed variability in the spatial patterns as fisheries have historically developed (e.g. Division 58.5.2), the spatial structure in toothfish distributions (Subarea 88.1) and the structural changes occurring to the management areas as a result of larger spatial management issues (e.g. marine protected areas).

71. Over longer time scales, a research program to investigate the utility of alternative models could be useful, but not at the expense of the spatial modelling.

Ecosystem inputs

72. Given the importance of the Southern Ocean and the unique role and mandate of CCAMLR to consider ecosystem processes in its management structure, the RP considered whether the environmental data collected as part of the broader science programs was within the scope of the terms of reference to comment upon. The RP is aware that a number of environmental and climate drivers may have profound effects on fish populations impacting vital rates, migration patterns and spawning patterns (among others), and that such changes may have impacts throughout the ecosystem. The RP felt that such research was valuable, and that many of the current fishery-based datasets being collected (growth, recruitment, movement, maturity), and the biennial assessments of stocks provided sufficient data to provide an early warning for changes to the biology and ecology of toothfish and to the ecosystem. How and when other ecosystem drivers should be provided to the assessment models was, however, beyond the scope of the terms of reference. **CCAMLR may wish to consider an external review whose goal is to consider this question specifically.**

The review process

73. In general, the review followed the agenda, with presentations followed by question and answer periods over the first two days. Given the terms of reference and number of assessments reviewed, the goal of this review was to evaluate the adequacy of the modelling approaches rather than the assessments themselves, no model runs were requested of the assessment scientists. On the third day, the RP worked to summarise their understanding of the various assessment inputs, and to develop further questions for the assessment scientists. The fourth day was devoted to further questions and clarifications about assessments and the report was completed on the fifth day. Clarifications and editorial corrections were made over the following few weeks by email correspondence, and the report was finalised by 31 July 2018.

74. While the number of documents provided to the RP demonstrated the continued development of the SAs, and highlighted the commitment of CCAMLR to a detailed assessment review process, much of the information necessary to evaluate the process by the RP was distributed across the many internal CCAMLR documents. This complicated the efficient discovery of documents that were necessary for the review.

References

Candy, S., A. Constable, T. Lamb and R. Williams. 2007. A von Bertalanffy growth model for toothfish at Heard Island fitted to length-at-age data and compared to observed growth from mark-recapture studies. *CCAMLR Science*, 14: 43–66.

Dunn A., M.H. Smith, D.J. Agnew and S. Mormede. 2011. Estimates of the tag loss rates for single and double tagged toothfish (*Dissostichus mawsoni*) fishery in the Ross Sea. Document *WG-SAM-11/18*. CCAMLR, Hobart, Australia: 14 pp.

Appendix A

Agenda and schedule
CCAMLR Independent Stock Assessment
Review for Toothfish
(Norwich, United Kingdom, 18 to 22 June 2018)

Monday (18 June)

1. Introduction – Review terms of reference and meeting timetable

2. Presentations

General format of presentations should include an over view of the fishery in the area, the main types of data that are collected, any stock hypotheses for context; data inputs, data grooming; model formulation, issues and challenges that have been addressed.

(i) Division 58.5.2 (Heard Island and McDonald Islands)
(ii) Subarea 88.1 and SSRUs 882A–B (Ross Sea region)
(iii) Subarea 48.3 (South Georgia)
(iv) Subarea 48.4 (South Sandwich Islands)

3. Begin discussion of Inputs (term of reference (i))

The format of this and following sections will be to compare and contrast the approaches amongst assessments (where applicable), given the differences in species (Antarctic and Patagonian toothfish), locations and other assessment-specific details with each assessment.

Tuesday (19 June)

4. Conclude discussion of Inputs (term of reference (i))

5. Questions for reviewers from participants forwarded to Chair during meeting

6. Begin discussion of Implementation (term of reference (ii))

Wednesday (20 June)

7. Conclude discussion of Implementation (term of reference (ii))

8. Questions for the expert review panel from participants forwarded to Chair during meeting

9. Discussion of Improvements to Modelling (term of reference (iii)), and Improvements to Data and Research (term of reference (iv))

Thursday (21 June)

10. Morning Wrap up/Outstanding questions

11. Afternoon convener with expert review panel to begin writing

Friday (22 June)

12. Morning – Expert review panel presents draft report and considers comments on factual clarifications from review participants

13. Drafting of the CCAMLR report of the workshop

14. Afternoon – Conclude preliminary draft of the CCAMLR report and the expert review panel conclusions.

The final report will integrate the CCAMLR report and the views of the expert review panel into a single report with recommendations highlighted by priority. Where differing opinions exist, these will be also be highlighted. Any individual comments by members of the expert review panel will be added to the report as an addendum. Summary papers provided by participants, and additional meeting documents that may be produced within the review meeting, will be attached as an appendix to the report. A draft report will be completed by Friday June 22 and submitted to the 2018 meeting of WG-SAM. Minor editing of the report may be required after the conclusion of the meeting, and the final report will be submitted to the 2018 meeting of WG-FSA and the Scientific Committee. The Convener will circulate the final report to the expert review panel and meeting participants once complete. The timeline for the review process and presentation of reports is given as Attachment I below.

Attachment I

Timeline for the review process and presentation of the report CCAMLR Independent Stock Assessment Review for Toothfish
(Norwich, United Kingdom, 18 to 22 June 2018)

1. The text of the Convention can be found at www.ccamlr.org/node/74286.

Timeline agreed by the Scientific Committee for the independent review

Timeline task	Timing
Scientific Committee endorses review, terms of reference and budget	October 2017
Reviewers identified and coordinated by the Chair of the Scientific Committee and the conveners of WG-SAM and WG-FSA and communicated via SC circular for comment	January 2018
Documents distributed	April 2018
Review occurs, including external experts	1 week prior to WG-SAM (2018)
CCAMLR report and external expert report presented to WG-SAM	June 2018
CCAMLR report and external expert report presented to WG-FSA	October 2018
Scientific Committee recommends actions based on review report and working group comments	October 2018
Update assessments and analyses as required for WG-SAM and WG-FSA	June to September 2019
Stock assessments and analyses presented based on the review recommendations	June to September 2019

Appendix B

Review panel and attendees
CCAMLR Independent Stock Assessment
Review for Toothfish
(Norwich, United Kingdom,18 to 22 June 2018)

A. Convener

Dr Christian Reiss
Antarctic Ecosystem Research Division
NOAA Fisheries
La Jolla, California, USA
Email: christian.reiss@noaa.gov

B. Expert review panel

Dr Noel Cadigan
Centre for Fisheries Ecosystems Research (CFER)
Marine Institute of Memorial University of Newfoundland
Newfoundland, Canada
Email: noel.cadigan@mi.mun.ca

Dr Mark Maunder
Inter-American Tropical Tuna Commission
La Jolla, California, USA
Email: mmaunder@iattc.org

Dr Marie-Pierre Etienne
Agrocampus-ouest
Paris, France
Email: marie-pierre.etienne@agrocampus-ouest.fr

C. Assessment review points of contact

Heard Island and McDonald Islands (Division 58.5.2):

Dr Philippe Ziegler
Australian Antarctic Division
Kingston, Tasmania, Australia
Email: philippe.ziegler@aad.gov.au

Ross Sea region (Subarea 88.1 and SSRUs 882A–B):

Dr Sophie Mormede
NIWA
Wellington, New Zealand
Email: sophie.mormede@niwa.co.nz

South Georgia (Subarea 48.3) and South Sandwich Islands (Subarea 48.4):
Dr Timothy Earl
Cefas
Lowestoft, Suffolk, UK
Email: timothy.earl@cefas.co.uk

The points of contact were asked to provide background documents regarding the assessments, including working group papers and other relevant material, and parameter files for the inputs into the CASAL models used in the most recent assessment used by CCAMLR, and other relevant background information. These documents were provided to the CCAMLR Secretariat for dissemination to the expert review panel under Rules for Access and Use of CCAMLR Data.

D. Registered attendees

Dr Noel Cadigan, MUN, CA
Dr Chris Darby, Cefas, UK
Mr Alistair Dunn, NIWA, NZ
Dr Timothy Earl, Cefas, UK
Dr Marie-Pierre Etienne, FR
Dr Simon Fischer, Cefas, UK
Dr Mark Maunder, IATTC
Dr Sophie Mormede, NIWA, NZ
Dr Steve Parker, NIWA, NZ
Dr Christian Reiss, NOAA, USA

Appendix C

Independent CCAMLR Stock Assessment Review – Terms of reference

1. The Scientific Committee of CCAMLR has discussed through its working groups the desire to independently assess the integrated toothfish stock assessments used to provide advice by the Scientific Committee to the Commission. The goal of these reviews is to improve the quality and transparency of CCAMLR's work.

2. At CCAMLR-XXXVI, the Commission agreed the terms of reference and agreed the selected toothfish assessments to be reviewed in 2018. The agreed toothfish assessments to be reviewed are the Heard Island and McDonald Islands (Division 58.5.2), the Ross Sea region (Subarea 88.1 and small-scale research units (SSRUs) 882A–B), South Georgia (Subarea 48.3) and the South Sandwich Islands (Subarea 48.4).

3. The objective for the expert review panel 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 improvements to the assessment methods where appropriate.

4. The United Kingdom agreed to host the Independent Assessment Review in June of 2018 at the University of East Anglia, in Norwich, UK.

5. The review was convened by Dr C. Reiss (USA).

Terms of Reference: Independent CCAMLR Stock Assessment Review

A. Evaluations of adequacy of the modelling approaches and methods

Specifically:

(i) Inputs: Review the extent to which the data, modelling assumptions, model structure, priors and penalties are appropriate (including assessment of both biological and fishery components). This includes the choice of observations (survey, catch per unit effort (CPUE), tag, age, length), treatment and processing of observations, and biological parameters (values and derivation).

(ii) Implementation: Review whether the statistical modelling and the resulting inferences on stock status and dynamics have been implemented using best-practice methods, including how these are implemented using CASAL. This includes modelling methods (i.e. best practices), estimation and data weighting, Markov Chain Monte Carlo (MCMCs) and diagnostics used.

(iii) Improvements to modelling: Comment on any improvements that could or should be made to the methods to increase the reliability of the results for future management decision-making – including the potential use of alternative models or model structures.

(iv) Improvements to data and research: Comment on other key areas of research or data collection that could decrease uncertainty or increase the utility of the modelling for future management decision-making.

B. The utility of alternative models and structures that could be explored for the assessment of CCAMLR stocks and provide input to the evaluation process.

Report of the Meeting of the Working Group
on Statistics, Assessments and Modelling
(Norwich, UK, 25 to 29 June 2018)

Contents

**Report of the Working Group
on Statistics, Assessments and Modelling**
(Norwich, UK, 25 to 29 June 2018)

Introduction and opening of the meeting

1.1 The 2018 meeting of WG-SAM was held at the University of East Anglia (UEA), Norwich, UK, from 25 to 29 June 2018. The meeting Convener, Dr S. Parker (New Zealand), welcomed participants (Appendix A). The meeting was hosted by Cefas and in welcoming participants to the meeting, Dr Stuart Rogers (Cefas Chief Scientist) highlighted the important relationship between Cefas and UEA in delivering high impact applied science to support fisheries. He wished participants every success in their meeting and an enjoyable stay in Norwich.

Adoption of the agenda and organisation of the meeting

2.1 Dr Parker reviewed the provisional agenda and the terms of reference for WG-SAM and highlighted that the priorities identified by the Scientific Committee for the work of WG-SAM should form the main part of the work of the Working Group. The meeting agenda was 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. Belchier and C. Darby (UK), A. Dunn (New Zealand), T. Earl (UK), C. Jones (USA), S. Mormede (New Zealand), C. Péron (France), K. Reid (Secretariat), M. Söffker (UK) and D. Welsford (Australia).

Assessments to estimate sustainable yield in established/assessed fisheries

3.1 The Working Group noted WG-SAM-18/14 and 18/P01 outlining the increased capabilities and flexibility of the Casal2 assessment software compared to the CASAL software currently used to provide management advice, and comparing performance in the Ross Sea region. The Working Group recalled its previous advice on the steps to be undertaken for validating stock assessment software (SC-CAMLR-XXXIII, Annex 5, paragraphs 2.26 to 2.29), and recognised the work already undertaken towards this. The Working Group recommended that in order to further validate the software, Casal2 models could be run in 2019 and compared with the 2019 CASAL assessment.

3.2 The Working Group noted that due to the modular nature of the software, consideration would need to be given to how validations of software versions would be undertaken. This may include incorporating current toothfish assessments within the software test suite to ensure quality control of updated software versions. The Working Group invited Members to participate by working intersessionally to look at the software and code on GitHub (https://github.com/NIWAFisheriesModelling/CASAL2), report errors or issues, test the software with current assessments, and to contribute additional unit tests and tests suites to the code base.

3.3 The Working Group noted WG-SAM-18/22, which discussed ways of incorporating trends in productivity parameters and parameter variability that may be related to changes in environmental conditions into future assessments and management. The Working Group noted the importance of potential environmental variability on the early stages of larval development, which will affect the level of recruitment estimated by the assessment models, and highlighted the importance of collecting data through egg and larval surveys to gain information on recruitment patterns of toothfish.

3.4 The Working Group recommended that WG-FSA consider updating CCAMLR's Fishery Reports to include a section on changes in model parameters and productivity assumptions, and that this section consider the impact of observed changes in biological parameters on management advice. The Working Group noted that the parameters that could be evaluated could include mean recruitment, recruitment variability, mean length at age, mean weight at length, natural mortality and maturation ogives. The Working Group encouraged Members to develop methods that can be used to evaluate the importance of observed changes on resulting advice.

3.5 The Working Group noted that CASAL has a limited capacity to model changes in productivity parameters (other than growth and recruitment), but that Casal2 (paragraph 3.1) can allow such changes to be incorporated. Changes in these parameters may lead to revised estimates of initial and current biomass, and yields, and hence the advice resulting from the CCAMLR decision rules. The Working Group noted that changes in the productivity parameters used in the assessment can be based on observations without an underlying hypothesis about the cause of the changes, but that such a hypothesis is required to choose the appropriate parameters for projections as used in the CCAMLR decision rule. Further work is required to consider the methods of incorporating this into projections. Sensitivity testing or management strategy evaluation would be informative to determine whether the decision rules remain precautionary under different assumptions about future potential changes in productivity parameters.

3.6 The Working Group noted the draft report from the Independent Stock Assessment Review for Toothfish (SC-CAMLR-XXXVII/02) and thanked the Convener, the independent experts and the participants for the thorough review. The Working Group noted that the review had concluded that the current assessment methodology is appropriate for the management of these stocks, and that the review panel had recognised the large body of ongoing work that has contributed to the assessments. The Working Group welcomed the suggestions for areas of future work to further develop these assessments and encouraged Members presenting stock assessments to address these.

3.7 The Working Group welcomed the acknowledgement by the review panel that CCAMLR was a leader in the use of tagging data in stock assessments, and that the review panel had noted that the approach to resolve differences in tagged fish survival and tag-detection rates between vessels in the Ross Sea region assessment was appropriate. The Working Group recommended Members continue to develop approaches to reduce differences in tagged fish survival and tag-detection rates between vessels.

3.8 The Working Group noted that advances in pop-up satellite archival tag (PSAT) tagging technology may allow for updated estimates of tagging mortality, and that analysis of tag recaptures at length may allow for estimation of ongoing tag mortality and identification of size-dependant survival. The Working Group noted that increasing scientific electronic monitoring using video cameras would provide insights into the relative importance of vessel procedure and environmental effects on tagged fish survival and tagged fish detection. The Working Group noted that conclusions drawn from vessel performance comparisons in assessed fisheries may be useful for informing the evaluation of research proposals.

3.9 The Working Group recommended the development of spatial overlap statistics to assist in evaluating the prospects of informative estimates of biomass being created from a proposed tagging program. The Working Group noted that improvements in tagging performance in individual vessels may provide useful insights that can be applied to improve the performance of all vessels, but recognised that changing tag performance adds additional complexity when compiling tagging data time series to estimate stock size.

3.10 The Working Group noted WG-SAM-18/34 which outlined a standard set of diagnostics that should be presented for icefish assessments, building on the work of WG-FSA-17 (SC-CAMLR-XXXVI, Annex 7, paragraphs 3.13 and 3.14).

3.11 The Working Group welcomed the work, and recommended that the diagnostics be included in the annual Fishery Reports for icefish and that Members continue to work to standardise the information presented in the assessment papers and Fishery Reports for toothfish assessments.

Development of management advice consistent with Article II for fisheries with more limited data

4.1 Following the recommendation by the Scientific Committee that the qualitative approach to setting catch limits in data-poor and research block fisheries developed by WG-FSA-17 should be tested and further developed, WG-SAM-18/23 presented a quantitative approach, formalising and coding the rules set out by WG-FSA-17. The paper presented results from a simulation approach examining the performance of the trend analysis rules through different scenarios of population abundances, uncertainty in biomass estimates and abundance trends. The paper concluded that the trend analysis rules performed well, and increased or decreased catch limits with increasing or decreasing simulated populations.

4.2 The Working Group noted that the qualitative assessment of trends and slopes by WG-FSA-17 was replicated in a quantitative approach, and advice on catch limits and trends in stock trajectory was almost identical when using the linear method or the ‘two-over-three’ method in these simulations. As the linear method allows the estimation to be performed when data for some years are not available, the Working Group considered that this method was more widely applicable, and should be used.

4.3 The Working Group noted that the trend analysis method was still in the early stages in the process of formalisation and testing, however, was confident that the method in its current form was an improvement over previous approaches to setting catch limits in data-poor and research block fisheries. The Working Group recommended further work to ensure that the advice derived was consistent with CCAMLR objectives, including:

(i) a management strategy evaluation, in particular including sampling error and model misspecification, would provide more information about the performance of the method, and potentially identify situations where an alternative method would be preferable

(ii) using data from the research fisheries directly could show different results from the linear regression component of the method – this step would require further method development and testing to ensure it considers the full suite of decisions carried out when calculating the biomass

(iii) test how the trend analysis rules perform with different coefficients of variation (CVs) and biomass estimate distributions, different catch-per-unit-effort (CPUE) and variable tag returns, and research-block specific simulations, as well as different scenarios where populations change in response to catches and overall management approaches

(iv) further work is needed to address uncertainties around tagging and CPUE-based biomass estimates, as they drive the algorithm to the specified bounds in decreasing or increasing catch limits

(v) statistically test between apparently conflicting trends in biomass point estimates, and test for significant differences between tag-based and CPUE-by-seabed based approaches.

4.4 The Working Group noted that the trend analysis rule to determine whether the trend was increasing, decreasing, stable, or uncertain, as described in WG-SAM-18/23, was applied during the meeting to the 2017 biomass estimates calculated by the Secretariat. Results were presented to the Working Group and showed that the management advice would have been identical to that reached at WG-FSA-17. The method was shown to provide almost identical results when using a slope definition of ± 0.15 instead of ± 0.1.

4.5 The Working Group recommended the above approach be used with a slope value of ± 0.1, noting no change in the slope determination as a result of biomass CVs of 0.2 or 0 and that this method be used to provide management advice for setting catch limits in research blocks.

4.6 The Working Group requested that the Secretariat calculate biomass estimations and corresponding slopes for each research block for WG-FSA-18 based on this approach, including methods to incorporate the CV of each biomass estimate used in the determination of slope for the trends in biomass for discussion at WG-FSA-18.

4.7 The Working Group recalled that in the past, it had highlighted that using tag-based assessments would be preferable over CPUE-by-seabed approaches in exploratory and data-poor fisheries (SC-CAMLR-XXX, Annex 5), however, that the success of recapturing tagged fish is variable between fisheries and that tagging performance metrics vary among vessels. It noted that simulations should be carried out to determine the number of tagged fish and tag recaptures considered sufficient to move to tag-based biomass calculations, and to examine tagging mortality and tag-detection performance and their effects on biomass estimation in data-poor fisheries.

Data acquisition and management

5.1 WG-SAM-18/20 provided results of a pilot study using a scientific electronic monitoring system that collects video data from three cameras along with time-linked sensor data on vessel operations and location.

5.2 The Working Group agreed that the system worked well in this pilot study, and has the potential to assist in improving the accuracy and quality of data recording, with an added benefit of allowing observers more time for biological and other sampling by reducing the time spent on tasks such as line setting observations, determining species mix, or size compositions.

5.3 The Working Group acknowledged that there are several vessels fishing in the Convention Area that are currently using systems similar to this, and some have low-light and thermal cameras that can detect seabirds prior to and during setting operations. The Working Group noted that whilst the initial cost of setting up such an integrated system on a vessel is significant, it is relatively minimal thereafter. The Working Group agreed that these sorts of systems showed great promise to support observers in their Scheme of International Scientific Observation (SISO) duties, and encouraged other Members to explore the use of scientific electronic monitoring on their vessels.

5.4 WG-SAM-18/24 provided a review of the toothfish tagging procedures on four Ukrainian vessels (*Calipso*, *Koreiz*, *Marigolds* and *Simeiz*) in the 2017/18 fishing season. The Working Group noted the tagging procedure of each vessel in relation to the factory location, the container of water designed to hold the fish before tagging, tagging tables and the distance fish are transported through the vessel during the tagging procedure.

5.5 The Working Group noted that the presentation of results accompanying WG-SAM-18/28 included a description of squid depredation on a tagged toothfish after it was released and noted that at present, knowledge on depredation by squid was based on anecdotal accounts and SISO reports. The Working Group recalled WG-FSA-15/07, which provides guidance on how to identify signs of depredation from different species, including giant and colossal squid. The Working Group encouraged Members to develop approaches to quantify the occurrence of squid depredation, including observations of post-capture mortality due to squid.

5.6 The Working Group inquired as to the utility and purpose of using holding tanks during the toothfish tagging process, as opposed to immediately tagging and releasing the selected toothfish. Dr L. Pshenichnov (Ukraine) clarified that fish can be held for a time to determine their condition and suitability for tagging, as some specimens may be more appropriate to retain than release. The Working Group agreed that it would be valuable to evaluate the use of holding tanks in relation to fish handling and tagging best practices.

5.7 The Working Group recommended that WG-FSA consider including a record of whether a vessel uses holding tanks, as well as the characteristics of the tank and water supplied, as part of its tagging procedure in future notifications, as this may assist in understanding variability in tag performance between vessels.

5.8 The Working Group recommended that the Scientific Committee consider holding a focus topic or workshop on toothfish tagging practices to better inform tagging practices by all Members fishing in the Convention Area, as these data serve as a primary driver underpinning current stock assessments of toothfish. Such a focus topic could be held during an off-assessment year under CCAMLR's current biennial toothfish assessment practice and could benefit from invited experts on fish handling procedures.

5.9 WG-SAM-18/27 described a preliminary analysis of oceanographic measurements collected on Ukrainian vessels undertaking research during the 2017/18 season. This initiative deployed compact microprocessor-controlled salinity, temperature, depth recorders (CTDs) on longlines. It was noted that Ukraine intends to undertake further analysis of these trials, and these results will be submitted to WG-FSA.

5.10 The Working Group noted that these compact CTDs provide useful information in relation to broad differences in habitats and water column physical characteristics used by toothfish. However, these compact CTDs need to be calibrated.

5.11 The Working Group agreed that it would be very useful to undertake comparisons of these and other compact CTD loggers paired with more sophisticated and precise CTD instrumentation to characterise their performance and nature of potential data errors collected with these CTDs.

5.12 The Working Group recommended that this information be made available or brought to the attention of established data infrastructures such as SCAR/SCOR through the Southern Ocean Observing System (SOOS), or PANGAEA.

5.13 WG-SAM-18/19 introduced a research proposal designed to collect information on catchability of longlines on toothfish by sampling an area with both bottom trawl and longline gear types.

5.14 The Working Group noted that there have been considerable difficulties catching toothfish with bottom trawls in previous research cruises. Further, there appear to be species- and size-specific difficulties catching toothfish with bottom trawl. Previous efforts have demonstrated little success catching Antarctic toothfish (*Dissostichus mawsoni*) relative to Patagonian toothfish (*D. eleginoides*), as well as difficulties catching larger toothfish possibly due to differences in vertical distribution or avoidance behaviour.

5.15 Comparisons of bottom trawl versus longline catchability are further complicated due to other factors that influence longline performance such as gear type, number of hooks, depth, soak time etc. The Working Group noted that there could also be substantial benthic impacts while undertaking such an experiment.

5.16 The Working Group noted that during previous exploratory fishing trials using bottom trawls to catch toothfish, very few were caught, although the method represents an effective way to sample other demersal species often caught by longlines, such as macrourids. These trials demonstrated no clear relationship between what was caught in the trawl versus what is captured with longlines.

5.17 The Working Group recommended that prior to undertaking such comparisons, it would be valuable to review previous efforts and trials using bottom trawls to catch toothfish in the Convention Area. Examples of such trials are described in WG-SAM-15/34, WG-FSA-12/51, WG-FSA-08/56 and van Wijk et al. (2000).

5.18 WG-SAM-18/18 described a photographic reference set of otoliths for *D. mawsoni* from the Ross Sea region. Two photographs are provided for each prepared otolith (one unaltered, and one with the location of each counted annulus indicated). Each otolith is linked to an Excel spreadsheet that provides associated metadata.

5.19 The Working Group welcomed the material provided in WG-SAM-18/18 and recalled that there are other reference sets (such as for *D. eleginoides*) that are either available, or could be made available for training purposes, or to verify consistency between readings.

5.20 The Working Group requested that the Secretariat develop a central repository for reference sets of otoliths provided by Members to facilitate access to reference sets, along with manuals associated with the preparation of otoliths included in the reference set.

5.21 WG-SAM-18/29 provided a summary of information on otolith ageing methodology of *Dissostichus* spp. by Ukrainian scientists and included descriptions of equipment and procedures for processing and reading ages from otoliths.

5.22 The Working Group welcomed this work and noted that there are a variety of methodologies that can be employed to prepare and age *Dissostichus* spp. otoliths. Dr Welsford invited Members with an interest in otolith ageing to contact the Australian Antarctic Division and visit Hobart, potentially just prior to WG-FSA, as an opportunity to compare methodologies between Members.

Data Management Group update

5.23 The Data Management Group (DMG) was first established in 2017 as an e-group. The current Convener of the DMG, Dr C. Reiss (USA), provided a summary of the intersessional activities of the DMG. The Working Group recalled that the role of the DMG is to be a conduit between CCAMLR data users and the Secretariat, and to provide feedback and advice on:

(i) communication of information on data and metadata management and development

(ii) development of data quality standards and rules

(iii) development of data infrastructure, including data submission processes

(iv) provision of data extracts to Members

(v) development of data analysis tools.

5.24 The Working Group noted that the e-group discussions summarised by the Convener of the DMG concerned 12 points, primarily in relation to quality assurance/quality control, automatic updates to the database, and whether data that Members requested had been adequate. Other issues raised in the e-group included other data-related activities such as electronic web-based Catch Documentation Scheme for *Dissostichus* spp. (e-CDS) data. There was some concern that this data may take precedence over Scientific Committee data issues, and the Convener underscored that it was important to have an optimal balance between the requirements of various data users.

5.25 The Working Group recalled the origins of the request to form a DMG (SC-CAMLR-XXXV, Annex 5, paragraphs 2.15 to 2.20, 5.7, 5.14, 5.15 and 6.8) and emphasised that its priorities lie with points i–v of the terms of reference, and was mindful that the DMG should focus on addressing some of the high-priority items outlined in the DMG e-group.

5.26 The convener of the DMG requested additional engagement and structured, specific feedback from all data end users in relation to progress and evaluation of paragraphs 5.23(i–v) above.

5.27 The Working Group received a report from the CCAMLR Executive Secretary on the status of data management. The Working Group noted the Secretariat's recognition that data management represents one of the key services it provides to CCAMLR, and that it has embarked on a program to respond to feedback and advice from the DMG. Specific feedback to the Secretariat stressed the need for transparency about the process, and the need to ensure integrity of the data.

5.28 The Working Group noted that preliminary work has been undertaken to establish the roles and responsibilities of different departments within the Secretariat in respect of the wide range of data that are held by the Data Centre. These data include:

- (i) catch and effort data
- (ii) data on compliance and management
- (iii) scientific data
- (iv) administrative data.

5.29 It was noted that roles and responsibilities will be defined in relation to data acquisition, entry, integrity, storage and extraction. The establishment of roles will be followed by documentation of processes, particularly the processes for engagement with data owners and data users and the development of data quality and integrity checks and algorithms. Dialogue with the DMG will be maintained throughout.

5.30 The Convener of the DMG noted that additional consideration from the e-group would be forthcoming as the Secretariat implements the elements of the new data systems. The Working Group recognised that the Secretariat is updating the data management in a way that data integrity is maintained, and that datasets will continue to increase in size and scope. The Working Group requested that a timeline of progress on the data systems be provided to Members.

Review of research plan proposals and results

Generic advice for research plans

6.1 In respect of the research plans involving toothfish, the Working Group recommended that:

- (i) research proposals provide a summary of previous WG-SAM, WG-FSA and Scientific Committee recommendations within their proposals, and describe how the proposal has addressed these points when these proposals are submitted to WG-FSA

(ii) all research plans submit a summary table comprising the applicable milestones of the research from the beginning of the plan, planned and actual achievement dates, papers submitted, and noting any changes in the milestone time tabling to assist the working groups in evaluating research plan performance and progress towards objectives (e.g. Table 1)

(iii) all research proposals provide a clear summary of the start of the program, the end date and the years that the current proposal covers

(iv) a summary of the information required to complete Table 1 of Conservation Measure (CM) 24-05 including the specific conservation measures from which an exemption is required to conduct the research be included

(v) by-catch should be recorded to the highest taxonomic resolution, in particular for macrourids and icefishes, where good identification guides exist

(vi) tag-overlap statistics be reported at the scale of the research block and at the scale required in CM 41-01 in order to address possible confounding effects of spatial differences in toothfish length frequency

(vii) greater clarity be provided in demonstrating the linkage between research objectives and the development and testing of stock hypotheses

(viii) the objectives of the research plans be described in terms of outcomes instead, with data collection as a means to achieving the outcomes.

6.2 The Working Group also noted that there was considerable variability in the timeframes over which future research programs were notified. The Working Group requested that the Scientific Committee consider how research timeframes could be standardised.

6.3 The Working Group recognised the potential for differences in the interpretation of the need for an exemption from conservation measures under CM 24-01 for different research activities involving Antarctic marine living resources. The Working Group requested the Scientific Committee to review the objectives and provisions of CM 24-01 and provide clear guidance to Members on appropriate criteria for the application of this measure.

Spatial context of Area 48 fisheries

6.4 The Working Group considered SC-CAMLR-XXXVII/01, the report of the Co-conveners of the CCAMLR Workshop for the Development of a *Dissostichus mawsoni* Population Hypothesis for Area 48 held from 19 to 21 February 2018 in Berlin, Germany, and noted that the main outputs of the Workshop were three alternative stock hypotheses which are provided in the report's annex (WG-SAM-18/33 Rev. 1).

6.5 The Working Group thanked the Co-conveners Drs Darby and Jones and all participants for their valuable contributions to the Workshop and, in particular, thanked Dr Söffker for her major contribution in preparing the annex containing the extensive background information developed through the Development of a *D. mawsoni* Population Hypothesis for Area 48 e-group and considered at the Workshop, as well as the subsequent outputs including detailed figures of the different stock hypotheses.

6.6 The Working Group noted that the meeting had been very productive and demonstrated that focussed meetings to consider specific questions were useful. The Working Group noted that such targeted meetings could be convened within the current working group structure rather than adding additional meetings to the annual Scientific Committee meeting schedule.

6.7 The Working Group noted that a key priority arising from the Workshop was the development of egg and larval dispersal models. Such modelling could be carried out as 'desktop' research without the need for further on-water research activities. The Working Group recognised that extensive modelling of krill transport and dispersion had been undertaken in Area 48 and should form a good basis for any future *D. mawsoni* studies. It was noted that egg and larval sampling could be carried out by plankton tows undertaken by fishing vessels.

6.8 The Working Group recommended that future toothfish research in the region should address the data gaps and hypotheses highlighted at the Workshop and this should be incorporated into Members' research plans within Area 48.

Tool for analysis of sea-ice distribution

6.9 The Working Group considered WG-SAM-18/01 which described the development by German scientists of a statistical 'decision support' tool for retrospective analysis of fishing ground accessibility in the Weddell Sea. The Working Group thanked the authors for providing information on this very useful development and noted that it could be used to assess trends in size and location of areas of ice-free waters with high productivity used by foraging predators, as well as assisting in the planning of potential fisheries research in the region.

6.10 The Working Group noted that the development of an interactive user interface gave the tool great flexibility and the use of 'sliders' meant that it was possible to investigate the differences in accessibility to a given area by vessels with different classes of ice strengthening and at any given period. The author's clarified that 'accessibility' was calculated on a daily basis.

6.11 The Working Group noted that the tool could be used for planning aspects of research in many disciplines in the Weddell Sea and that it could also be used to assess longer-term trends in accessibility in the region. The Working Group looked forward to using the tool and would be able to provide feedback on its use to the developers once available.

Proposals and research results from Area 48

Proposals and research results from Subarea 48.1

6.12 WG-SAM-11/18 was presented describing a proposal by Ukraine to conduct research on *D. mawsoni* in Subarea 48.1.

6.13 The Working Group recalled discussions at WG-FSA-17 (SC-CAMLR-XXXVI, Annex 7, paragraphs 4.53 to 4.55) and SC-CAMLR-XXXVI (SC-CAMLR-XXXVI, paragraphs 3.83 and 3.85) regarding a similar proposal by Ukraine in 2017. It requested clarification as to how the new proposal had taken account of these discussions.

6.14 Dr K. Demianenko (Ukraine) noted that the vessel proposed now had experience of operating in the CCAMLR area, and that it had documented tagging procedures on board, addressing concerns expressed in 2017. He also noted that the vessel intended to conduct plankton tows and CTD casts during research fishing.

6.15 The Working Group agreed that several substantial issues identified in WG-FSA-17 and the Scientific Committee still remained to be addressed before the Ukrainian proposal was suitable to be assessed according to the checklist developed at WG-FSA-17 (e.g. SC-CAMLR-XXXVI, Annex 7, Table 4). It also requested that information in the proposal be structured so that the research plan checklist could be easily completed by WG-FSA-18. It further noted that the research plan should take account of the new CM 24-05 which applies to research notified under CM 24-01. Dr Demianenko agreed to provide a revised proposal addressing all these points to WG-FSA-18.

Proposals and research results from Subareas 48.2 and 48.4

6.16 WG-SAM-18/13, summarising the results from a third year of research fishing for *D. mawsoni* by Ukraine in Subarea 48.2, and WG-SAM-18/28, describing the plan for the fourth year of research under the plan, were presented.

6.17 The Working Group noted that the majority of information presented in the results related to toothfish. It recalled that the proposal indicated that there would be detailed studies of by-catch species, seabirds and mammals observed during the research. It noted that as these studies had been planned, and the research was now in its fourth year, they should be presented to WG-FSA-18. It also recalled that WG-FSA-17 had provided specific recommendations on reporting (SC-CAMLR-XXXVI, Annex 7, paragraphs 4.45 to 4.49) from this research plan, and recommended that a paper be submitted to WG-FSA-18 addressing those points. It further recommended that length-frequency data in research reports should be catch weighted if every fish is not measured from the catch, and that the CCAMLR GIS could be used to present maps of sampling stations. It also requested that the proposal include reporting against research milestones to enable WG-FSA-18 to assess how the research was progressing towards its objectives.

6.18 WG-SAM-18/26 was presented summarising results from a longline survey conducted by Chile in the northern area in Subarea 48.2. The Working Group noted that the research fishing had not achieved its planned objectives as the vessel had ceased fishing due to low catch rates and operational difficulties. It further noted that there was no proposal for Chile to continue research in Subarea 48.2. It therefore requested the proponents of the Ukrainian research consider the impact of Chile's withdrawal on progress towards the objectives of its research plan in Subarea 48.2.

6.19 WG-SAM-18/15, summarising the second year of study by the UK to determine connectivity between toothfish populations in Subareas 48.2 and 48.4, and WG-SAM-18/30, describing the plan for the third year of research under the plan, were presented. The Working Group noted that the research was proceeding according to plan with 3 years of data collection to be followed by 2 years of data analysis. It noted that in the third year, two stations would be moved to sample fishable grounds with lower risk to lost gear, and cameras would be deployed on the fishing gear. The Working Group noted that under the current sampling design, the two vessels involved sampling stations such that temporal and spatial effects on catch and by-catch may be confounded. It therefore recommended that sampling in the forthcoming season address this issue, for example by randomly allocating sampling stations to vessels. It also recommended that the species composition of Macrourid by-catch be determined to the finest taxonomic resolution possible.

6.20 WG-SAM-18/25 was presented summarising results from a demersal finfish survey conducted by Chile in the northern area of Subarea 48.1 and Subarea 48.2, including collection of biological data, parasites and tissue samples from 21 species of notothenioids.

6.21 The Working Group noted that the survey stations in Subarea 48.1 were unable to be completed due to a large catch (33 tonnes) of mackerel icefish (*Champsocephalus gunnari*) taken during a target trawl of an acoustic mark, and the stations in Subarea 48.2 could not be completed due to time constraints. Consequently, the demersal trawl data was unsuitable to develop robust biomass estimates, however, it did indicate that marbled rockcod (*Notothenia rossii*) was the dominant species on the Elephant Island Shelf, and catches of small juvenile *C. gunnari* (~10 cm) on the western shelf of Elephant Island in depths <100 m during this survey have been observed in previous surveys in this region, indicating the presence of a nursery area for this species.

6.22 The Working Group noted that there was no plan for Chile to conduct surveys in this region in the next season, however, the acoustic data collected would be further analysed and presented to WG-FSA-18, and future surveys are being considered.

Proposals and research results from Subarea 48.6

6.23 The Working Group considered three papers relating to research plans and results of research conducted in Subarea 48.6, including a summary of results from research fishing carried out by Japan and South Africa (WG-SAM-18/32), a joint proposal by Japan and South Africa to continue the research in Subarea 48.6 (WG-SAM-18/04), and a new research proposal to conduct research in the exploratory longline fishery for *D. mawsoni* in Subarea 48.6 submitted by Spain (WG-SAM-18/02).

6.24 The Working Group welcomed the joint progress report on research fishing from South Africa and Japan (WG-SAM-18/04) and noted that the disaggregation of data by vessel was very useful and provided additional clarity on the distribution of fishing activities. The Working Group noted that there was little spatial overlap of vessels in some areas which made it hard to disentangle vessel and spatial effects and this should be addressed in future research plans.

6.25 The Working Group noted that catch limits had been reached in three of the four research blocks but <30% of the catch limit was taken from research block 486_4 although the Scientific Committee had previously discussed whether this block was a higher priority than research block 486_5 (SC-CAMLR-XXXV, paragraphs 2.7 (i) and (ii)). The Working Group noted that a combination of timing and coordination issues between vessels and inaccessibility of research block 486_4 due to sea-ice had led to this situation arising.

6.26 The Working Group noted a considerable amount of data had now been collected during the course of the research undertaken by Japan and South Africa in Subarea 48.6 but greater clarity was needed on what subsequent analyses were to be carried out and over what timescale.

The Working Group noted that it was difficult to track current outputs against the original milestones set out at the outset of the research. The Working Group welcomed the development of a table of milestones presented in WG-SAM-18/04 but noted the timeframe for the development of stock assessment models had been pushed back by a year. It encouraged the research proponents to collaborate on development of stock assessments as well as the on-water research activities. It was also noted that Japan had started to process otoliths from this research and anticipated that > 200 would be processed this year.

6.27 The Working Group considered a proposal by Spain to conduct research fishing in Subarea 48.6 (WG-SAM-18/02) and noted that the vessel proposed by Spain to undertake the research had a higher degree of ice strengthening than the South African or Japanese vessels that may allow better access to research blocks 486_4 and 486_5.

6.28 The Working Group noted that there was a need to consider each new research proposal in its own right, however, it was also necessary to consider what additional value and scientific knowledge the research proposal would bring to an area within which multi-Member research activity was already undertaken. The Working Group also noted that the addition of another vessel using a different gear type (Spanish longline system versus trotline) could slow progress towards the existing research objectives. The Working Group noted that there was uncertainty around the temporal overlap between Spain's proposed research and the planned activities of South Africa and Japan in the region, especially given the participation of the Spanish vessel in other fisheries and research plans.

6.29 The Working Group noted uncertainty around the process by which the Spanish proposal could be integrated with the existing research proposals from South Africa and Japan given that they are at different stages of development. The Working Group recommended that the proposal should be developed further and Spain should coordinate its research efforts with Japan and South Africa and encouraged the submission of a multi-Member proposal for consideration at WG-FSA.

Proposals and research results from Subarea 58.4

Proposals and research results from Division 58.4.1 and 58.4.2

6.30 WG-SAM-18/35 reported the initial results of the exploratory fishery in Divisions 58.4.1 and 58.4.2 in 2017/18 on behalf of all the proponents. Four trips from three Members (Australia, France and Spain) were carried out, noting that two research blocks were not sampled this year. The authors noted that extensive biological data had been collected, toothfish ageing is ongoing, and CTD and video data are now also collected. Further details of the results will be presented at WG-FSA.

6.31 The Working Group thanked the proponents for their thorough report, carried out in a replicable format using R markdown, and suggested it might form the start of a standardised fishery characterisation (paragraph 6.1). The R markdown scripts are available to Members from the Secretariat.

6.32 The Working Group noted that although two research blocks were not fished, all proponents were involved in planning and coordinating fishing operations and off-the-water research and, therefore, not attaining full catch limits did not compromise the research.

6.33 The Working Group noted movements of tagged fish between the research blocks, including the movement of a fish at liberty for eight years, tagged originally in small-scale research unit (SSRU) 881H and recovered in research block 5841_5. It noted recaptures of several tagged fish moving among research blocks and that there was potential to calculate tag loss due to movement out of research blocks as per methods developed for Divisions 58.5.1 and 58.5.2. The Working Group further noted that 14 tagged fish were recaptured in 2018 in research block 5841_2 compared to a maximum of one recapture a year in previous years, which warranted further investigation. As there is a good spatial overlap between vessels in this exploratory fishery, the Working Group recommended that the case-control estimation of effective tagging survival and effective tag-detection rates be applied to these data, and compared with the results of the same method applied in the Ross Sea region, where some of the same vessels also fish.

6.34 The Working Group noted that this exploratory fishery has accumulated enough data to investigate an integrated assessment of stock size. It further noted that it was a good case study for the transition from local area estimates of biomass in research blocks to the assessment of stock size. The proponents noted that although the area is very large, and may contain more than one stock, a fully integrated assessment was the ultimate goal. However, for this year the plan was to attempt to combine local biomass estimates from research blocks with habitat models using the method presented in WG-FSA-17/16 to provide broader-scale abundance indices.

6.35 WG-SAM-18/17 presented a four-year research proposal for exploratory fishery in Divisions 58.4.1 and 58.4.2 on behalf of all Members. Significant progress was made in the first research plan, including understanding the ecology of the target species, and by-catch. The proponents developed an approach to reviewing research blocks based on the number of tagged fish available, ice conditions and a series of other parameters to identify the best locations to further progress a stock assessment. They noted that the number of vessels notified for Divisions 58.4.1 and 58.4.2 has increased to seven, which is likely to increase the proportion of the catch limit taken and collection of data over the entire area. A more detailed research plan will be provided at WG-FSA, including research blocks to be considered.

6.36 The Working Group congratulated the proponents on the matrix of potential survey areas (Figure 1) and recommended that stock hypotheses be included in the matrix when proposing research blocks for the new proposal. The Working Group looked forward to the development of stock hypotheses being presented to CCAMLR.

6.37 The Working Group recognised that this proposal follows on from a five-year research plan with many outputs still to come and welcomed the reassurance that this plan would be reviewed in the light of newly available information.

Proposals and research results from Division 58.4.3a

6.38 WG-SAM-18/08 presented an updated research plan for research blocks 1 and 2 in Division 58.4.3a from France and Japan, proposing to continue the current research on *D. eleginoides* with an unmodified survey design.

6.39 The Working Group noted that a stock hypothesis was not included as part of this research proposal. It encouraged the development of a stock hypothesis (Table 1) for Division 58.4.3a and noted that the *D. eleginoides* found there are likely associated with the broader Kerguelen Plateau stock.

6.40 The Working Group recommended that a summary of progress and a revised research proposal be presented to WG-FSA and that it provide a summary of previous WG-SAM and WG-FSA working group and Scientific Committee recommendations, and describe how the proposal has addressed these points.

Proposals and research results from Division 58.4.4b

6.41 WG-SAM-18/31 summarised the progress of the research fishery for *D. eleginoides* in Division 58.4.4b. WG-SAM-18/03 presented an updated research plan for research blocks 1 and 2 in Division 58.4.4b, proposing to continue the current research operation with the same survey design as to date.

6.42 The Working Group noted the use of two different gear types on two different vessels, which have sometimes operated in separate locations over time. The Working Group recommended that catch and tagging results be presented for both vessels and for each vessel individually, and recalled its advice from WG-SAM-17 that recommended the use of mixed models (GLMM, GAMM) to establish whether factors such as year, vessel, or fishing location drive the observed results, or whether the patterns observed were independent of the patterns in fishing activities.

6.43 The Working Group noted the catch of 45 kg of sea pens (*Pennatulacea*) as by-catch from the research, and noted that the catch of sea pens appeared high. The Working Group requested that further information on the location(s) and amount of catch of this taxon be presented at WG-FSA in 2018.

6.44 The Working Group noted the ongoing decline in CPUE in research block 5844b_2 since the beginning of this research program, and noted that this issue should be considered by WG-FSA.

Review of research proposals and results for Subarea 88.1

6.45 The Working Group noted WG-SAM-18/21 which reviewed priority research topics and identified key attributes for fisheries-directed research programs that would be needed to evaluate the objectives of the Ross Sea region marine protected area (MPA). The authors noted that key priority research elements had been set out in CM 91-05, Annex 91-05/C, and that these should be used to provide guidance in the design of regional research program objectives. The authors outlined a set of criteria that could be used by the Scientific Committee and its working groups for ranking the quality and priority of current and future multiyear research programs:

(i) identify which priority research elements are addressed

(ii) explicitly integrate core concepts of good experimental 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 areas

(v) demonstrate that coordinating vessels will employ robust standardised procedures, including that the vessels involved will provide high-quality and comparable data, especially with respect to toothfish tagging performance

(vi) demonstrate the capacity to conduct high-quality and timely off-the-water analyses necessary to utilise the data to inform the research and monitoring plan (RMP) evaluation process.

6.46 The Working Group noted that there has been confusion as to the linkage between the application of CM 24-01 and the interpretation of the regulations for the MPA special research zone (SRZ). It was noted that, while the SRZ has specific objectives as outlined in CM 91-05, there is no mechanism to separate the effects of structured research plans from the Olympic fishery and that interactions are currently highly likely and that this will likely confound the results of the research.

6.47 The Working Group therefore considered that, in addition to the criteria that it has developed for evaluating research plans, the criteria outlined in the paper were useful in guiding the Scientific Committee and its working groups in their evaluations of research within and outside of the Ross Sea region MPA and, consequently, recommended that WG-SAM-18/21 be distributed and presented at the other 2018 Scientific Committee working group meetings and to the Scientific Committee for consideration and further development of recommendations.

6.48 WG-SAM-18/09 presented a proposal for a winter survey in the north of Subareas 88.1 and 88.2. The survey follows the successful survey conducted in the Ross Sea in the winter of 2015/16. The survey will be coordinated with a survey to be conducted within the SPRFMO area adjacent to the CAMLR Convention Area at a similar time.

6.49 The survey objectives are to test three hypotheses to describe the reproductive ecology of *D. mawsoni*:

(i) *D. mawsoni* eggs are buoyant and accumulate under sea-ice
(ii) *D. mawsoni* spawn throughout the Pacific–Antarctic fracture zone
(iii) biological characteristics of the northern spawning population change as younger, fatter, female fish move to the north for spawning during winter.

6.50 The aim of the survey design is to sample across the Pacific–Antarctic fracture zone of the Ross Sea region for spawning toothfish while conducting plankton tows to sample eggs and larvae during September and October. It is also proposed that five satellite tags will be deployed in collaboration with the USA.

6.51 The Working Group noted that the catch limit would need to be held back from the Olympic fishery, but that it may not be achieved in the effort-limited survey. It was considered that it may be more optimal to allocate the catch limit from the upcoming season and then to reallocate any uncaught catch into the upcoming season.

6.52 The Working Group also noted the potential for the collection of genetic samples across a range of life-history stages to complement and contribute to research that is ongoing by Australia, and which would contribute to the stock definition across the area. The proponents confirmed that these samples, and other requests that fit within the scope of the survey, would be collected.

6.53 WG-SAM-18/10 presented a report of the first year of the two-year Ross Sea shelf survey. It was noted that the survey is contributing information to the assessment on the strength of recruitment year classes, which can be seen passing through the age structures generated each year. The further development of such surveys and the importance of such surveys for young fish coming into the assessed population was highlighted by the stock assessment review panel (SC-CAMLR-XXXVII/02).

6.54 WG-SAM-18/07 presented a proposal for a research survey to be conducted by four vessels within the SRZ of the Ross Sea region MPA (RSRMPA). The research program has the objectives of investigating the life cycle, distribution and movement, biological parameters and stock structure of *Dissostichus* species in the eastern part of the Ross Sea over the shelf and continental slope within SSRU 882A.

6.55 Dr S. Kasatkina (Russia) noted that the proposal includes research considered a priority within the research and monitoring plan for the RSRMPA and that the proposal would provide information on genetic linkages, gonad histology, diet studies and biological parameters.

6.56 The Working Group welcomed the undertaking to link the outcomes of this research with the topics from the RMP (SC-CAMLR-XXXVI/20) presented in the proposal.

6.57 The Working Group recalled that WG-FSA-17 had noted that a systematic survey design in the proposal was a suitable approach to develop time series of a range of data such as abundance indices and catch composition and biological characteristics in the SRZ, but systematic surveys may not be able to account for changes in sea-ice or catch limits and this may compromise the survey series.

6.58 WG-SAM requested further information in the revised proposal concerning:

(i) the rationale for the change to the catch limits in the revised proposal

(ii) the alternative stock hypothesis that the proposal is trying to test

(iii) why a CASAL assessment or Chapman biomass estimate is required for a subregion within the Ross Sea, when there is an assessment conducted for the wider area

(iv) the inclusion of a vessel which has released approximately 700 tagged toothfish in the Ross Sea, which have resulted in no recaptures

(v) how the research can be conducted without interaction with the SRZ Olympic fishery.

6.59 Dr Kasatkina indicated that further clarification would be provided in the next version of the proposal presented to WG-FSA-18. She also noted that after a grid pattern of fishing positions was achieved in the first year, a stratified design for future years would be presented to allow more powerful statistical analysis to be conducted.

6.60 The Working Group recalled previous discussions at WG-SAM and WG-FSA concerning some confusion surrounding the application of CM 24-01 within the SRZ, particularly:

(i) the separation of research and Olympic fishing within the SRZ
(ii) administration of catch limits.

6.61 The Working Group recalled the previous WG-FSA advice (SC-CAMLR-XXXVI, Annex 7, paragraph 3.114) that this issue should be considered by the Scientific Committee.

6.62 WG-SAM-18/06 presented a proposal for a new fishery for crabs in Subareas 88.2 and 88.3 to be conducted by two vessels. The proposal was submitted as a research plan under CM 24-01.

6.63 The objective of the 3-year program is to study the species composition, biology, life cycle, distribution and structure of the crab stocks to assess their resource potential in the Bellingshausen Sea (Subarea 88.3) and Amundsen Sea (Subarea 88.2). The target species of the program is any member of the crab group (Order Decapoda, infra-orders Anomura and Brachyura). Dr Kasatkina informed the Working Group that no pots are proposed to be set in Subarea 48.1.

6.64 The Working Group requested that the Scientific Committee consider this proposal as a new fishery under CM 21-01 not CM 24-01.

6.65 It also noted that the fishery in Subarea 48.3 had failed due to poor condition of the crabs and a high degree of parasitism. Discard of small crabs was high and there were concerns about discard survivorship. The Scientific Committee had recommended pot modifications to introduce panels that decayed to ensure that lost pots did not constitute a ghost fishing risk.

6.66 The Working Group asked for details as to the research design of the survey, which seemed to concentrate at the depths at which toothfish vessels have fished which could result in high by-catch. It was noted that in Subarea 88.3 the fishery had operated at depths between 500 and 1 000 m and that a stratified research design with depth should be applied in order to examine the depth distribution of the species.

6.67 Further, the Working Group suggested that the experimental design of exploring new areas may benefit from the approaches used in developing research plans for toothfish in new areas, such as using short lines (minimal effort) and a mechanism to spread effort to better characterise CPUE across a large area (SC-CAMLR-XXXII, Figure 1).

6.68 Dr Kasatkina thanked the Working Group for the constructive comments and indicated that further clarification would be provided in a revised proposal for the new fishery. She also noted that national observer training would be provided in the identification of craboids prior to the survey.

Review of research proposals and results for Subarea 88.3

6.69 The progress report on the joint research for *Dissostichus* spp. in Subarea 88.3 by the Republic of Korea and New Zealand in 2017/18 (WG-SAM-18/05) was presented. The Working Group noted that the New Zealand vessel *Janas* did not complete the survey because the vessel could not access the southern research blocks due to heavy sea-ice conditions and safety considerations.

6.70 The Working Group noted that no toothfish had been recaptured during the survey and that this was likely due to the low catches and ice/weather conditions. The proponents recognised that recapturing tagged fish was the highest priority, particularly in research blocks 883_3 to 883_5, which are typically more accessible. The Working Group noted that recovery of tagged fish, and therefore biomass estimation, was most likely in research blocks 883_3, 883_4 and 883_5.

6.71 The Working Group recognised that fishing in research blocks 883_1 and 883_2 could provide information to inform a stock structure hypothesis but was unlikely to contribute to biomass assessment. The Working Group recommended the proponents consider mechanisms to reallocate the available research catch limit among participants to increase the probability of tagged fish recaptures to meet the research plan objectives.

6.72 The Working Group noted that *Macrourus* spp. was the main by-catch taxon during the Korean research fishing. The Working Group agreed that with little information available from this area, it was important to identify by-catch to species level during research fishing and report the results to WG-FSA-19 (paragraph 6.1).

6.73 The Working Group noted that the tag-overlap statistic from WG-SAM-18/05 was 72% but that the size distribution of tagged fish did not reflect very well the size distribution of the large fish from the catch. The Working Group recommended to document the tagging procedure and fish handling practices through scientific electronic monitoring recordings from the survey to better understand why large fish were not tagged in proportion to the catch.

6.74 The Working Group considered the new research proposal for *Dissostichus* spp. in Subarea 88.3 by Ukraine (WG-SAM-18/12). Ukraine noted that scientific electronic monitoring has been installed on the proposed vessel and that the recordings could be made available to the working groups. The Working Group noted that there was a need to consider each new research proposal in its own right, however, it was also necessary to consider what additional value and scientific knowledge the research proposal would bring to an area within which multi-Member research activity was already undertaken (paragraph 6.28). The Working Group recommended Ukraine to highlight this additional value of their research survey and to address the criteria in Table 6 of WG-FSA-17 in a revised proposal to WG-FSA-18.

6.75 The Working Group recommended to better describe the fishing gear configuration proposed and submit the description to the CCAMLR gear library. The Working Group noted that having three gear types included in the research could allow comparisons among gear types but could also introduce variability in research performance.

6.76 The Working Group noted uncertainty around the process by which the Ukrainian proposal could be integrated with the existing research proposals from Korea and New Zealand given that they are at different stages of development. The Working Group recommended that the proposal should be developed further and Ukraine should coordinate its research efforts with Korea and New Zealand before the submission of a multi-Member proposal for consideration at WG-FSA-18.

Future work

7.1 The Working Group noted that a considerable amount of its time was spent reviewing research proposals for research fisheries. Further, it noted that these research proposals were expected to be revised and reviewed again at WG-FSA each year. It also noted that there were examples of research plans that were successfully delivering on their on- and off-water milestones, and that if research proponents used these as examples to emulate in developing research plans, any review process would be more efficient.

7.2 The Working Group recommend that these plans do not need to be reviewed twice each year, and that a single review could be completed by WG-FSA.

7.3 The Working Group noted that the Scientific Committee had identified nine high-priority items for consideration by WG-SAM on its work program (SC-CAMLR-XXXVI/BG/40), but that it was unable to consider all of these at its meeting this year due to the large number of research plans presented.

7.4 The Working Group also noted that it may be able to progress high-priority items at future meetings if focus topics or workshops were scheduled and prioritised above other items. It noted that there had been considerable success in progressing the work of the Scientific Committee at focused workshops previously, and noted the success of last year's SISO meeting and at the Berlin Workshop to develop a stock hypothesis for toothfish in Area 48.

7.5 The Working Group noted that development and review of quantitative methods was still required by the Scientific Committee and that WG-SAM could continue to provide this function. However, the Working Group also noted that many of these functions could be carried out by focused workshops that had the benefit of bringing together a broad range of expertise of regular delegates and other experts.

7.6 The Working Group noted that the development of Casal2 may require additional work at a future meeting to consider validations and comparisons of the software with CASAL before being used to provide management advice, but that this was not likely to be required before assessment advice was due to be reviewed in 2021. It further noted that the development of stock assessments from new areas resulting from successful research plans, and quantitative work to further progress management of krill, and a response to the outcomes from the stock assessment review panel, will also need to be developed and progressed in the coming years.

7.7 The Working Group therefore requested the Scientific Committee consider the most efficient and effective way to ensure priority issues are addressed, through working groups and/or workshops.

Other business

8.1 WG-SAM-18/16 provided an update on the proposal for the MPA in the Weddell Sea (WSMPA) to CCAMLR that will be submitted to CCAMLR-XXXVII. The main changes in the proposal compared to 2016 included:

(i) extending the proposal for the general protection zone (GPZ) along the Antarctic Peninsula, including the Larsen ice shelf to protect more toothfish habitat, which has allowed greater flexibility in the design of the eastern part of the WSMPA

(ii) focussing the research and monitoring plan on all life-history stages of toothfish rather than simply focussing on adult toothfish

(iii) the requirement for reference areas for examining the ecosystem effects of fishing, noting that the MPA proposal would not seek to interfere with existing conservation measures including the designation of research blocks in Subarea 48.6.

8.2 The authors of WG-SAM-18/16 requested feedback from WG-SAM on the aspects of the proposal, in particular on the design, selection and location of reference areas.

8.3 The Working Group recognised the need for reference areas (i.e. fished and unfished areas) as a tool for studying the effects of the fishery on biodiversity. The Working Group noted that while it was unlikely to find a fished and an unfished area that are otherwise ecologically identical, this may not be necessary if there are gradients of the levels of historical fishing across otherwise comparable areas with which to examine potential impacts. It also noted that methods existed for estimating the historical fishing footprint in the Convention Area and that these could be updated to inform this process (WG-FSA-15/62 Rev. 1).

8.4 The Working Group agreed that there was a range of criteria that could be used to identify appropriate reference areas and that these would depend on the specific objective of the comparisons. The Working Group recommended that the approach used in Figure 1 to categorise the information available relative to the selection of research areas in Division 58.4.1 could be a useful way to approach selection of reference areas.

8.5 The Working Group agreed that the impact of sea-ice-conditions on vessel accessibility in the Weddell Sea is a critical factor in planning research and monitoring in the WSMPA (WG-SAM-18/12; WS-DmPH-18/02) and that this should be included in the revision of the boundaries of WSMPA and the reference areas.

8.6 Dr Kasatkina noted that the revision of the WSMPA proposal also requires information on target species in the MPA in order to designate areas for protection and fishing activity.

Advice to the Scientific Committee

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

(i) Development of management advice consistent with Article II for fisheries with more limited data –

(a) the application of the trend analysis rule to determine whether the trend was increasing, decreasing, stable, or uncertain to be used to provide management advice for setting catch limits in research blocks (paragraph 4.5).

(ii) Data acquisition and management –

(a) approaches to understanding variability in tag performance between vessels. as these data serve as a primary driver underpinning current stock assessments of toothfish (paragraphs 5.7 and 5.8).

(iii) Generic advice for research plans –

(a) information requirements for research plans (paragraph 6.1)

(b) approaches to standardising the timeframes for research proposals (paragraph 6.2)

(c) guidance to Members on appropriate criteria for the application for exemption from conservation measures under CM 24-01 (paragraph 6.3).

(iv) Review of research plan proposals and results –

(a) research to address data gaps and hypotheses for *D. mawsoni* life history in Area 48 (paragraph 6.8)

(b) request for advice on the separation of research and Olympic fishing and the administration of catch limits within the SRZ (paragraph 6.61)

(c) request that the Scientific Committee consider a proposal for a new fishery for crabs in Subareas 88.2 and 88.3 submitted as a research plan under CM 24-01 be considered under CM 21-01 not CM 24-01 (paragraph 6.64).

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. He also noted that this was his fourth meeting as Convener and that it was timely to consider a succession strategy to introduce a new Convener of WG-SAM.

10.2 Dr Parker thanked the hosts, in particular Drs Earl and Söffker, for the support provided by Cefas to the successful Working Group meeting.

10.3 On behalf of the Scientific Committee and the Working Group, Mr Sarralde (Senior Vice-Chair of the Scientific Committee) thanked Dr Parker for his four years of successfully convening the Working Group as well as his considerable intersessional work to progress the important issues on the agenda of WG-SAM.

Reference

van Wijk, E.M., A.J. Constable, R. Williams and T. Lamb. 2000. Distribution and abundance of *Macrourus carinatus* on BANZARE Bank in the southern Indian Ocean. *CCAMLR Sci.*, 7: 171–178.

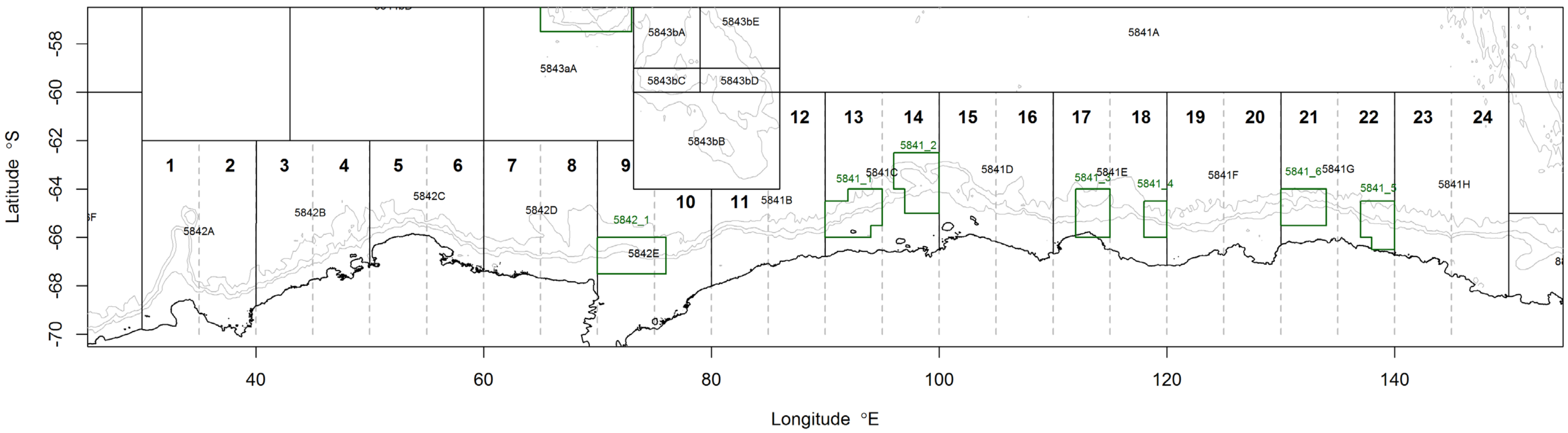
Table 1: Example table of potential milestones and proposed and actual achievement dates that could be appended to annual research reports for research plans and research proposals.

Milestones (from SC-CAMLR-XXXVI, Annex 7, Table 2)	Milestone applicable	e.g. Year 1		e.g. Year 2		e.g. Year 3	
		WG-SAM e.g. paper #	WG-FSA e.g. paper #	WG-SAM e.g. paper #	WG-FSA e.g. paper #	WG-SAM e.g. paper #	WG-FSA e.g. paper #
Fishing operations:							
1. Fishing operational data specified in the research plan (e.g. standardisation of gear or procedures or data to be collected).							
2. Sampling requirements as specified in the research plan (e.g. fish length, weight, otoliths, by-catch species composition, tags deployed, VME sampling).							
Biological sampling and analysis:							
3. Tissue samples collected as specified: otolith sampling, gonad sampling, other.		e.g. due date		e.g. preliminary	e.g. reported	e.g. updated protocol	e.g. reported
Sample processing as agreed:							
4. Otoliths to be aged, validation procedures completed and adequate for use.		e.g. due date	e.g. due date	e.g. new due date	e.g. new due date	e.g. some aging, due date for validation	e.g. preliminary results
5. Maturity analysis as specified (methods, sample sizes, by sex)							
Biological parameter estimation:							
6. Length-weight relationships		e.g. due date		e.g. preliminary results	e.g. preliminary results		e.g. final results
7. Maturity ogive parameter values							
8. Age-length keys, growth model parameters.							
Tagging data:							
9. Tagging rate achieved, tag releases by season in each research block, overlap statistic achieved.							
10. Vessel calibration studies conducted		e.g. n/a		e.g. n/a		e.g. n/a	
By-catch data:							
11. Data and samples collected as specified in the research plan							
12. Analyses conducted as specified in the research plan (e.g. Satellite tagging, Oceanography, Diet)							

(continued)

Table 1 (continued)

Milestones (from SC-CAMLR-XXXVI, Annex 7, Table 2)	Milestone applicable	e.g. Year 1		e.g. Year 2		e.g. Year 3	
		WG-SAM e.g. paper #	WG-FSA e.g. paper #	WG-SAM e.g. paper #	WG-FSA e.g. paper #	WG-SAM e.g. paper #	WG-FSA e.g. paper #
Data analysis, as specified in the research plan:							
13. Hypothesis testing of stock structure							
14. Vessel calibration studies as specified: catch rate and size selectivity, tagged fish survival, and tag detection analysis							
15. IUU estimation (current and historical)							
16. Expected tagging programme performance							
17. Preliminary stock status, and biomass estimates, and harvest rate incorporating data collected to date (e.g. selectivity, size, biological parameters)							
18. Analysis of biological data for target and non-target species							
19. Analysis of potential effects of fishing on the ecosystem		e.g. n/a		e.g. n/a		e.g. due date	
Other milestones in the proposal							



	Division	58.4.2										58.4.1													
	SSRU	A	A	B	B	C	C	D	D	E	E	B	B	C	C	D	D	E	E	F	F	G	G	H	H
	With research block									1				1	2			3	4			6	5		
	Segment	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
a) Objectives	Available tags	M	L	L	L	L	L	L	L	H	H	L	L	H	H	M	L	H	H	L	L	H	H	H	M
	Recaptures	L	L	L	L	L	L	L	L	L	L	L	L	M	M	L	L	H	M	L	L	H	M	M	L
	Local assessment	L	L	L	L	L	L	L	L	H	L	L	L	H	H	L	L	H	H	L	L	H	H	L	L
	Area-wide assessment	L	L	L	L	L	L	L	L	M	M	M	M	H	H	H	H	H	H	H	H	H	H	L	L
	Key life-history stages	H	M	L	L	L	L	L	M	H	H	M	L	M	H	H	L	M	M	L	L	L	L	L	L
	No data for habitat model	M	H	H	H	H	H	M	L	L	L	M	L	L	L	L	L	L	L	L	L	L	L	L	L
	Avoid VME	H	M	M	M	H	M	M	M	H	H	M	M	H	H	M	M	H	H	M	M	H	H	L	L
b) Viable fishery	Catch rates	M	L	M	M	H	H	H	H	H	M	M	H	H	H	M	L	M	M	M	M	M	M	H	H
	Fishing history	L	L	L	L	L	L	L	L	M	M	L	L	H	H	M	L	H	M	L	L	H	H	M	L
	Habitat area	H	L	L	M	L	L	L	L	L	L	L	L	L	M	H	L	M	L	L	M	M	L	L	L
	Sea ice	H	L	M	M	H	M	M	M	M	M	M	M	M	M	M	M	M	M	M	H	H	H	M	M
c) Stock hypothesis	See Key life-history stages																								

Figure 1: Suitability of geographic five-degree-longitude sections (upper panel) against the criteria under WG-SAM-11 (SC-CAMLR-XXX, Annex 5, paragraph 2.40) (lower panel). Suitability is marked as high (H, green), medium (M, orange) or low (L, red). Upper panel: Black lines = SSRU boundaries, green lines = research blocks in Divisions 58.4.1 and 58.4.2 as set out in Conservation Measures 41-11 and 41-05 (from WG-SAM-18/17, Figure 1).

Appendix A

List of Participants

Working Group on Statistics, Assessments and Modelling
(Norwich, United Kingdom, 25 to 29 June 2018)

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Appendix B

Agenda

Working Group on Statistics, Assessments and Modelling
(Norwich, United Kingdom, 25 to 29 June 2018)

1. Introduction

2. Opening of the meeting

    2.1 Adoption of the agenda and organisation of the meeting

3. Assessments to estimate sustainable yield in established/assessed fisheries

4. Development of management advice consistent with Article II for fisheries with more limited data

5. Data acquisition and management

6. Review of research plan proposals and results

    6.1 Proposals and research results from Area 48

        6.1.1 Proposals and research results from Subarea 48.1
        6.1.2 Proposals and research results from Subareas 48.2 and 48.4
        6.1.3 Proposals and research results from Subarea 48.6

    6.2 Proposals and research results from Subarea 58.4

        6.2.1 Proposals and research results from Division 58.4.1
        6.2.2 Proposals and research results from Division 58.4.2
        6.2.3 Proposals and research results from Division 58.4.3
        6.2.4 Proposals and research results from Division 58.4.4

    6.3 Review of research proposals and results for other areas

        6.3.1 Review of research proposals and results for Subarea 88.1
        6.3.2 Review of research proposals and results for Subarea 88.2
        6.3.3 Review of research proposals and results for Subarea 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
(Norwich, United Kingdom, 25 to 29 June 2018)

WG-SAM-18/01	Predicting fishing ground accessibility in the Antarctic Weddell Sea H. Pehlke, K. Teschke and T. Brey
WG-SAM-18/02	Research plan for the 2018/19 exploratory longline fishery of *D. mawsoni* in Subarea 48.6 by Spain Delegation of Spain
WG-SAM-18/03	Continuation proposal of a multi-Member longline survey on Patagonian toothfish (*Dissostichus eleginoides*) in Division 58.4.4b in 2018/19 by Japan and France Delegations of Japan and France
WG-SAM-18/04	Proposed continuation of a multi-Member longline survey on Antarctic toothfish (*Dissostichus mawsoni*) in Statistical Subarea 48.6 in 2018/19 by Japan and South Africa Delegations of Japan and South Africa
WG-SAM-18/05	Progress report on the joint research for *Dissostichus* spp. in Subarea 88.3 by the Republic of Korea and New Zealand and notification of research in 2018/19 Delegations of the Republic of Korea and New Zealand
WG-SAM-18/06	Research program on study of life cycle, species compositions, biology and resource potential of craboids (Anomura, Decapoda) in the Pacific Ocean Antarctic Area in 2018–2021 by Russian Federation Delegation of the Russian Federation
WG-SAM-18/07	Research program to examine the life cycle and resource potential of *Dissostichus* species in the Special Research Zone within the Ross Sea region marine protected area (RSRMPA) in 2018–2027 by Russian Federation Delegation of the Russian Federation
WG-SAM-18/08	Continuation of multi-Member research on the *Dissostichus eleginoides* exploratory fishery in 2018/19 in Division 58.4.3a by France and Japan Delegations of France and Japan

WG-SAM-18/09	Notification for scientific research in 2019/20 under CM 24-01: Proposal for a winter longline survey of Antarctic toothfish in the northern region of Subareas 88.1 and 88.2 Delegation of New Zealand
WG-SAM-18/10	Results of the seventh Ross Sea shelf survey to monitor abundance of Antarctic toothfish in the southern Ross Sea, January 2018, and notification for research in 2018/19 D. Stevens, X. Fu, S. Mormede and S. Parker
WG-SAM-18/11	Plan of research program of the Ukraine in Subarea 48.1 in 2019 Delegation of Ukraine
WG-SAM-18/12	Plan of research program of the Ukraine in Subarea 88.3 in 2019 Delegation of Ukraine
WG-SAM-18/13	Proposal for continuation of the Ukrainian research survey in Subarea 48.2 in 2018/19 season (fifth year of research) Delegation of Ukraine
WG-SAM-18/14	Introducing Casal2 for toothfish stock assessments S. Mormede
WG-SAM-18/15	Outline for year 3 of the 3-year longline survey to determine toothfish population connectivity between Subareas 48.2 and 48.4 M. Söffker and M. Belchier
WG-SAM-18/16	Informing and seeking advice from WG-SAM-18 about the revisions of the WSMPA proposal S. Hain, K. Teschke, H. Pehlke and T. Brey
WG-SAM-18/17	Draft proposal for 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-18/18	A photographic reference set for Antarctic toothfish (*Dissostichus mawsoni*) from the Ross Sea region C. Sutton and S. Parker
WG-SAM-18/19	Research concept on catchability to study toothfish abundance/stocks in the Antarctic marine areas K. Demianenko, L. Pshenichnov, O. Diripasko and V. Gurianov

WG-SAM-18/20	Results of a scientific electronic monitoring pilot study on the FV *Janas* during the 2017/18 Ross Sea fishing season B. Plum, A. Smith and S. Parker
WG-SAM-18/21	Guidelines for fisheries-directed research addressing the Ross Sea region Marine Protected Area Research and Monitoring Plan S. Parker and A. Dunn
WG-SAM-18/22	Monitoring and managing the effects of environmental change on toothfish assessments M. Pinkerton, A. Dunn, S. Mormede and S. Parker
WG-SAM-18/23	Simulating performance of trend analysis for setting catch limits in exploratory toothfish research plans S. Hoyle, S. Parker, A. Dunn and S. Mormede
WG-SAM-18/24	Short review of the procedure for realisation of the fish tagging program on vessels of Ukraine in the season 2017/18 Delegation of Ukraine
WG-SAM-18/25	Cruise Report – Research Project: Demersal finfish distribution, abundance, and their biological characteristics in Statistical Subareas 48.1 (northern area) and 48.2 Delegation of Chile
WG-SAM-18/26	The preliminary report on the survey for *Dissostichus* spp. in Subarea 48.2, season 2017/18 Delegation of Chile
WG-SAM-18/27	Preliminary results of oceanological research of Ukrainian vessels in the CCAMLR area for the season 2017/18 V. Paramonov
WG-SAM-18/28	The preliminary report on the survey in Subarea 48.2 in 2018 (the fourth year of the planned 5-year-old investigations) Delegation of Ukraine
WG-SAM-18/29	Information report on the age determination methods of toothfish *Dissostichus* spp. I.V. Slypko and P.M. Zabroda
WG-SAM-18/30	Preliminary results from the second year of a three-year survey into the connectivity of toothfish species in Subareas 48.2 and 48.4 M. Söffker, K. Olsson and M. Belchier

WG-SAM-18/31	Annual report of research fishing operations at Division 58.4.4b in 2016/17 fishing season Delegations of Japan and France
WG-SAM-18/32	Annual report of research fishing operations at Subarea 48.6 in 2016/17 fishing season Delegations of Japan and South Africa
WG-SAM-18/33 Rev. 1	Annex to WS-DmPH-18 report: Towards the development of a stock hypothesis for Antarctic toothfish (*Dissostichus mawsoni*) in Area 48 M. Söffker, A. Riley, M. Belchier, K. Teschke, H. Pehlke, S. Somhlaba, J. Graham, T. Namba, C.D. van der Lingen, T. Okuda, C. Darby, O.T. Albert, O.A. Bergstad, P. Brtnik, J. Caccavo, A. Capurro, C. Dorey, L. Ghigliotti, S. Hain, C. Jones, S. Kasatkina, M. La Mesa, D. Marichev, E. Molloy, C. Papetti, L. Pshenichnov, K. Reid, M.M. Santos and D. Welsford
WG-SAM-18/34	Diagnostic tools for *Champsocephalus gunnari* stock assessments D. Maschette, T. Earl and R. Sinègre
WG-SAM-18/35 Rev. 1	Joint report on exploratory fishing in Divisions 58.4.1 and 58.4.2 between the 2011/12 and 2017/18 fishing seasons Delegations of Australia, France, Japan, Republic of Korea and Spain

Other Documents

WG-SAM-18/P01	Casal2: New Zealand's integrated population modelling tool I. Doonan, K. Large, A. Dunn, S. Rasmussen, C. Marsh and S. Mormede *Fish. Res.*, 183 (2016): 498–505
SC-CAMLR-XXXVII/01	Report of the Co-conveners of the CCAMLR Workshop for the Development of a *Dissostichus mawsoni* Population Hypothesis for Area 48 (19 to 21 February 2018, Berlin, Germany) Workshop Co-conveners (C. Darby (UK) and C. Jones (USA))
SC-CAMLR-XXXVII/02	Summary Report of the CCAMLR Independent Stock Assessment Review for Toothfish (Norwich, United Kingdom, 18 to 22 June 2018)

Annex 7

Report of the Meeting of the Workshop on Spatial Management
(Cambridge, UK, 2 to 6 July 2018)

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Report of the Meeting of the Workshop on Spatial Management
(Cambridge, UK, 2 to 6 July 2018)

Introduction

1.1 The Workshop on Spatial Management was held at the British Antarctic Survey (BAS), Cambridge, UK, from 2 to 6 July 2018. Prof. Dame Jane Francis (Director of BAS) welcomed participants (Appendix A) to BAS and highlighted the critical importance of the scientific outcomes from the workshop in CCAMLR's science-led role in Antarctic conservation.

1.2 Dr M. Belchier (Chair of the Scientific Committee) informed the Workshop that Dr M. Korczak-Abshire (Poland), one of the Workshop Co-conveners, was not able to attend the Workshop. He conveyed Dr Korczak-Abshire's disappointment at not being able to attend and also her best wishes for a successful meeting. Following a proposal from Dr Belchier, the Workshop welcomed the offer from Dr S. Grant (UK) to convene the workshop. Dr Grant thanked Dr Korczak-Abshire for her support in preparation for the workshop.

1.3 In welcoming the participants to the Workshop, Dr Grant explained that the meeting was being held in the new 'Aurora Cambridge' building, a centre for collaboration and innovation, and she hoped that this would provide a suitable inspiration for a successful Workshop. She also noted the broad engagement by Members in the Workshop that highlighted the importance of the topics on the agenda.

1.4 Dr Grant clarified that the outcome of the workshop would be an adopted report that would be submitted to the Scientific Committee following the process for intersessional working groups. She emphasised the importance of providing clear advice and recommendations to the Scientific Committee on both specific issues for technical questions for regional projects and also for general principles that are relevant to all planning domains. The agenda was adopted unchanged (Appendix B).

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

1.6 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 8.

1.7 The report was prepared by T. Brey (Germany), C. Cárdenas (Chile), A. Capurro (Argentina), R. Cavanagh (UK), A. Dahood (USA), C. Darby (UK), A. Dunn and D. Freeman (New Zealand), C. Jones and E. Klein (USA), P. Koubbi (EU), A. Lowther (Norway), M. Santos (Argentina), P. Penhale (USA), K. Reid (Secretariat), M. Söffker (UK), K. Teschke (Germany), P. Trathan (UK), A. Van de Putte (Belgium), G. Watters (USA) and D. Welsford (Australia).

Development of general principles for the use of spatial management tools in the CCAMLR area

2.1 WS-SM-18/14 was presented, highlighting the need for a mechanism to report progress towards the establishment of a representative system of marine protected areas (MPAs) to the

Scientific Committee and the Commission as agreed in 2009, and noting that CCAMLR was behind in its objective of developing a representative system of MPAs by 2012. It described some simple criteria to assess progress towards a representative system of MPAs, taking account of key drivers of large-scale patterns of biodiversity such as ocean depth and temperature between ocean basins. It noted that under these criteria, currently designated MPAs did not constitute a representative system of MPAs, however, if the current Weddell Sea, Domain 1 and East Antarctic MPAs were adopted with their current boundaries, they would make a substantial contribution to achieving a representative system of MPAs.

2.2 WS-SM-18/12 Rev. 1 was presented, assessing the levels of representation of the Douglass et al. (2014) benthic bioregions and Raymond (2014) pelagic bioregions in currently designed and proposed MPAs within the CCAMLR area. The authors made similar conclusions to WS-SM-18/12 Rev. 1, namely that designation of the currently proposed MPAs would make a substantial contribution to overall protection and representativeness of the Southern Ocean and increase their representativeness.

2.3 The Workshop noted that there are multiple ways of achieving regionalisation of oceanic areas. It recognised that this process depends on the spatial scale considered. At the large scale, the bioregionalisation process is mainly constructed on abiotic data that are considered to be proxy of species assemblages or habitats. Bioregions can be defined as biogeochemical provinces as defined by Longhurst (1998) when adding biogeochemical variables to oceanographic and geomorphologic variables, the prefix 'bio' in that case means the addition of chlorophyll or information on planktonic characteristics. Ecoregions are used when combining biogeographic patterns or species assemblages to abiotic regions. Studies (Koubbi et al., 2010 and 2011) have shown that at the macro or mesoscale, ecoregions are principally explained by abiotic regionalisation.

2.4 The Workshop noted that within particular regions or planning domains, there is the capacity to characterise bioregions and ecoregions taking account of fine-scale features and dynamics that may not be reflected in the circumpolar-scale bioregionalisations (e.g. WS-MPA-11/06; Douglass et al., 2014), and it noted that all designated MPAs and MPA proposals currently being considered by CCAMLR were developed using this finer-scale information.

2.5 The Workshop noted that representative protection was one important objective of CCAMLR MPAs, however, other factors such as protection of vulnerable and rare species and unique features, adequacy, connectivity and replication were also important factors to consider in achieving CCAMLR's objectives for MPAs as reflected in Conservation Measure (CM) 91-04. The Workshop noted that in this context, connectivity should be considered at different spatial scales within and between bioregions and latitudes, both within and beyond the CCAMLR area.

2.6 The Workshop noted that CCAMLR used a range of mechanisms other than MPAs to manage activities in space and time, such as shallow water closures, closed fisheries, prohibitions on certain fishing gears, closure of registered vulnerable marine ecosystems (VMEs) etc. that contributed to protection consistent with that provided by MPAs.

2.7 The Workshop agreed to draw on the information contained in WS-SM-18/14 and 18/12 to provide a concise summary of the contribution of current and proposed MPAs towards a representative system of MPAs, and gaps that have yet to be addressed (Table 1).

2.8 The Workshop noted that seven MPAs currently exist in the Convention Area (South Orkney Islands southern shelf (SOISS) MPA, Ross Sea region MPA (RSRMPA), Heard Island and the McDonald Islands, Prince Edward Islands, Crozet Islands, Kerguelen and South Georgia and the South Sandwich Islands); these occur in all three basins of the Southern Ocean (Atlantic, Indian and Pacific) and cover a wide range of depths and latitudes. Several benthic and pelagic bioregions in the Southern Ocean are underrepresented by the existing set of MPAs. These include:

(i) 15 benthic ecoregions identified by Douglass et al. (2014) (Amundsen, Atlantic Basin, Antarctic Peninsula, Central Indian – East Kerguelen Subregion, Central Indian – Prydz Bay Subregion, Central Indian – Wilkes Subregion, Central Indian – West Kerguelen Subregion, Dronning Maud, East Indian Abyssal, Kerguelen – BANZARE Bank Subregion, Kerguelen – Deep Kerguelen Subregion, Ob and Lena, Pacific Basin, South Atlantic, Weddell Shelf)

(ii) four pelagic clusters identified by Raymond (2014) (2 – various polynyas, 3 – icy shallow shelf areas, 11 – one of four sea-ice zones, 17 – temperate waters).

2.9 The Workshop recalled three MPA proposals that have been previously considered by the Scientific Committee (East Antarctic MPA (EAMPA), Weddell Sea MPA (WSMPA), and the MPA in Planning Domain 1 (D1MPA)) can fill many of these gaps and substantially increase representativeness. If these proposals are added to the system of MPAs already in place within the Convention Area, relatively few benthic and pelagic bioregions will remain underrepresented. These include:

(i) six benthic ecoregions identified by Douglass et al. (2014) (Amundsen, Central Indian – Wilkes Subregion, East Indian Abyssal, Ob and Lena, Pacific Basin, South Atlantic)

(ii) one pelagic cluster identified by Raymond (2014) (17 – temperate waters).

2.10 The Workshop advised the Scientific Committee that within the Convention Area:

(i) the existing set of MPAs is not representative of all benthic and pelagic bioregions in the Southern Ocean

(ii) establishment of the EAMPA, WSMPA and D1MPA would substantially increase representativeness.

2.11 The Workshop noted that the pelagic cluster which is currently underrepresented by the existing and proposed MPAs (17 – temperate waters) will be included within an initiative to develop a new MPA in the high seas of Planning Domains 5 and 6 (CCAMLR-XXXI, paragraph 5.57; SC-CAMLR-XXXV, paragraphs 5.30 and 5.31).

2.12 The Workshop recalled that the Commission had made the development of a representative system of MPAs a priority for the Scientific Committee in 2009, and had requested that progress towards this objective be provided. The Workshop therefore recommended that the Scientific Committee evaluate and report progress towards achieving the Commission's stated goal of a representative system of MPAs. The Workshop suggested the Scientific Committee and Commission review Table 1, and regularly update it to continue to track progress.

2.13 The Workshop recommended that the Scientific Committee continue to develop criteria to enable the assessment of CCAMLR's progress towards a representative system of MPAs and the other goals of CM 91-04.

2.14 WS-SM-18/10 commented on the use of MPAs for spatial management in the CCAMLR area. The paper noted that MPA designation requires baseline data established in advance of the MPA coming into force as part of the planning process. This data should be provided for development and justification of objectives, boundaries, monitoring and research plans, measurable criteria and indicators of the performance and efficiency of the MPA. This baseline data will be used to assess whether the MPA achieves its specific objectives.

2.15 WS-SM-18/10 further pointed out the necessity to clarify how long an MPA can exist without baseline data and provided proposals to unify requirements for designating MPAs, including:

(i) developing a standardised approach and criteria for designating MPAs, using the current Japanese MPA checklist (CCAMLR-XXXIV/19) as a basis. This checklist should be endorsed as an annex to CM 91-04

(ii) endorsing the baseline data and related measurable criteria and indicators of the performance and efficiency of the MPA as an annex to the Research and Monitoring Plan (RMP) and the relevant changes in CM 91-04

(iii) the RMP should be detailed for reporting periods: both in relation to planned research and monitoring activity and the information that should be obtained.

2.16 The Workshop did not discuss all the matters raised in the paper, as they were beyond the terms of reference of the Workshop. In response to proposal (ii), it noted that there were links on the CCAMLR website to the *Basic Documents* that developed the scientific case for the designation of MPAs in the Ross Sea region and the SOISS MPAs, and the EAMPA proposal.

2.17 The Workshop further recalled the agreement of the Scientific Committee (SC-CAMLR-XXXIII, paragraph 5.46) on the development of MPA reports, analogous to Fishery Reports, and noted that this could be a useful mechanism to summarise the information used to support designation of CCAMLR MPAs, and data derived from research and monitoring activities relevant to each MPA's specific objective. Mechanisms for providing access to baseline data used to develop MPAs and RMPs was discussed under Item 5.

2.18 SC-CAMLR-XXXVI/01 was presented summarising the discussions at the CCAMLR Workshop for the Development of a *Dissostichus mawsoni* Population Hypothesis for Area 48 (WS-DmPH-18) that was held in Berlin, Germany, in February 2018.

2.19 The Workshop noted that all three stock hypotheses developed at WS-DmPH-18 indicated that the spatial extent of Antarctic toothfish (*Dissostichus mawsoni*) populations were likely to be mesoscale or greater, and hence spatial protection of habitats of all life stages of species may span more than one planning region. It noted that one key uncertainty in the description of habitats for this species is the distribution of early life-history stages such as eggs and larvae, and encouraged Members to develop research to address this data gap. It also noted that circulation models in this area could be usefully applied to understand connectivity between areas during the pelagic life stages of *D. mawsoni*. It further encouraged Members to collect tissue samples to facilitate high-throughput sequencing studies of *D. mawsoni* population structure as described in WS-DmPH-18/08.

2.20 The Workshop noted that CCAMLR managed *D. mawsoni* fisheries consistent with Article II through measures other than just spatial protection, such as the conservation measures that regulate exploratory fishing in this region. It also noted that WS-DmPH-18 had concluded that, as the Weddell Sea MPA was developed to protect more than just *D. mawsoni* habitats, consideration of *D. mawsoni* should not be the only driver for the development of MPAs in this region. However, it welcomed the consideration of the outcomes of WS-DmPH-18 in the revised documentation to support the WSMPA (paragraphs 3.50 to 3.73).

Development of MPA proposals

3.1 WS-SM-18/P01 described a modelling framework that combines satellite data on sea-surface chlorophyll-a, a regional oceanographic model and diatom abundances from sediment grabs with particle tracking to model the food available to benthic biota. It demonstrated that fluctuating seabed currents are important in the redistribution of surface productivity at the seafloor along the East Antarctic shelf and the modelled food availability is important in determining the distribution of benthic biota. The availability of suspended food near the seafloor was shown to be correlated with the abundance of benthic suspension feeders, while the deposition of food particles was correlated with decreasing suspension feeder richness and more abundant deposit feeders in depths >200 m.

3.2 The Workshop agreed that this was a useful framework that could potentially be applied in other parts of the Convention Area to predict spatial distributions of benthic biodiversity, as well as how changes in the environment may influence the composition of seafloor communities and benthic ecosystems.

3.3 The Workshop also noted that this approach could be used to provide broad predictions of the presence of VME indicator taxa that may be present in areas where Members notify their intention to conduct bottom fishing, and where there is currently no information. The Workshop agreed that this framework could be useful as part of a review of CCAMLR's approach to managing impacts on VMEs.

3.4 WS-SM-18/P02 described a new multi-species modelling approach, called Regions of Common Profile, for characterising ecoregions. This method characterises ecoregions by grouping sites with a similar composition of species, and describes the patterns of variation in assemblages using environmental data. This approach was exemplified using demersal finfish and environmental data on the Kerguelen Plateau, and was successful at quantifying seven ecoregions and mapping their spatial distribution across the northern plateau. Validation at independent sites indicates the model was able to reasonably predict the occurrence of individual species across the plateau, as well as the species composition at sites.

3.5 The Workshop agreed that this approach can potentially be used for characterising ecoregions, and can assist in spatial management of specific regions of the Southern Ocean.

3.6 The Workshop cautioned that different demersal finfish can demonstrate ontogenetic changes as a function of their life-history strategy, with adult demersal fish often utilising different habitats than juveniles. The focus of this study, however, was the distribution of adult fish assemblages. The Workshop acknowledged that distributions can change with seasons, and noted that this particular study was designed to provide average spatial distributions across seasons, but predictions for the individual seasons sampled can be generated if included in the model as a sampling factor. The Workshop further noted that the approach could be used with either presence–absence, abundance or biomass data, depending on the data available, to produce different types of ecoregions.

3.7 The Workshop agreed that this approach has several potential uses. For example, outputs from the Regions of Common Profile method can potentially be used to:

- define biogeographic patterns and provide an ecological understanding of them
- inform or assess the representativeness of spatial planning options
- provide a baseline map of the distribution of assemblages/ecoregions
- inform the design of future sampling (e.g. ecological stratification), with potential applications to monitoring.

3.8 The Workshop noted that related statistical methods have the further potential to detect, attribute and understand ecological change using temporal data (i.e. which species are changing; drivers of change; which areas are undergoing change; where monitoring efforts should be targeted).

3.9 The Workshop noted that the statistical methods presented have advantages for analysing and interpreting ecological and biodiversity data, and recommended their further development and application within CCAMLR.

Planning Domain 1 (western Antarctic Peninsula and southern Scotia Sea)

Reference areas

3.10 WS-SM-18/05 reviewed some of the reasons why the krill fishery is challenging to manage and considered ways in which management could be improved, whilst responsible and precautionary harvesting continues. The authors proposed an experimental framework to help improve the scientific basis for management, following support for such an approach by the Scientific Committee (SC-CAMLR-XXXVI, paragraphs 3.17 to 3.22). The paper suggested that the framework will increase ecological understanding by using an experimental approach to fishing, coupled with the use of krill reference areas (KRA) and krill fishing areas (KFA).

3.11 WS-SM-18/05 used specific terms (KRA and KFA) in order to avoid confusion with other uses of the term ‘reference area’, recognising that spatial management processes may have a number of differing objectives that could each benefit from a reference area.

3.12 The authors emphasised that the proposed experimental framework should not be seen as an alternative approach to the designation of an MPA in Domain 1 (D1MPA), as introduced to the Scientific Committee in 2017 (SC-CAMLR-XXXVI/17, XXXVI/18, XXXVI/BG/21 and XXXVI/BG/22) and which is still under development and discussion by CCAMLR Members.

3.13 WS-SM-18/05 proposed the use of the existing small-scale management units (SSMUs), modified to take into account biological and physical environmental characteristics, as the geographic and spatial basis for a set of differing treatments. The paper also highlighted that small adjustments of SSMU boundaries would enhance reporting for the krill fishery in Subareas 48.1 and 48.2.

3.14 WS-SM-18/05 identified a number of treatments based on seasonal, or year-round closures, and highlighted how enhanced scientific data collection using existing methods and approaches could be used to enhance ecological understanding of possible impacts (or lack thereof) of krill fishing. The authors also considered how treatments could be designed to help disentangle confounding drivers of change, including climate change.

3.15 The Workshop thanked the authors of WS-SM-18/05, recognising that this was a discussion document intended to help further the management of the krill fishery, noting that any such experimental framework would need to be undertaken in the context of the precautionary approach. It also noted that it should be considered in the context of feedback management (FBM), the developing risk assessment framework for krill and the D1MPA proposal, since all these initiatives contemplate the use of reference areas. It noted that considerations of these initiatives and how to harmonise relevant aspects might be undertaken at the planned joint meeting of WG-EMM and SG-ASAM scheduled for 2019.

3.16 The Workshop noted a number of candidate hypotheses that could be addressed by the experimental framework in WS-SM-18/05, recognising that the design of the framework was important for the type of questions or hypotheses that might be addressed. The Workshop also noted that temporal reversal of treatments, where treatments are switched on, or off, offers a useful way to identify impacts. The Workshop emphasised that understanding the likely effect size would be important and that a power analysis would be useful.

3.17 WS-SM-18/17 was presented by CCAMLR scholarship recipient Lic. A. Capurro, mentored by Drs Grant and Santos. The paper noted the importance of scientific reference areas in D1MPA and highlighted that well-designed reference areas could help maintain resilience in the face of climate change, assess the potential impact of fisheries on dependent predators and contribute to monitoring the efficacy of the D1MPA. The paper recognised that these areas need to be characterised based on the availability of scientific information, the understanding of krill fishery dynamics, and the existence of scientific long-term monitoring programs or study sites, and that in Domain 1 there was already available a considerable understanding of these topics. The paper illustrated potential locations for scientific reference areas in the South Orkney Islands (SOI), northwest Antarctic Peninsula (NWAP) and southwest Antarctic Peninsula (SWAP) based on a two-level scheme that considered areas upstream and downstream of fishing grounds, and climate change as a mean to provide further comparisons to disentangle the confounding effects of impacts of natural variability, climate change and fishing. The authors indicated that CCAMLR Ecosystem Monitoring Program (CEMP) sites provided a useful and valuable framework to compare sites across the Convention Area and that it might be useful to review and revise the CEMP methods, including an agreement on the information it can provide to progress with the data collected in relation to D1MPA.

3.18 The Workshop thanked the authors for the paper and noted the importance of scientific reference areas in the context of MPA planning, in particular for Domain 1. It recognised these areas could serve different purposes, including providing resilience to climate change, assessing the effect of fisheries and evaluating broader D1MPA conservation objectives. The Workshop highlighted the need to define clear hypotheses for scientific reference areas, including their potential location, size and duration, the specific purposes each area was designed for, also in relation to the objectives of the D1MPA. The Workshop noted that General protection zones (GPZ) already included in the D1MPA proposal could serve as scientific reference area(s). It also recognised that different proposals in different MPA domains could define scientific reference areas differently according to their own specific objectives.

3.19 The Workshop welcomed the paper, and acknowledged the valuable contributions made by Lic. Capurro to the progression of work on Planning Domain 1 as part of her CCAMLR scholarship during the last two years and encouraged her ongoing engagement in the work of CCAMLR.

General discussion on reference areas

3.20 The Workshop noted the commonalities between establishing scientific reference areas in the D1MPA (WS-SM-18/17) and developing an experimental approach to evaluating the effects of fishing (WS-SM-18/05). The Workshop highlighted that scientific reference areas should serve to test specific hypotheses, which included, but were not limited to, understanding the effects of fishing. It noted that reference areas could be designed in concert with experimental fishing areas to further test hypotheses related to understanding fishing impacts. The Workshop recognised that an experimental approach for evaluating the effects of krill fishing could be incorporated in a research and monitoring plan for D1MPA. It also noted that particular attention was needed in relation to the scale and size of the potential krill fishing reference areas so that they do not compromise any of the MPA conservation objectives.

3.21 The Workshop recalled that the majority of predator monitoring data available for addressing questions related to predators in an experimental framework have been collected under CEMP, and most relate to penguin population processes.

3.22 The Workshop noted that monitoring technology, particularly for predators, is changing. CEMP might usefully include any monitoring data that are used in management advice. The Workshop therefore recommended that the Scientific Committee undertake a comprehensive review of CEMP.

3.23 The Workshop considered the utility of CEMP in an experimental framework, and recalled previous analyses of CEMP data (SC-CAMLR-XXX, paragraph 3.18), which highlighted the need to ensure congruence of monitoring metrics in order to address some key questions in relation to fishery–predator ecosystem interactions, recognising also that some CEMP indices can be used as leading or trailing indicators.

3.24 Dr S. Kasatkina (Russia) recalled that in her opinion at present there is no scientific evidence that the fishery affects the resources of krill and dependent predators. She stressed that such evidence is not present even in the years of the greatest pressure of the fleet (1980–1991) both in terms of catch and in terms of fishing effort. She pointed out that at present there are no scientifically tested indicators for revealing the impact of the fishery on dependent predators. Moreover, in her view there is no understanding of how CEMP indices can be used to identify the impact of the fishery, or even how many years would be required to detect a response to a given impact. She underlined that it was her opinion that it is impossible to reveal or assume the ecosystem effect of the fishery in the absence of data on krill biomass and distribution variability over different spatial–temporal scales, the abundance and population characteristics of predators (rather than one penguin species), and their krill consumption.

3.25 The Workshop agreed that there is no evidence that the krill fishery has not been managed in a precautionary and ecosystem-based manner using CCAMLR's existing management approaches. It further noted that developing an experimental approach for advancing the management of the krill fishery requires the comprehensive analysis of available data from the fishery, including acoustic survey data, environmental sampling and CEMP data. This analysis should form part of the establishment of an experimental approach, providing baseline data for candidate hypotheses.

Discussion of krill reference areas

3.26 The Workshop discussed the utility of krill reference areas in the context of D1MPA planning, recognising that the experimental approach is not an alternative or competing proposal to D1MPA, but is a complementary initiative.

3.27 The Workshop recognised that reference areas could be used for a variety of purposes and could form part of the RMP for the MPA. It agreed that within the D1MPA proposal there is a need to consider reference area for understanding the impacts of the krill fishery.

3.28 The Workshop recalled that finite research programs have been used within the management of the toothfish fishery (CM 24-01, Annex 24-01/B), but that this was a new concept in relation to the krill fishery. It therefore recognised that developing a 'proof of concept' whereby key questions could be addressed by the use of contrasting treatments in fished areas and closed areas, would be valuable for the development of the krill fishery in Domain 1.

3.29 In considering the development of krill reference areas, the Workshop agreed that a number of issues required attention. It noted that, inter alia, it would need to consider:

(i) the feasibility of defining one or more practical and tractable questions related to local krill abundance, and dependent predators (especially when attempting to provide a 'proof of concept')

(ii) whether particular questions were more likely to provide answers within a reasonable time scale

(iii) the operational and logistic capacity required to undertake relevant research and monitoring, as well as analysis of results

(iv) what the indicators might be that could be used to address a particular question; whether it is possible to make direct measurements on particular ecosystem components, or whether proxies have to be measured; and the spatial and temporal resolution of data required

(v) what outcomes of the experiment might be, and what the management actions should be, given a particular result.

3.30 The Workshop recognised that there are many questions related to the impact of the fishery on both krill and upon krill-dependent predators. It noted that interpreting results may be more difficult if initial questions were related to upper trophic levels, given the cumulative impacts of environmental variability on primary production, secondary production and on krill consumers. The Workshop noted that a hierarchy of questions could eventually be considered, but each question might require a different reference area and experimental framework, and that starting simply would maximise the likelihood of a useful result.

3.31 In considering questions about krill, the Workshop agreed that issues of flux and oceanographic and ecological connectivity were of considerable importance. However, it noted that addressing questions related to krill swarm size distribution, depletion, dispersal and disturbance are likely to be relevant for land-based krill predators, and might be feasible over small spatial and temporal scales.

3.32 The Workshop recalled previous work (e.g. WG-EMM-09/18; WG-EMM-16/17; SC-CAMLR-XXXV/11; SC-CAMLR-XXXV/BG/14; WG-EMM-18/P11) which showed changes in krill catch per unit effort (CPUE) as the fishing fleet targeted krill fishing hotspots. When CPUE decreased, the fleet moved in order to achieve higher CPUE values elsewhere. Such displacements occur every 4–17 days and, according to persistence and sea-ice conditions, previously exploited zones might be revisited (WG-EMM-18/P11). Such a pattern of fishing is plausibly related to dispersal or depletion of the aggregation. At present, it is uncertain whether declines in CPUE are due to reduced biomass levels, disrupted krill swarm dynamics, altered flux, or for other operational reasons (SC-CAMLR-XXXV/BG/14). Without further information, it appears that the replenishment of krill is apparently insufficient to maintain catch rates within an area where catches are concentrated. However, more information is needed to validate this interpretation.

3.33 Dr Kasatkina cautioned that it will be difficult to understand the impact of variability in krill distribution in the fishing grounds without taking into account the behaviour of different vessels.

3.34 The Workshop noted that addressing such questions would help increase understanding about the ecosystem consequences of the krill fishery, as it would provide answers to questions about the potential for localised fishing effort to cause depletion, dispersal and disturbance over spatial and temporal scales relevant to predators. Such questions, including in relation to fishery performance, could be addressed using a combination of CPUE, acoustic assessments during fishing operations, and repeated research surveys over small spatial scales. The Workshop also noted that data on natural variability in krill distribution patterns, as well as local estimates of predator abundance and krill consumption (e.g. WG-EMM-18/33), would be important. With an improved understanding about krill depletion or disturbance, the Workshop noted that questions about impacts on predators may be easier to address. For example, does depletion or disturbance of fished aggregations have impacts on predators and on subsequent fishery operations? However, the Workshop also recognised that some questions about the impact of the fishery on predators may be straightforward to address without information on krill.

3.35 The Workshop noted that new methods, such as the risk assessment (e.g. WG-FSA-16/47 Rev. 1, 16/48 Rev. 1, WS-SM-18/04 and 18/P03), can synthesise predator data to develop management advice; such methods did not exist, and were not contemplated, when CEMP was established.

3.36 In developing questions related to krill, the Workshop agreed that a plausible scenario might include a krill fishery research zone (KFRZ) (recognising the value of replication where feasible) within D1MPA, possibly near to existing CEMP sites in the Bransfield Strait.

3.37 The Workshop agreed that a suitability decision matrix (e.g. WG-SAM-18/17, Figure 1), modified for use with the krill fishery, would be valuable. The matrix summarises the characteristics of cells within an underlying geographical grid. Such an approach might also be developed through a process comparable to the stock hypothesis developed for toothfish (WG-SAM-18/33 Rev. 1). The Workshop considered how to develop a suitability matrix relevant to the krill fishery in Subareas 48.1 and 48.2, based on a geographic grid of cells overlaid across the areas of krill fishing. This would then allow candidate reference areas to be identified. The Workshop recognised that in developing a 'proof of concept' the question(s) to be addressed should be tractable, but that with experience, more complex questions could be considered.

3.38 The Workshop agreed that candidate research questions should be developed related to detecting reduced biomass levels, disrupted krill swarm dynamics, altered flux, or for other operational reasons associated with aggregation of fishing vessels in fishing hotspots, and spatial and/or functional overlap with predators.

3.39 The Workshop agreed that it would be necessary to produce a table of attributes for each cell in the suitability matrix. It further agreed that the question(s) and table(s) should be developed intersessionally in the D1MPA Expert Group, in order that candidate reference areas could be proposed at a future date. It further agreed that the D1MPA Expert Group should consider how to develop the suitability matrix, in order to explore whether multiple questions can be addressed by one geographical grid represented by a single matrix, or whether a separate matrix is necessary for each question. The Workshop recognised that both spatial and temporal scale were important in developing the KFRZ and that the initial proposed resolution (1.0° longitude × 0.5° latitude) may be too coarse for some questions.

3.40 The Workshop recalled recent work directed towards the RSRMPA RMP, recalling the three elements in relation to the MPA-specific objectives, which include representativeness, threat mitigation and scientific reference areas (CM 91-05, Annex 91-05/C). The Workshop agreed that this structure could provide a useful and overarching framework for developing the D1MPA RMP. It also recalled that such a plan should deliver sufficient scientific information to allow the Scientific Committee to advise the Commission on what management actions may be required to ensure the achievement of the D1MPA objectives. The Workshop noted that reference areas to assess the potential impact of the krill fishery could be included within this framework.

Representing a krill cost layer in Marxan analyses in D1MPA

3.41 WS-SM-18/18 described the process for considering how to best represent the krill fishery in Marxan analyses for the Domain 1 MPA process. It provided a wide range of Marxan scenarios considering different cost layers with different krill fishing periods and dynamic ranges, noting the limitations of using fishery cost layers to represent the high spatial–temporal variability of the krill fishery in Domain 1. It concluded that using fishery cost layers was not the most effective means of considering the fishery in the D1MPA preliminary proposal and that other methods, for example, fishery displacement, could be more appropriate to deal with the krill fishery dynamics. In addition, the paper included the valuable contributions made in the D1MPA Expert Group, as the appropriate mechanism to discuss, evaluate and incorporate Members' varying interests and opinions to finally develop an agreed set of boundaries towards the designation of the D1MPA.

3.42 The Workshop thanked the authors of the paper and recognised that, given the spatial and temporal variation observed in the environment and in the krill fishery, it was not possible to generate a meaningful cost layer given available data in Domain 1 and noted that consideration of the fishery displacement could be a better approach.

3.43 The Workshop also noted the active work, participation and high level of engagement of the D1MPA Expert Group, highlighting the importance of sharing documents and expertise. It congratulated the D1MPA Expert Group for its collaborative approach to developing technical advice as part of MPA planning process. It also encouraged other Members to join and participate in the e-group.

Displacement of fishing catch and effort

3.44 WS-SM-18/P03 highlighted that a principal concern with implementing MPAs is the potential for new and unexpected consequences brought about by the displacement of fishing effort from closed areas. WS-SM-18/P03 evaluated two MPA scenarios with associated displacement of the krill fishery, quantifying the potential for altered risks of krill depletion for predators, as well as outcomes for the fishery. The authors employed both a static and a dynamic risk assessment, and considered three alternative redistributions of displaced catches. Collectively, results of the study indicated a well-designed MPA in the Scotia Sea may protect krill-dependent predators, and give rise to both benefits and costs for the fishery. Results further indicated such an MPA may also preclude requirements for further spatial management of fishing outside its boundaries and substitute for spatially explicit catch limits in the Antarctic krill (*Euphausia superba*) fishery. Finally, WS-SM-18/P03 noted the value of using both static and dynamic approaches to risk assessment in dialogue.

3.45 The Workshop thanked the authors and noted the usefulness of employing both static and dynamic approaches to assess the costs and benefits associated with implementing MPAs with associated fisheries displacement. It welcomed the finding that both approaches reached similar conclusions, regarding risks and benefits of MPAs.

3.46 The Workshop considered a number of areas where further development might be valuable. These included varying competition coefficients for individual predators and the fishery; whether spatial–temporal scales of predator–fishery interactions could be varied to more specifically reflect known aggregation of the fishery; whether some areas are more valuable for the fishery; and whether fishing fleet dynamic models might be included. The Workshop also considered that displacement of effort was an important criterion to consider. Other areas discussed, i.e. (i) increasing fishing levels beyond the trigger and (i) outcomes of climate change in relation to krill biomass, are already considered in the current work (i) or under consideration by the authors of WS-SM-18/P03 in ongoing work (ii).

3.47 The Workshop recognised that it may not be possible to address all of these areas of development, given the existing modelling. Nevertheless, it recognised that continued development and use of the model would be valuable, particularly as coherent results from this, and other modelling approaches (e.g. Ecopath with Ecosim (Dahood, 2017), WG-FSA-16/47 Rev. 1 and 16/48 Rev. 1) would build confidence for management. The authors of WS-SM-18/P03 noted they are also in the process of engaging other modelling approaches (namely Ecopath with Ecosim). The Workshop therefore encouraged future work and further development, and the potential for connections with static risk assessment introduced (WS-SM-18/04).

Other research fishing

3.48 The Workshop noted that existing research fishing for toothfish (WG-SAM-18/05 Rev. 1) and a proposal for crab fishing (WG-SAM-18/06) overlap with Domain 1 and agreed that consideration should be given to how these broader issues are integrated with the D1MPA process.

Summary of activities for the D1MPA

3.49 The Workshop recognised the progress made in relation to the D1MPA planning work carried out intersessionally. For example, it recalled discussions at WG-EMM, the Scientific Committee and the Commission in 2017, which proposed further consideration of fishing activities (SC-CAMLR-XXXVI, paragraph 5.27), including the use of a krill cost layer (WS-SM-18/18) and potential displacement of fishing effort in relation to the D1MPA preliminary proposal (WS-SM-18/P03). The Workshop also recalled discussions about mitigation of the effects of climate change and the risks of krill fishing having a negative impact on the ecosystem (SC-CAMLR-XXXVI, paragraph 5.29), which have been considered through the use of reference areas (WS-SM-18/05 and 18/17). It also welcomed the initiation of the D1MPA Expert Group (CCAMLR-XXXVI, paragraph 5.67) which has been established to engage interested parties, including industry experts and non-governmental organisations (NGOs). It noted that work by different participants has already been shared through this Expert Group, indicating the value of engagement, and that this will contribute to a revised D1MPA proposal.

Planning Domains 3 and 4 (Weddell Sea)

3.50 WG-SAM-18/33 reviewed the current knowledge existing on *D. mawsoni* in Area 48 in terms of spatio–temporal distribution patterns, reproduction biology, behaviour (including, e.g. feeding and diet) and movement.

3.51 The review brought together information considered in pre-meeting discussions, e-groups and document reviews, the discussions on the relevant information and data gaps, potential stock hypotheses and approaches to testing them. The deliberations resulted in formulation of three alternative, nested stock hypotheses for *D. mawsoni* in Area 48, and recommendations for research to test these hypotheses were developed. The hypotheses will be used by WG-FSA and WG-SAM in the evaluation of future research proposals.

3.52 The report of WS-DmPH-18 (SC-CAMLR-XXXVII/01) emphasised that the alternative hypotheses should not hinder progress toward spatial management in this or any other region of the Convention Area.

3.53 The Workshop noted that the information in the review covered a large area and time scale and in some cases, data is sparse, but was sufficient to formulate hypotheses for testing using more focused research.

3.54 The Workshop noted that the analysis is in its first phase and discussed the categories used for determining life history stages, movement of fish based on the release of tagged fish and recapture positions only, and the need for distinguishing toothfish eggs to species in analysis of breeding areas where species overlap.

3.55 The Workshop congratulated the authors and contributors on the volume and detail of the information collated and noted that such collaborative documents, prior to a meeting, could form a useful basis for future large-scale reviews.

3.56 WS-DmPH-18/01 summarised the knowledge on the occurrence of pelagic and demersal fish species as well as krill occurrence in the wider Weddell Sea based on Soviet and German expeditions. The participants of the Workshop welcomed the valuable summary of knowledge of fish and krill occurrence in the historic sampling. It was noted that some of the data and conclusions related to areas outside the Weddell Sea, for example Joinville and D'Urville Islands. It was also highlighted that:

(i) in recent years the areas noted as historically exploited have been ice covered and are not accessible

(ii) following the ban on bottom trawling in the majority of the Convention Area, many of the benthic species described in the paper as commercially exploited would no longer be available to a fishery

(iii) in several instances the taxonomy used in the paper needs to be updated.

The Workshop noted that this historic data was a valuable resource and asked Members who held historic data for the Weddell Sea to consider making the data available to all CCAMLR Members.

3.57 Dr Kasatkina noted that the revision of the WSMPA proposal is needed. This revision requires new information on the commercial potential for dominant species in the MPA to designate areas for protection and fishing activity. This new information may be provided from research programs in the Weddell Sea.

3.58 WS-DmPH-18/02 represented a statistical analysis of ice conditions in the Weddell Sea with the aim of identifying areas suitably ice-free for research related to MPA development. One aim of this study was to provide estimates of accessibility that facilitate planning of fishery research carried out by commercial vessels.

3.59 The Workshop noted that ice-breaking research vessels are capable of carrying out research and monitoring in areas of the Weddell Sea, particularly those less regularly accessible to commercial vessels. Also, that there are remote sensing methods currently available that allow generating data without having to be on-site.

3.60 Dr Kasatkina noted that the revisions of the WSMPA proposal should provide clarifications of the MPA boundary as well as the boundary of reference areas taking into account ice cover and accessibility.

3.61 WS-SM-18/08 explained modifications in the draft WSMPA area and asked for advice regarding the establishment of reference areas. The Workshop participants requested clarification on:

(i) the differences in management measures between GPZ and fisheries research zone (FRZ)

(ii) the basis for the 5 tonne research limit for toothfish.

3.62 It was noted that the approach used in Annex 6, Figure 1, could be a method by which the potential for research area(s) to viably address specific objectives in the research and monitoring of an MPA could be evaluated.

3.63 In conclusion, the Workshop provided the following advice:

(i) the location and size of reference areas would depend on the scientific question/hypothesis and may involve areas inside or outside MPAs

(ii) investigations of the potential impact of longline fishing on benthic ecosystems (i.e. whether longlines cause physical disturbances on the benthic fauna) could be carried out within the existing research blocks in Subarea 48.6 by comparing fished areas (i.e. known longline tracks) with unfished areas between these tracks

(iii) large-scale unfished reference areas outside the existing fisheries research blocks might be used to answer other scientific questions, for example whether longline fishing for *D. mawsoni* has wider trophic impacts. This could be accompanied by a statistical power analysis to determine that the sampling design would be able to detect such impacts

(iv) the most appropriate location and size of such reference areas should be determined on the basis of a set of parameters/attributes specific to the question to be answered. These parameters/attributes could be compiled in form of a table (see example in Table 2) as a transparent decision-support tool to aid the establishment of the reference area by indicating the occurrence of these parameters/attributes (e.g. in terms of high, medium or low) within the investigated area.

3.64 The authors of WS-SM-18/08 thanked the Workshop for this advice and informed the meeting that regarding answering the specific question about potential wider trophic impacts from longline fishing, they will further work on the relevant parameters/attributes to be taken into account and further develop Table 2 accordingly. The results of this work will be posted on the WSMPA e-group on the CCAMLR website.

3.65 Dr S. Hain (Germany) invited all participants at the Workshop to become a member of the WSMPA e-group and to post there any further scientific questions/hypotheses, which would require establishing a reference area within the proposed WSMPA to allow comparative analyses between fished and unfished areas.

3.66 WS-SM-18/09 presented a discussion on the conclusions from WS-DmPH-18. The authors considered that the current lack of knowledge, particularly the unknown influence of spatio–temporal variability in environmental conditions, make the interpretation of the existing sparse data difficult. An alternative approach to collect data was proposed, in the context of opening exploratory fisheries in Subareas 48.1, 48.2, 48.4, 48.5 and 48.6 with obligatory operational research actions by each vessel, including a large-scale longline international survey.

3.67 The Workshop noted that the approach proposed in WS-SM-18/09 was unlikely to enhance CCAMLR's ability to achieve its objective. Furthermore, it was noted that a substantial volume of information is available and that further analysis of these data, as outlined in WG-SAM-18/33, will identify research/data gaps that can be targeted within research proposals.

3.68 Dr Kasatkina noted that multivessel surveys should be designated for a period of four years with 10 participating vessels from Member countries. She noted that implementation of the abovementioned will allow to collect adequate data to support the available retrospective data and develop a science-based hypothesis of the life history and stock for *D. mawsoni* in Area 48 as well as obtain data for parameterising the model and facilitating stock assessment in Area 48.

3.69 WS-SM-18/10 commented on the use of MPAs for spatial management in the CCAMLR area. The authors of this paper mentioned that MPAs for spatial management in the Convention Area require clarity regarding the designation of MPAs, including its rationale, planning and functioning. Proposals on unified approaches and criteria for designating MPAs were suggested.

3.70 WS-SM-18/11 stressed the distinct spatio–temporal variability in atmospheric and oceanographic conditions in the Weddell Sea and questioned the validity of a toothfish stock hypothesis that does not take into account this variability. The authors suggested that more research time is needed before the impact of environmental variability can be factored into the hypotheses. The authors noted that spatial–temporal variability of environmental conditions will be the critical factor in the synthesis of the available retrospective data for the development of the hypothesis on life cycle and toothfish stock in Area 48.

3.71 The Workshop noted that, at the scale at which the stock hypotheses were developed for *D. mawsoni* in Area 48 for the design of future research, environmental variability would not undermine the hypotheses (paragraphs 3.51 to 5.53). Therefore, those developed by WS-DmPH-18 were considered suited to the needs of evaluation of research plans and MPA design.

3.72 The Workshop discussed the potential links between atmospheric and oceanographic conditions and toothfish life-history stages and recognised the difficulties in identifying those links. Furthermore, the need was raised to develop robustness tests for evaluating if management tools, such as MPAs, can help to get a better idea on, for example, spatial–temporal variation.

3.73 WS-SM-18/13 reflected on recommendations concerning issues and questions raised at WG-EMM-17 and SC-CAMLR-XXXVI with respect to the WSMPA proposal. The authors presented updates on data layers and a robustness testing of the WSMPA Marxan model and discussed the critical use of some data layers (including cost layer). The Workshop acknowledged the huge amount of work and welcomed the updates from the WSMPA project team.

Planning Domains 5 and 6 (Del Cano–Crozet and Kerguelen Plateau)

3.74 WS-SM-18/07 presented a new analysis on top predator trophic hotspot distribution in the sub-Antarctic Indian Ocean area. It complements WG-EMM-16/43 and 16/54 which provided scientific elements to the development of MPAs around Crozet and Kerguelen Islands. The paper used a comprehensive dataset of telemetry-derived movement across a guild of marine top predators to spatially resolve trophic hotspots, and then compare these to the national jurisdiction MPAs designated around Crozet, Kerguelen and Heard Islands. The authors clearly show that adequate protection of a suite of top predators would incorporate high-seas areas, and highlight that areas both within and beyond the CCAMLR area must be considered in order to afford increased protection. For example, 50% of predator trophic hotspots are located in the high seas, including the CCAMLR area.

3.75 Building on the results of this paper and on WG-EMM-16/43 and 16/54, future work will focus on: (i) highlighting that the new bioregionalisation analysis conducted also considered spatio–temporal dynamic features, (ii) extending the research and monitoring timeseries with additional biologging and oceanographic surveys, and (iii) testing for differences between this recent bioregionalisation approach with previous efforts at ecoregionalisation based on mid-trophic pelagic species (i.e. euphausiids and myctophids).

3.76 On behalf of the authors of WS-SM-18/07, Prof. Koubbi asked the Workshop to provide advice on the following:

(i) Considering that WS-SM-18/07 only includes data from the French and Australian sub-Antarctic islands, how should work progress to include similar data on the Prince Edward Islands, and should efforts be extended further west towards Bouvetøya?

(ii) Determine general and specific objectives for a new MPA proposal, inter alia, trophic hotspots, pelagic (including mid-trophic level species such as euphausiids and mesopelagic fish) resources and the inclusion of climate change-driven consequences on the representativeness of ecoregions.

3.77 The Workshop noted that similar top predator work had been conducted at the Prince Edward Islands, and welcomed the offer by Dr A. Makhado (South Africa) to assist with inclusion of these data in a future proposal.

3.78 The Workshop also noted that a logical progression of this work westwards to Bouvetøya was warranted given the growing evidence of movement overlap between sub-Antarctic islands of multiple predator species. It further noted that, given the movement of top predators across large latitudinal gradients, marine spatial planning should integrate across sub-Antarctic and Antarctic regions as far as possible.

3.79 The Workshop noted that including dynamic features within static MPA boundaries is challenging, unless MPAs are of a sufficient size to incorporate dynamic variability. It further noted a challenge in affording spatial protection across multiple jurisdictions and requested that the Scientific Committee consider how CCAMLR might communicate with regional fisheries management organisations to address these issues into the future.

3.80 The Workshop noted that the Retrospective Analysis of Antarctic Tracking Data, a Scientific Committee on Antarctic Research (SCAR) initiative to provide circumpolar characterisation of top predator hotspots, could be useful to CCAMLR as an additional data layer to facilitate consideration of latitudinal and longitudinal connectivity in current and future marine spatial planning.

3.81 The Workshop welcomed the further development of MPA proposals in Planning Domains 5 and 6 and looked forward to results being tabled to the Scientific Committee and its working groups as they are developed. The Workshop recommended that the Scientific

Committee consider the creation of an expert group to continue the development of MPAs in these planning domains, using the model established for the D1MPA. It noted that not everyone involved in the proposed work was directly involved in the CCAMLR community and requested that mechanisms be developed to allow external experts to participate in the expert group (paragraph 6.13).

Research and monitoring plans

General principles for MPA research and monitoring

4.1 WS-SM-18/04 described considerations for developing the risk assessment for the krill fishery in Area 48. This process had the potential to support several CCAMLR initiatives and might be particularly relevant to maintaining spatial management of the trigger level if CM 51-07 were to lapse as scheduled in 2021.

4.2 The Workshop welcomed the paper and noted the importance of working collaboratively to develop a risk assessment. It further highlighted the utility of collating available data into a risk assessment framework which would allow for greater understanding of the spatial and temporal distribution of data, risks and uncertainty. It also observed that one of the strengths of the risk assessment approach was to guide decisions in cases of limited data availability. It noted the example of the Spatially Explicit Fisheries Risk Assessment being utilised by New Zealand (see Ministry for Primary Industries, 2017, chapter 3). The Workshop commented on the need to consider ecological processes and functions such as flux and measuring the impact of the fishery on krill predators when developing the risk assessment. The Workshop encouraged interested Members to participate in this collaborative work and looked forward to seeing future results from this project.

4.3 WS-SM-18/06 focused on hierarchical monitoring plans and their use for determining patterns of change in the Antarctic marine ecosystem. It highlighted the technical advances made in research techniques since the implementation of CEMP, and the potential of a hierarchical approach for identifying and using appropriate, cost-effective new tools. The paper elaborated on the utility of hierarchical approaches to monitoring for detecting ecological changes, encouraging collaboration and providing valuable insight into MPA processes.

4.4 The Workshop observed that the hierarchical approach highlighted the importance of scales, which had been discussed in several sessions at the Workshop. It also noted the importance of collaborating and coordinating research efforts with international groups such as the Southern Ocean Observing System (SOOS), SCAR and the Ocean Biogeographic Information System (OBIS).

4.5 The Workshop emphasised the challenge of identifying ecological and environmental changes outside the normal range of variation, and that such determinations would be scale dependent. It observed that such shifts could require management action or further scientific inquiry, but more discussions would be needed to determine the appropriate action. Finally, the Workshop recalled the importance of identifying knowledge gaps, and that the hierarchical approach could aid in identifying such gaps, determining achievable actions and developing specific plans for responses to change.

4.6 WS-SM-18/10 focused on the collection and availability of scientific evidence and information to designate and monitor MPAs and underlined that establishment of the baseline data should be provided in advance to the MPA planning process. This paper proposed unified approaches and criteria for designating MPAs and relevant changes in CM 91-04.

4.7 The Workshop agreed that the collection of field data was important, but noted that the particular need for this depended on the particular objectives and scale of an MPA. The Workshop noted that the availability of new sampling techniques such as satellites, and the use of these alternative approaches to collecting data, were also of relevance to MPA monitoring and research (for example, the techniques described in WS-SM-18/07). The Workshop noted that CCAMLR's working groups routinely discussed matters relating to experimental design and monitoring and that this advice could be drawn upon in relation to MPA monitoring.

Development of specific MPA research and monitoring plans

4.8 WS-SM-18/01 presented baseline data layers used for spatial planning, monitoring and research in relation to the RSRMPA. It was noted that CM 91-05 and the RSRMPA RMP require that information that supported the proposal for the establishment of the MPA be made available. This paper detailed the baseline data layers used to develop the RSRMPA.

4.9 WS-SM-18/02 presented candidate baseline data for seven previously identified key indicator species which described the current status of marine ecosystems in the Ross Sea region and could be used as benchmarks to evaluate MPA performance. The Workshop recognised the value of having a collated set of agreed baseline data which could aid in documenting future population changes. The Workshop observed that it could be useful to reference additional zooplankton data collected by the Continuous Plankton Recorder Survey (SCAR-CPRAG) and to review the data provided for silverfish and krill.

4.10 The Workshop noted that baseline data described the information available at the onset of the MPA designation. Baseline data comprised both synthesised data used to develop the MPA boundaries (e.g. as described in WS-SM-18/01) as well as describing indicator data that can be used to assess whether the objectives have been met (e.g. as described in WS-SM-18/02).

4.11 Dr Kasatkina noted that it is important to clarify how indicators in WS-SM-18/02 can be used to assess whether the RSRMPA achieves its objectives. If there is no fishing, the change of these indicators will be primarily determined by the influence of the environmental variability and natural ecological interaction and not direct human activities.

4.12 WS-SM-18/03 presented projects from New Zealand that could be contributed to the project list for the RSRMPA RMP. The Workshop recommended that the project list database specification be revised to include additional fields (x–xiv below) and revise the fields (i) and (viii) as per below:

Revised fields –

(i) Principal scientist and point of contact
(viii) What information will be or has been obtained.

Additional fields recommended –

(x) Index (to assist with sorting)
(xi) Project title
(xii) Project identification code (e.g. project or funding number)
(xiii) Status (complete, ongoing, future)
(xiv) Contact affiliation.

4.13 The Workshop thanked the authors for developing this type of initiatives and noted the importance of making this information visible not only for Members but also for national Antarctic programs in order to allow for potential collaboration with scientists that might not necessarily engage with CCAMLR.

4.14 The Workshop noted that the collation of projects presented in WS-SM-18/03 demonstrated that considerable progress had been made towards the ambitious program of work specified in the RMP. The Workshop recommended that Members contribute to the project list database as detailed in the RSRMPA RMP (SC-CAMLR-XXXVI/20).

4.15 Dr M. Vacchi (Italy) indicated that the Italian Antarctic Research Program (PNRA) has also been developing a similar exercise, compiling information on projects related to the Ross Sea region from season 2012/13 to date. The initiative is expected to be fully developed later in the year and results will be available during the Scientific Committee meeting in 2018. In addition, Dr Vacchi announced that PNRA has recently launched a call in which there is a specific topic dedicated to the proposals related to research and monitoring of the RSRMPA under indications of CM 91-05.

4.16 WS-SM-18/16 presented a plan to release 15 pop-off satellite tags (PSATs) in the southern and western RSRMPA GPZ(i) and five additional PSATs on the northern Subarea 88.1/88.2 seamounts in the 2018/19 season using a redesigned and reengineered PSAT specifically for use on toothfish. In addition, juvenile and adult otoliths will be collected with the intention of analysing otolith microchemistry.

4.17 The Workshop noted that the PSAT component could provide insight into movements between various zones of the RSRMPA, whereas the otolith microchemistry component could address key gaps in relation to the life-history hypothesis for *D. mawsoni* in the Ross Sea, as well as confirm the role of the RSRMPA in relation to providing ecosystem services in the form of fish migrating downstream to regions outside the MPA.

4.18 The Workshop welcomed the planned research, noting that this was a US and New Zealand collaborative effort, and was a good example of collaborative efforts between Members to undertake research under the RMP.

4.19 WS-SM-18/15 presented a framework for an RMP for the SOISS MPA.

4.20 The Workshop agreed that the proposed framework sets out the components of a draft SOISS MPA RMP to be developed as part of the 2019 review, based on the draft initially proposed in 2014 (SC-CAMLR-XXXIII/11). This aims to address the requirements of CM 91-04, and takes account of general principles from the RSRMPA RMP (SC-CAMLR-XXXVI, paragraphs 5.39 to 5.42) and the proposed WSMPA RMP.

4.21 The Workshop noted that a report on the analyses from research and monitoring in the area will need to be undertaken in order to provide scientific advice for review by the Commission in 2019, including to provide scientific advice on the extent to which the objectives of the MPA were being met.

4.22 Dr Kasatkina noted that Domain 1 was characterised by different oceanic environments, ecosystems and biodiversity of pelagic and benthic zones. Dr Kasatkina noted that the choice of the SOISS MPA as a reference area may not allow useful comparative studies to monitor natural variability and long-term change or to understand the effects of harvesting or other human activities on Antarctic marine living resources and ecosystems.

4.23 Dr Trathan noted that there are various different uses for reference areas, and one of the properties of the SOISS MPA is that the southern portion of the MPA shows interannual variation in oceanographic and sea-ice properties, something that is potentially related to krill availability. How krill gets onto the shelf is a vital issue for understanding availability to both the fishery and predators.

4.24 The Workshop agreed the proposed framework for the SOISS MPA RMP in WS-SM-18/15 and recommended that it be submitted to the Scientific Committee, and that a project list and summary of research and monitoring activities be developed in time for the next review of the MPA in 2019.

4.25 The Workshop noted that while general principles may help to determine research and monitoring activities or themes that are common across different MPAs, individual RMPs will be uniquely designed, given the specific characteristics and objectives of individual locations.

Spatial planning data management

Research and monitoring plan website

5.1 The Secretariat provided an overview of progress made on the development of the website for interaction with the RSRMPA RMP as requested during the Scientific Committee meeting in 2017 (SC-CAMLR-XXXVI, paragraphs 5.44 to 5.46). The website has two parts: a web-based architecture to submit and explore project documentation and associated metadata along with a link to the (meta)data repository (data.ccamlr.org).

5.2 The Secretariat demonstrated the (meta)data repository (data.ccamlr.org repository) that used the DKAN structure, an open-source open data publishing platform that identifies locations where relevant data are deposited, either in external open-access data repositories or within the DKAN data repository for data that cannot be found elsewhere.

5.3 The Workshop noted that different resources in the portal might require different levels of accessibility consistent with CCAMLR's rules for data access and rules. It suggested that it would be useful for the Secretariat to develop the system following the same access permissions as for other parts of the CCAMLR website.

5.4 The Secretariat showed a test version of the portal that allows Members to interact with the RSRMPA RMP (including Project Lists) and facilitates automated tracking of indicators that quantify scientific effort, and provides links and access to baseline data and associated datasets through the DKAN (meta)data repository/data.ccamlr.org.

5.5 The Workshop congratulated the Secretariat on the impressive progress and requested the Secretariat to continue this work and make the portal available to Members as soon as possible.

5.6 The Workshop expressed interest in providing regular feedback to the Secretariat to further improve the system through active participation of representatives in the Data Management Group (DMG).

5.7 The Workshop recommended that information in the DKAN (meta)data repository and the RSRMPA RMP should be explorable in a geospatial context within the portal. An approximate geospatial extent of the region of interest would be desirable and facilitate discovering who is working in the area or is executing relevant research. Additionally, shapefiles with spatial data should be easily viewable in the CCAMLR online geographic information system (GIS), noting that this might introduce a requirement for file type specification.

5.8 The Workshop agreed that the areas to which a research project is aligned should be entered as text rather than having a more formal geospatial definition.

5.9 The Workshop suggested that the project data should also include information on outcomes, as well as linkages to the relevant (CCAMLR) papers/publications and the relevant metadata records in the DKAN repository (paragraph 4.12).

5.10 The Workshop noted that one of the important features of the portal is that it provides linkages between RSRMPA RMP objectives, projects, datasets, data products and CCAMLR publications. The Workshop encouraged approaches that ensure that the linkages are easy to understand and that the differences between objective, projects, datasets and publication are clear.

5.11 The Workshop noted that different Members have different systems for aggregating information on relevant projects, however, all Members should encourage researchers to contribute relevant information. The Workshop noted that it is important to make the submission process as simple and easy as possible, including having the entry form and the project information available in all four languages of the Commission.

5.12 The Workshop recommended that adding projects to the project list portal follows a similar workflow to the submission of meeting papers by requiring approval from the nominated representative of the submitting Member.

5.13 The Workshop also recommended that in the future it may be useful to consider how research being conducted by non-Members can be incorporated into the system.

5.14 The Workshop noted that the current web-based portal is predominantly an input system and development efforts should include mechanisms to provide the required outputs for reviews through the generation of effort and coverage indicators in the required periodic reports.

5.15 Regarding integration or discovery of information available in other systems, the Workshop recommended that the Secretariat and the DMG should survey relevant sources and consider mechanisms for facilitating access where necessary. This includes projects and data from non-Members and/or organisations such as SCAR and the Committee for Environmental Protection (CEP). Specific systems that were discussed in the Workshop include:

(i) DueSouth, a database for sharing plans for upcoming Southern Ocean and Antarctic research projects developed by SOOS

(ii) the SOOS Southern Ocean mooring sites map that provides information on the deployment locations of moorings in the Southern Ocean

(iii) the SCAR Antarctic Biodiversity Portal that aggregates publicly available Antarctic and Southern Ocean data.

5.16 The Workshop noted that the repository should not attempt to duplicate data held outside CCAMLR but that data used for determining the MPA boundaries should be kept within the repository as it is a snapshot of synthesised data used to determine the MPA boundaries.

5.17 The Workshop agreed that having a GIS repository for baseline data that is easily accessible would be valuable. The Workshop noted the importance of this in order to enable others to reanalyse and reinterpret data layers that were compiled during the RSRMPA planning process. The authors also encourage other Members to contribute additional information that could complement this database.

5.18 The Workshop also recalled the requirements of CM 91-05, paragraph 24, on monitoring traffic within the MPA and requested the Secretariat to include a web-based entry system for Members to notify entry and exit of vessels into and out of the MPA.

Future work

Fisheries research evaluation

6.1 WG-SAM-18/21 provided an overview of priority research topics and identified key attributes for fisheries-directed research programs that would be needed to evaluate the objectives of the RSRMPA.

6.2 The Workshop noted that this paper had been discussed at WG-SAM (Annex 6, paragraphs 6.45 to 6.47) and agreed with the views of WG-SAM that the criteria outlined in the paper were useful in guiding the Scientific Committee and its working groups in their evaluations of research within and outside of the RSRMPA. The Workshop also recalled that, as one aspect of the RSRMPA is to provide a gradient in local exploitation rates for toothfish, this would have to be taken into account when determining which catch limit allocations facilitate research fishing.

6.3 The Workshop highlighted the need to ensure that a mechanism is needed to coordinate research fishing when conducted by multiple Members in the same area and to ensure that the research being conducted is not compromised by operations of the Olympic fishery.

6.4 The Workshop recommended that the Scientific Committee use the following for ranking the quality and priority of current and proposed fisheries-related research that contributes towards research under MPA RMPs. The research proposal 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.

6.5 The Workshop agreed that the general principles described in WG-SAM-18/21 should be relevant to fisheries-related research generally under CM 24-01.

Mechanisms to progress future work on spatial management

6.6 The Workshop agreed that the Workshop had provided an excellent opportunity for detailed consideration on a range of spatial management issues, and had underlined the need for ongoing work required to provide advice to the Scientific Committee.

6.7 The Workshop agreed that due to the increased workload related to spatial management, and expectation of that workload continuing to increase, including with the requirement for MPA reviews, there was a need for further focused meetings to maintain progress and to avoid the fragmentation of effort.

6.8 The Workshop requested the Scientific Committee to consider how best to achieve the ongoing work on spatial management in the context of its other priorities. Options discussed included the creation of a new working group or further spatial management workshop(s); however, differences in the interpretation of the relative status of Scientific Committee working groups or workshops may need to be taken into consideration.

6.9 The Workshop recalled the request from the Scientific Committee for the Secretariat to establish a position in the Secretariat dedicated to spatial management/MPA-related work (SC-CAMLR-XXXVI, paragraph 5.47 and CCAMLR-XXXVI, paragraph 4.9). The Science Manager informed the Workshop that this issue was currently being addressed as part of the review of the Secretariat Strategic Plan that would be considered by the Commission at CCAMLR-XXXVII.

6.10 The Workshop further recalled the discussion of the Scientific Committee following the Scientific Committee Symposium (SC-CAMLR-XXXV/12) and the recognition of the need for flexibility in the approach to address strategic issues and respond to emerging priorities of the Scientific Committee.

6.11 The Workshop noted the updated terms of reference for the MPA Special Fund (SC-CAMLR-XXXVI, paragraph 5.52), which can be used to support a range of activities relating to the further development and management of a system of MPAs, including facilitating workshops and the attendance of scientific experts.

6.12 The Workshop noted that cooperation with other scientific programs is important for spatial management, for example the Domain 1 Expert Group involves SCAR, SOOS and the Integrating Climate and Ecosystem Dynamics in the Southern Ocean (ICED) and the RSRMPA process involved SOOS and SCAR. The Workshop noted the positive experience in inviting relevant experts to meetings and receiving information from expert groups, noting that current mechanisms include:

(i) invitation of individual experts

(ii) contributions outside the CCAMLR process (i.e. contributions by individuals and groups in the absence of representation at meetings), for example via papers, discussions, meetings and other involvement in the broader process

(iii) expert participation via the Member delegations. Noting, however, that different Member delegations have differing policies in this regard.

6.13 The Workshop recommended that the Scientific Committee consider means to facilitate and improve engagement and interactions with relevant scientific programs and experts. The Workshop agreed this was particularly important given the range of science expertise required to address the diverse issues involved in spatial management. It requested the Scientific Committee clarify the mechanisms for inviting relevant experts to participate in its work.

6.14 The Workshop noted examples of existing, effective interactions with other scientific programs, including, but not limited to:

(i) SOOS Regional Working Groups –

Ongoing interactions include representation and involvement of CCAMLR Members on SOOS Regional Working Groups, including the Ross Sea and West Antarctic Peninsula. A CCAMLR–SOOS Synergies Workshop was held in April 2018 (SC-CAMLR-XXXVI, paragraph 10.17).

(ii) ICED –

The ICED program is undertaking integrated circumpolar analyses to improve understanding of change and the implications for Southern Ocean ecosystems and for management of human impacts (WG-EMM-17/36). There is much potential for ICED and CCAMLR to work together on spatial management (e.g. WS-SM-18/17). This includes, but is not limited to, joint ICED–CCAMLR activities on projections of change with a focus on Area 48, including a recent workshop on krill (SC-CAMLR-XXXV, paragraphs 6.18 and 6.19; WG-EMM-18/09), together with ICED research focused on understanding the structure and functioning of Southern Ocean ecosystems, their variability and response to change across a range of spatial and temporal scales, on key species – from krill to whales, and the structure of food webs (WG-EMM-16/22). ICED will continue to develop activities, in consultation with CCAMLR and with SCAR, to support CCAMLR's work.

(iii) SCAR –

The Workshop welcomed an update from Dr A. Terauds (Australia) on new SCAR initiatives, including the agreement to form a Krill Action Group (SC-CAMLR-XXXVI, paragraphs 10.9 to 10.11), and a new SCAR Proposed Scientific Research Programme Planning Group: Integrated Conservation Planning for Antarctica and the Southern Ocean (Ant-ICON) that will focus on coordinating, facilitating and delivering science to support conservation in Antarctica and the Southern Ocean. Much research within SCAR has relevance to spatial planning and SCAR indicated its willingness to assist in the continued provision of objective scientific advice to CCAMLR in this regard. SCAR also indicated it will work actively with CCAMLR Members to ensure that this advice is timely and relevant.

Communication and outreach

6.15 The Workshop noted that there was relatively little publicly accessible information on CCAMLR's work on MPAs, including the establishment of the Ross Sea MPA. A potential consequence of this is that rather than celebrate its achievements in respect of MPAs it was left to others to create the public narrative on the subject. The Workshop suggested that options for involving Members in reviewing web content may provide a mechanism for the Secretariat to include a greater diversity of content on the website.

Advice to Scientific Committee

7.1 The paragraphs containing the advice of the Workshop to the Scientific Committee are summarised below; these advice paragraphs should be considered along with the body of the report leading to the advice:

(i) progress towards establishing a representative system of MPAs (paragraphs 2.10, 2.12 and 2.13)

(ii) review of CEMP (paragraph 3.22)

(iii) spatial management and experimental approaches in the krill fishery (paragraph 3.25)

(iv) development of RMPs (paragraph 3.40)

(v) MPAS that span multiple jurisdictions (paragraph 3.79)

(vi) development of MPA proposals in Domains 5 and 6 (paragraph 3.81)

(vii) RMP for the SOISS MPA (paragraph 4.24)

(viii) website development for the RSRMPA RMP (paragraph 5.12)

(ix) criteria for the evaluation of proposals for research fishing in MPAs (paragraph 6.4)

(x) future work planning to achieve the required work on spatial management (paragraphs 6.8 and 6.13).

Close of meeting

8.1 Dr Grant thanked all participants for their cooperative and constructive engagement that had led to such a productive and successful outcome. She particularly thanked the rapporteurs, the Secretariat and the local hosts, in particular Ms Pilvi Muschitiello, who had provided excellent facilities in the Aurora building.

8.2 On behalf of the Workshop, Prof. Koubbi thanked Dr Grant for her hard work and friendly chairing that had allowed intense and fruitful discussions. He also thanked Dr Grant for her considerable intersessional work that had helped to make substantial progress on spatial management issues.

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Table 1: Preliminary assessment of indicators of representativeness by existing and proposed MPAs in the Convention Area. Adapted from WS-SM-18/12 and 18/14. This table does not include representative coverage that is provided by other conservation measures (paragraph 2.6).

	Area (10^3 km^2)	Ocean Basin	Bathymetric range	Latitudinal range	# of benthic ecoregions represented[1]	# of pelagic clusters represented[1]
CCAMLR MPAs						
SOISS MPA (CM 91-03)	93.8	Atl	0–2000 m	62–64°S	1	0
RSRMPA (CM 91-05)	2060.0	Pac	0–5000 m	60–85°S[2]	3	6
Sub-Antarctic MPAs						
HIMI	70.8	Ind	0–3500 m	49–57°S	1	1
Prince Edward Is	161.3	Ind	0–3500 m	42–51°S	1	2
Crozet Is	574.7	Ind	0–4600 m	42–50°S	1	2
Kerguelen	567.2	Ind	0–4900 m	45–53°S	1	3
SG & SSI	1069.9	Atl	0–8300 m	51–60°S	3	4
Proposals considered by SC-CAMLR						
D1MPA (SC-CAMLR-XXXVI/18)	447.1[3]	Atl, Pac	0–5600 m	58–73°S	2	6
EAMPA (CCAMLR-XXXVI/17)	1095.0	Ind	0–5000 m	60–68°S	5	8
WSMPA (CCAMLR-XXXV/18)	1800.0	Atl	0–5300 m	60–78°S[4]	4	7
Summary[5]						
Total existing MPAs	4597.7 (13%)	Atl, Ind, Pac	0–8300 m	42–85°S	8 (35%)	15 (79%)
Total proposed MPAs	3432.0 (10%)	Atl, Ind, Pac	0–5600 m	58–83°S	10 (43%)	12 (63%)
Total existing and proposed	8029.7(23%)	Atl, Ind, Pac	0–8300 m	42–85°S	17 (74%)	16 (84%)
Total Convention Area	35724.3	Atl, Ind, Pac	0–8400 m	45–85°S	23	19[6]

1 Benthic ecoregions and pelagic clusters are respectively from Douglass et al. (2014) and Raymond (2014). An ecoregion or cluster is considered 'represented' if at least 5% of its area is included within an MPA or set of MPAs. The threshold of 5% is arbitrary and does not indicate whether coverage is comprehensive or adequate. These bioregions may differ from those actually used to develop each MPA (paragraph 2.4).
2 Approximately the southernmost latitude of the Ross Ice Shelf.
3 Does not include the area of the SOISS MPA.
4 Approximately the northern latitude of the Ronne-Filchner Ice Shelf.
5 Values in parentheses indicate percentages relative to the Convention Area.
6 Raymond (2014) identified 19 pelagic clusters, however, one of these (Cluster 18 temperate waters) does not occur in the Convention Area and is not considered here.

Table 2: Example table to be used in investigating the establishment of reference areas in Subarea 48.6 to enable comparisons between fished and unfished areas.

Examples of parameters/attributes	Geographic areas							
	20°W–15°W	15°W–10°W	10°W–05°W	05°W–0°	0°–05°E	05°E–10°E	10°E–15°E	15°E–20°E
Ice conditions/accessibility								
Possibility of long-term analyses in the context of national Antarctic programs								
Background information available on benthic ecosystems and food webs								
Similar benthic habitats and ecosystems								
Distance to fisheries research blocks								
Previous fishing effort								
Current fishing effort								
Contribution to specific objectives of the WSMPA, such as:								
• Representative examples of ecosystems and habitats based on ecological and environmental features								
• Higher productivity areas								
• Ecosystems and habitats vulnerable to the effects of climate change								

Appendix A

List of Participants

Workshop on Spatial Management
(Cambridge, United Kingdom, 2 to 6 July 2018)

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Appendix B

Agenda

Workshop on Spatial Management
(Cambridge, United Kingdom, 2 to 6 July 2018)

1. Introduction
   - 1.1 Opening of the meeting
   - 1.2 Adoption of the agenda and organisation of the meeting
2. Development of general principles for the use of spatial management tools in the CCAMLR area
3. Development of MPA proposals
   - 3.1 Planning Domain 1 (western Antarctic Peninsula and southern Scotia Sea)
   - 3.2 Planning Domains 3 and 4 (Weddell Sea)
   - 3.3 Planning Domains 5 and 6 (Del Cano–Crozet and Kerguelen Plateau)
4. Research and monitoring plans
   - 4.1 General principles for MPA research and monitoring
   - 4.2 Development of specific MPA Research and Monitoring Plans
5. Spatial planning data management
6. Future work
   - 6.1 Priority research topics to inform future work on spatial management
   - 6.2 Cooperation with other scientific programs
   - 6.3 Future organisation of spatial management work by the Scientific Committee and its working groups
7. Other business
8. Advice to the Scientific Committee
9. Adoption of report and close of meeting.

Appendix C

List of Documents

Workshop on Spatial Management
(Cambridge, United Kingdom, 2 to 6 July 2018)

WS-SM-18/01	Baseline data layers used for spatial planning, monitoring and research in relation to the Ross Sea region Marine Protected Area M. Pinkerton and B. Sharp
WS-SM-18/02	Candidate baseline data for ecosystem indicators in the Ross Sea region A. Dahood and G.M. Watters
WS-SM-18/03	Summary of New Zealand research projects relevant to the Ross Sea region Marine Protected Area M. Pinkerton and J. Scarrow
WS-SM-18/04	Developing the risk assessment framework for the Antarctic krill fishery in Area 48 P. Trathan, V. Warwick-Evans, E. Young, S. Thorpe, E. Murphy, N. Kelly, S. Kawaguchi and D. Welsford
WS-SM-18/05	An experimental approach for the Antarctic krill fishery: advancing management and conservation through the use of Krill Reference Areas and Krill Fishing Areas P.N Trathan and O.R. Godø
WS-SM-18/06	Hierarchical monitoring plans to determine patterns of change in the Antarctic Marine Ecosystem P. Trathan
WS-SM-18/07	Predator trophic hotspots in the Indian sector of the subantarctic Southern Ocean: how do they overlap with marine protected areas? M. O'Toole, S. Sergi, A. Baudena, C. Cotté, C. Bost, C. Guinet, H. Weimerskirch, M.A. Hindell, P. Koubbi and F. d'Ovidio
WS-SM-18/08	Informing and seeking advice from WS-SM 2018 about the revisions of the WSMPA proposal S. Hain, K. Teschke, H. Pehlke and T. Brey

WS-SM-18/09	Comments on the development of a *Dissostichus mawsoni* Population Hypothesis for Area 48. Proposals on the WS-SM-18 advice to the to the Scientific Committee and its Working Group Delegation of the Russian Federation
WS-SM-18/10	Comments on the use of MPA for spatial management in the CCAMLR area Delegation of the Russian Federation
WS-SM-18/11	Peculiarities of spatial-temporal variability of oceanological conditions in the Weddell Sea region in the context of the development of a stock hypothesis for Antarctic toothfish (*Dissostichus mawsoni*) in Area 48 V. Shnar and S. Kasatkina
WS-SM-18/12 Rev.	Progress towards a representative network of Southern Ocean protected areas C. Brooks, S. Chown, L. Douglass and B. Raymond
WS-SM-18/13	Scientific background document in support of the development of a CCAMLR MPA in the Weddell Sea (Antarctica) – Version 2018 – Reflection on the recommendations by WG-EMM-17 and SC-CAMLR-XXXVI K. Teschke, H. Pehlke and T. Brey
WS-SM-18/14	Are we there yet? Evaluating and reporting progress towards a Representative System of Marine Protected Area across the CAMLR Convention Area D.C. Welsford
WS-SM-18/15	Research and Monitoring Plan for the South Orkney Islands Southern Shelf Marine Protected Area (MPA Planning Domain 1, Subarea 48.2) P.N. Trathan and S. Grant
WS-SM-18/16	Proposed initiative to contribute to Ross Sea region MPA research and monitoring activities using pop-up satellite tags and otolith chemistry on *Dissostichus mawsoni* C.D. Jones
WS-SM-18/17	The identification of scientific reference areas in the wider context of MPA planning – report of the CCAMLR scholarship recipient A. Capurro, M.M. Santos, R. Cavanagh and S. Grant

WS-SM-18/18	Further information in relation to krill fisheries in the D1MPA process A. Capurro and M.M. Santos with contributions from the D1MPA Expert Group

Other Documents

WS-SM-18/P01	Abundance and richness of key Antarctic seafloor fauna correlates with modelled food availability J. Jansen, N.A. Hill, P.K. Dunstan, J. McKinlay, M.D. Sumner, A.L. Post, M.P. Eléaume, L.K. Armand, J.P. Warncock, B.K. Galton-Fenzi and C.R. Johnson *Nature Ecology & Evolution*, 2 (2017): 71–80, doi: 10.1038/s41559-017-0392-3
WS-SM-18/P02	Model-based mapping of assemblages for ecology and conservation management: A case study of demersal fish on the Kerguelen Plateau N.A. Hill, S.D. Foster, G. Duhamel, D. Welsford, P. Koubbi and C.R. Johnson *Diversity Distrib*., 23 (2017): 1216–1230
WS-SM-18/P03	What's the catch? Profiling the risks and costs associated with marine protected areas and displaced fishing in the Scotia Sea E.S. Klein and G.M. Watters *PLos ONE* (submitted)
SC-CAMLR-XXXVII/01	Report of the Co-conveners of the CCAMLR Workshop for the Development of a *Dissostichus mawsoni* Population Hypothesis for Area 48 (19 to 21 February 2018, Berlin, Germany) Workshop Co-conveners (C. Darby (UK) and C. Jones (USA))
WS-DmPH-18/01	Materials on biodiversity in Subareas 48.6 and 48.5 in the frame of the Weddell Sea MPA Delegation of the Russian Federation
WS-DmPH-18/02	On seasonal and interannual dynamics of ice conditions in the Weddell Sea and its relation to the WSMPA planning Delegation of the Russian Federation
WG-SAM-18/21	Guidelines for fisheries-directed research addressing the Ross Sea region Marine Protected Area Research and Monitoring Plan S. Parker and A. Dunn

WG-SAM-18/33 Rev. 1	Annex to WS-DmPH-18 report: Towards the development of a stock hypothesis for Antarctic toothfish (*Dissostichus mawsoni*) in Area 48 M. Söffker, A. Riley, M. Belchier, K. Teschke, H. Pehlke, S. Somhlaba, J. Graham, T. Namba, C.D. van der Lingen, T. Okuda, C. Darby, O.T. Albert, O.A. Bergstad, P. Brtnik, J. Caccavo, A. Capurro, C. Dorey, L. Ghigliotti, S. Hain, C. Jones, S. Kasatkina, M. La Mesa, D. Marichev, E. Molloy, C. Papetti, L. Pshenichnov, K. Reid, M.M. Santos and D. Welsford

Report of the Working Group on
Ecosystem Monitoring and Management
(Cambridge, UK, 9 to 13 July 2018)

Contents

Report of the Working Group on Ecosystem Monitoring and Management

(Cambridge, UK, 9 to 13 July 2018)

Introduction and opening of the meeting

1.1 The meeting of the Working Group on Ecosystem Monitoring and Management was held at the British Antarctic Survey (BAS), Cambridge, UK, from 9 to 13 July 2018. Dr Beatrix Schlarb-Ridley (BAS Director of Innovations and Impact) welcomed participants to the Aurora Innovation Centre at BAS. She described the particular importance of the collaborative research that characterised the output work of WG-EMM and hoped that this week's meeting would include more of the same

1.2 Dr M. Belchier (Chair of the Scientific Committee) informed the workshop that Dr M. Korczak-Abshire (Poland), the Convener of WG-EMM, was not able to attend the Working Group. He conveyed Dr Korczak-Abshire's disappointment at not being able to attend and also her best wishes for a successful meeting. As there had been insufficient time to appoint an alternative Convener, Dr Belchier undertook to take on the role of Convener for this meeting.

1.3 Dr Belchier also welcomed all participants (Appendix A) to Cambridge and hoped that they would have an enjoyable time at the Working Group meeting and also an opportunity to enjoy the unprecedented hot and sunny weather.

1.4 The Agenda was adopted unchanged (Appendix B).

1.5 Dr Belchier noted the large number of papers (listed in Appendix C) that had been presented to the meeting and requested the indulgence of those presenting papers to be brief and focus on the key issues for consideration by the Working Group. He also emphasised the importance of providing clear advice and recommendations to the Scientific Committee.

1.6 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.

1.7 The report was prepared by T. Brey (Germany), R. Cavanagh, C. Darby and S. Fielding (UK), D. Freeman (New Zealand), S. Hill (UK), J. Hinke and C. Jones (USA), S. Kawaguchi and N. Kelly (Australia), B. Krafft and A. Lowther (Norway), B. Meyer (Germany), E. Murphy (UK), K. Reid (Secretariat), G. Robson (UK), M.M. Santos (Argentina), E. Seyboth (Brazil), I. Staniland (UK) and G. Watters (USA).

Ecosystem impact of the krill fishery

Risk assessment framework for Divisions 58.4.1 and 58.4.2

2.1 The Working Group noted WG-EMM-18/37, which described an application of a risk assessment to krill fishing in East Antarctica, particularly in Divisions 58.4.1 and 58.4.2 to evaluate whether the current management procedure has a high likelihood of achieving

CCAMLR's objectives in this region. Application of the risk assessment method was largely as it was described by WG-FSA-16/47 Rev. 1, a method endorsed by SC-CAMLR (SC-CAMLR-XXXV, paragraph 3.62). In this implementation of the risk assessment framework, predation needs of baleen whales, crabeater seals (*Lobodon carcinophagus*) and Adélie penguins (*Pygoscelis adeliae*) were explored, in parallel with the currently agreed krill biomass estimates across Divisions 58.4.1 and 58.4.2. This risk assessment found the regional risk of the current conservation measures in Divisions 58.4.1 and 58.4.2 to be higher than the baseline regional risk. That would suggest that, in the event that krill fishing within a CCAMLR season begins to approach the catch/trigger limits, krill predators across Division 58.4.1 could be potentially exposed to disproportionate effects of fishing (noting that the regional risk of historical krill fishing from 1974 to 1995 did not approach the baseline regional risk). Given this result is largely driven by the krill biomass/density estimates across Divisions 58.4.1 and 58.4.2, it would be useful to have updated surveys (Table 1), in addition to data from the fishery, to ensure the potential risk can be managed as it expands.

2.2 The Working Group welcomed the further work on the risk assessment for the krill fishery in Divisions 58.4.1 and 58.4.2. In terms of future data streams for risk assessments for krill fishing, it suggested that there was potential in emerging remote sensing methods for estimating abundances of pack-ice seals, particularly in East Antarctica. It also noted existing smaller-scale surveys in East Antarctica (such as the Collaborative East Antarctic Marine Census for the Census of Antarctic Marine Life (CEAMARC) collaboration in 2007/08; Amakasu et al., 2011) are promising sources of data to inform on the more recent distributions and abundances of krill, but stressed the importance of updating these parameters for CCAMLR management units, which is planned for Divisions 58.4.1 (WG-EMM-18/17) and 58.4.2 (proposal in development). In terms of refining the risk assessment approach, it noted that more accurate and precise estimates of krill consumption rates by various krill predators could help the risk assessment framework move from providing relative risk to being able to provide estimates of absolute risk. The Working Group suggested modifying the risk assessment framework to account for the potential for stochastic broad-scale events, such as calving of ice shelves. It also noted the potential of a Bayesian approach to improve the krill fishery risk assessment framework, which has already been applied to a spatially explicit fisheries risk assessment (Ministry for Primary Industries, 2017).

Risk assessment framework for Area 48

2.3 The Working Group noted the discussion on the risk assessment approach for Area 48 described in WS-SM-18/04 which took place during the Workshop on Spatial Management (WS-SM-18).

Fishing activities

2.4 The Secretariat presented the Working Group with an update to the krill fishing information for 2016/17 and 2017/18, and noted that:

(i) in 2016/17 (1 December 2016 to 30 November 2017), for Subareas 48.1, 48.2 and 48.3, the total catch of krill reported was 236 939 tonnes

(ii) in 2017/18 (to June 2018), Subareas 48.1 and 48.2 were fished; the total catch of krill reported was 250 159 tonnes of which 151 564 tonnes were taken from Subarea 48.1 (closed on 25 June at 98% of the catch limit) and 98 595 tonnes taken from Subarea 48.2

(iii) in both 2016/17 and 2017/18, main fishing activity took place in Subarea 48.2 and then shifted to Subarea 48.1 from March–April, with most effort concentrated within Bransfield Strait in May and June

(iv) in both 2016/17 and 2017/18, fishing activity took place in Subarea 58.4, with a total catch of 513 tonnes (9 tonnes and 504 tonnes from Divisions 58.4.1 and 58.4.2 respectively) in February 2017, and 246 tonnes from Division 58.4.2 in January 2018.

2.5 The Working Group congratulated the Secretariat on the effective implementation of the fishery forecasting process for the krill fishery that had resulted in the fishery closure in Subarea 48.1 on 25 June within 2% of the catch limit.

2.6 The Working Group noted that projection of catch to determine the timing of fishery closures is based on the reported catch under Conservation Measure (CM) 23-06, which is reported monthly until a set percentage of the catch limit is reached, then it moves to five-day reporting. The Working Group noted that with monthly reporting, catches at the start of one month might not be reported until the end of the following month. The Working Group noted that real-time submission of vessel monitoring system (VMS) data will allow the Secretariat to confirm the presence of a vessel in the fishery and this would improve the ability of CCAMLR to ensure data required to forecast the closure of the fishery is available in a timely manner.

Fishery notification

2.7 The Working Group noted that 12 vessels from five Members had notified their intention to fish for krill in 2019, with two vessels notified to fish in Area 58.

Fishery index

2.8 The Working Group noted that an index of krill fishery performance in all three subareas was strongly negative in 2015 while CCAMLR Ecosystem Monitoring Program (CEMP) combined standardised indices (CSIs) in 2015 were generally positive, but were negative in all three subareas in 2016 (WG-EMM-18/44). It was suggested that this lag may mean that the performance of the fishery in the post-breeding season (winter) could be a better indicator of predator performance/krill availability in subsequent breeding seasons.

Scientific observation

Finfish by-catch observation

2.9 WG-EMM-18/30 outlined a study carried out to examine the accuracy of juvenile fish taxonomy as reported by observers in the Antarctic krill (*Euphausia superba*) fishery using

DNA barcoding to provide independent identification from those identified by observers over two krill fishing seasons. The observer taxonomic identification was reasonably accurate. The diversity of fish identified by observers (five families; eight species) was considerably lower than with DNA barcoding (seven families; 20 species). How important this additional level of information is for CCAMLR management needs to be considered. The authors of the paper recommended some additional observer training and improved manuals for fish taxonomic identification are warranted given the effort invested in the high-quality observer program.

2.10 The Working Group highlighted the accuracy of finfish larvae identification by scientific observers. It also emphasised the importance of correctly identifying species that are recovering from historical overfishing, such as mackerel icefish (*Champsocephalus gunnari*) and marbled rockcod (*Notothenia rossii*).

2.11 The Working Group noted that the potential cost and effort involved in the DNA barcoding method may not allow it to be applied as a routine tool to monitor fish by-catch samples for taxonomic identification, but would be more suitable to periodically confirm identifications and/or highlight where any errors in identification occur.

2.12 The Working Group suggested that photographs of finfish larvae identified to species level based on DNA analysis could be used as an identification guide for observers, highlighting the sources of incorrect identification and requested that those photographs be sent to the Secretariat for inclusion in CCAMLR Scheme of International Scientific Observation (SISO) materials.

Revised krill trawl logbook for the 2019 season

2.13 The Working Group noted WG-EMM-18/39 that summarised the changes to the e-logbook for proposed introduction in the 2019 season. The data collection requirements for krill observers were discussed at the Workshop on the Scheme of International Scientific Observation (WS-SISO-17) (SC-CAMLR-XXXVI/08) for amendments to the krill e-logbook used by observers.

2.14 The Working Group endorsed the proposed changes, including the removal of the subsampling requirement from each 25 kg sample of krill for fish by-catch sampling and the inclusion of invertebrate by-catch reporting in addition to finfish. The Working Group noted that the proposed new format had been developed via the SISO e-group.

Ice krill by-catch

2.15 WG-EMM-18/05 analysed publicly available aggregated decadal-scale krill catch data to evaluate the likelihood that ice krill (*Euphausia crystallorophias*) will have been included in the reported Antarctic krill catch. The Antarctic krill fishery operates in geographic areas that overlap with the known range of ice krill, potentially occupying similar depths in the water column. The authors of the paper concluded that as both species are morphologically similar, the possibility of ice krill being caught as by-catch, and the failure to detect it, cannot be dismissed and that the likelihood of ice krill by-catch is effectively 100%.

2.16 The Working Group noted that some krill fishery operations occur in areas where datasets from scientific net hauls indicate the likelihood of co-existence of these two species. The Working Group further noted that the absence of ice krill reports does not necessarily indicate an absence of ice krill by-catch, and underlined the importance of providing scientific observers with the appropriate materials needed to identify ice krill in their routine observations.

2.17 The Working Group noted that there are various methods to detect ice krill and other by-catch, such as the use of lipid or DNA markers. However, it was also noted that these methods may not be practical to apply to a large number of samples in a routine manner. The Working Group noted that a combination of different approaches, including DNA barcoding and traditional analyses such as morphology, as presented in WG-EMM-18/03, might be useful in order to address this issue.

2.18 The Working Group noted that the absence of ice krill in by-catch could be because the fishery is targeting Antarctic krill, and avoiding catch of ice krill due to its smaller size.

2.19 Dr S. Kasatkina (Russia) recalled that Russian research surveys provided in previous years in Area 48 did not reveal the presence of ice krill in catches using research gear.

2.20 The Working Group requested that Members compile relevant survey and catch data in order to provide advice in the future on by-catch in terms of finfish and invertebrates in the krill fishery.

Krill biology, ecology and population dynamics

2.21 WG-EMM-18/06 provided an update on work to improve the current understanding of the regional and local-scale processes that determine the distribution of Antarctic krill in Area 48. The modelling is focused on the South Orkney Islands at regional scales relevant to the krill fishery and predators. Results suggested that resolving the interaction of krill with sea-ice is critical for determining the pathways and timescales of transport into and out of the region.

2.22 The Working Group noted that the analysis in WG-EMM-18/06 indicated that krill from the parts of Subarea 48.1 used by the fishery had a very low probability of being advected to the part of Subarea 48.2 used by the fishery when only the ocean flows were considered. The Working Group agreed that improving understanding of krill interactions with both the ocean currents and sea-ice drift is important.

2.23 The Working Group welcomed the development of this work and encouraged further modelling studies to examine controls on distribution and abundance of krill at multiple scales. It was noted that such high-resolution modelling would be extremely valuable to provide information on krill movement and distribution at scales relevant to inform the development of small-scale management measures.

2.24 WG-EMM-18/21 described an analysis of krill flux across the Scotia Sea using geostrophic circulation, spatial distribution of krill density, water flow intensity and krill biomass based on the analysis of data from the CCAMLR 2000 Krill Synoptic Survey of Area 48. The results indicated that the krill flux through the Antarctic Peninsula area and the South Orkney Islands area may be higher than the annual catch of krill and the catch limits in place for Area 48. The authors of WG-EMM-18/21 concluded that the results show that development of krill resource management schemes requires a study of the variability of its distribution under the influence of geostrophic flux at various space–time scales and that such information is necessary to understand the competitive relationship between predators and fisheries for krill resources.

2.25 The Working Group noted transport of krill in ocean currents is an important process in generating the observed large-scale distribution of krill, however, the pathways and timescales of movement and retention affecting krill distribution at scales relevant to the fishery and predators are particularly important.

2.26 It was noted that the data used in WG-EMM-18/21 were based on a single snapshot observation and that more data across time (seasonal and interannual) and in specific areas are needed to improve understanding of stock dynamics. Recognising that field studies of these processes are logistically and technically challenging, the Working Group welcomed the modelling studies that are implemented at fine-scale (<5 km) resolution and include sea-ice movement that can be used to provide insights into the krill distribution relevant to management.

2.27 Dr Kasatkina recalled that data from Soviet/Russian meso- and small-scale surveys and local area surveys (6 × 8 n miles) as well as data from the CCAMLR-2000 Survey suggest that the variability of krill biomass in the studied fishing grounds is more a reflection of krill flux in the region rather than the effect of fishing on krill resources.

2.28 WG-EMM-18/07 provided a summary of research published last year, to obtain a mechanistic understanding of the interaction between krill larvae and sea-ice (WG-EMM-18/P04 and 18/P05). Earlier studies led to the development of a traditional concept that early onset of sea-ice formation and prolonged sea-ice coverage result in higher krill recruitment the following summer. An important assumption in this hypothesis is that krill larvae are able to access food within the sea-ice. A study in late winter of 2013 on board the icebreaker *Polarstern* demonstrated that the pack-ice zone represents a nutrient-poor habitat for larvae development, whereas ice-free areas provide enhanced food conditions during winter. Chlorophyll-a concentration, as well as particulate organic matter underneath the ice within the pack-ice zone, can only sustain consistently low growth rates of larvae krill during winter. This contradicts the traditional hypothesis outlined above. These new insights have challenged a long-standing hypothesis and initiated a paradigm shift concerning the relationship between krill population dynamics and sea-ice. Based on these findings on larval krill and sea-ice, future studies conducted during autumn, late winter and early spring should focus on the northeastern Weddell Sea to get a better understanding of krill connectivity between the northeastern Weddell and the Scotia Sea to better predict krill population dynamics in the future.

2.29 The Working Group noted the importance of this paradigm shift in understanding of the processes influencing krill recruitment, which is recognised as the key driver of interannual variability in biomass, as well as the identification of areas and times of the year that are important for future studies.

2.30 WG-EMM-18/P18 presented stomach content analysis, as well as a stable isotope and fatty acid analysis, providing information on the diet of krill larvae and age class 0 (AC0) juveniles in late winter. The study highlighted the high diversity of autotrophs and heterotrophs in the diet of the larvae and AC0 juveniles in winter, which reflects the food availability in the regions where the individuals were caught, and suggest that AC0 krill mainly feed on ice-associated food sources. Variability in the diet, revealed by fatty acid profiles and stable isotope values, suggested that less availability of sea-ice resources over a long term may negatively affect larval condition in ice-covered waters.

2.31 The Working Group noted that the complementary investigations on the same expedition (WG-EMM-18/07 and 18/P04) indicated that the ice-associated food sources may not support high growth rates during winter, but are probably important for larval krill that are residing in pack-ice regions.

2.32 WG-EMM-18/34 provided information on the interannual variability in indices of krill density, recruitment and diurnal vertical distribution at South Georgia during winter based on Japanese krill fishery data during the period 1990–2012. The paper highlighted that the eastern region of South Georgia tends to be a highly stable fishing ground during winter. The krill recruitment index at South Georgia showed a congruent pattern with that in the Antarctic Peninsula in the 1990s, whereas this congruence was not apparent during 2000–2006. In addition, the data show that median winter trawling depth (a proxy for krill vertical migration) for each daytime and night-time was significantly positively correlated with average krill body length in winter. The authors suggested that this could be the optimal behaviour of krill to balance food intake against predation risk by Antarctic fur seals (*Arctocephalus gazella*), the most abundant krill-eating predator in the region.

2.33 The Working Group welcomed this analysis that highlighted the large amount of information available from the fishery that could provide insight into krill ecology and population dynamics. The Working Group also noted that the study used to define fur seal diving depths was based on data from lactating female seals, whereas during the winter months the population at South Georgia will be made up of a greater mix of the two sexes and different age classes.

2.34 WG-EMM-18/42 provided information on the spatial distribution and swarm characteristics of Antarctic krill which were studied using the swarm-based method established in SG-ASAM. Acoustic data were collected by the FV *Fu Rong Hai* using Simrad EK60 echosounders (38/70/120 kHz) in December 2013, March 2015, January 2016 and February 2018 around the South Shetland Islands. The mean krill densities in December 2013 and February 2018 were markedly higher than in the other two years, whereas many more swarms (1 055) were detected in February 2018 than in the other three years. The majority of swarms were found in the upper 100 m layer with the exception of March 2015 when more krill swarms were located in deeper water layers.

2.35 The Working Group agreed that the swarm-based method provides a useful approach to estimate krill biomass and to provide biologically relevant data on swarm characteristics.

2.36 The Working Group discussed the relative roles of local processes of retention and larger-scale processes of advection and flux in relation to krill distribution and abundance. It noted that fine-scale processes such as ocean current interaction around bathymetric features and krill behaviour are likely to be important in determining the distribution of krill at scales relevant to the fishery.

2.37 The Working Group noted that more research is required to improve the basic understanding of the physical and biological processes that determine the spatial structure of these ecosystems and that in addition to undertaking repeat mesoscale surveys, use of new autonomous technologies (e.g. moorings or gliders being developed in US AMLR and BAS programs) is likely to be important for improving understanding of seasonal changes in distribution and abundance.

Krill life-history parameters

2.38 WG-EMM-18/P16 provided information on a method for estimating krill age by detecting the growth bands of eyestalk sections of krill fixed in 70% ethanol and 5% formalin. This study presented important information for age determination, particularly for specimens preserved in formalin, and will benefit the stock assessment of this species in the future. Further studies are required to validate the correlation between growth bands and age. Additionally, more samples from different seasons and regions are also needed to fully understand the growth dynamics of this species.

2.39 The Working Group highlighted the importance of this study and strongly encouraged performing further studies to validate the correlation of age and annual bands in eye stalks with known age samples from krill grown in aquaria.

CPUE and spatial dynamics

2.40 WG-EMM-18/41 provided information on temporal and spatial dynamics of the krill population and the krill fishery in Subarea 48.1 by using catch per unit effort (CPUE) data collected from the Chinese FV *Fu Rong Hai* from the 2012/13 to the 2016/17 fishing seasons. Acoustic data collected throughout the fishing season showed the krill population development and that in most years krill abundance in the fishing area was higher in autumn than in the summer season.

2.41 WG-EMM-18/P11 provided an update of WG-EMM-16/52 on krill fishing hotspots and daily CPUE patterns for the krill fishery. The fleet took 48–57% of the seasonal catch in fishing hotspots that persisted for 2–6 months with high catch densities. Within these fishing hotspots there was a dome-shaped pattern of CPUE over time such that when CPUE decreased, the fleet moved to contiguous zones; such displacements occurred every 4–17 days and previously exploited zones were revisited.

2.42 The Working Group noted the importance of the data in WG-EMM-18/41 and 18/P11 in providing information on the seasonal distribution behaviour of krill and encouraged Members to contribute to such analyses. The Working Group noted that the results corroborate the outcomes of the AMLR winter surveys that indicated that krill biomass increases inshore in winter.

2.43 The Working Group also noted that the behaviour of the krill fishing fleet shows a consistent pattern of distribution in Subarea 48.1 with fishing initially in the Drake Passage and then focusing in Bransfield Strait and it was useful to understand the drivers of this behaviour of the fleet. The Working Group noted that VMS data from the krill fishery could be used to examine fleet dynamics to better understand the relationship between krill distribution and behaviour and the activities of the krill fishery.

Continuous trawl catch recording

2.44 WG-EMM-18/22 provided a review of the recording of two-hourly catch weight from the Norwegian continuous trawling vessels, as requested by the Scientific Committee in 2016 and 2017 (SC-CAMLR-XXXVI, paragraphs 3.6, 3.7 and 7.6vii). The questions raised by the Scientific Committee had been addressed in accordance with a plan proposed to the Scientific Committee in 2017 and included analysis of historic data from the vessels and onboard investigations during the 2017/18 season.

2.45 The Working Group noted that:

(i) the time lag between krill entering the trawl until it was taken on board was negligible (nine minutes) compared to the tow duration and the sampling time periods

(ii) the reported catch per two-hour interval is the total catch over a longer period that is scaled by an onboard estimate taken from the rate at which the holding tank fills. However, differences between vessel and officer procedures generate variation between the data series of samples

(iii) reporting differences and delays cause uncertainty in any reported catch value but not major bias

(iv) the geographical distribution of reported catch at different spatial scales showed only minor deviances between what was previously reported to CCAMLR and the catch reallocated in relation to the delay in reporting.

2.46 The Working Group noted that the uncertainty associated with the historical reported catch data is higher than has been previously assumed, and that whereas bias appears small, precision is lower than expected using the previously applied estimation approaches.

2.47 The Working Group noted that while the total catch and catches reported as part of monthly or five-day catch and effort reporting would not be impacted, the C1 data should be used with caution when conducting fine-scale (i.e. haul-by-haul) analyses.

2.48 While methods for determining less variable estimates of continuous trawling two-hour catch rates are developed, users of data should be informed of the uncertainty regarding the uncertainty associated with individual records. The records appear robust, at the finest spatial scale analysed (0.25° longitude by 0.125° latitude), however, temporal aggregation at or greater than, for example, 24-hour intervals will be required to provide unbiased estimates of catch.

2.49 The Working Group agreed that appropriate metadata should accompany any data extracts, and contain an advisory wording that the data from continuous fishing vessels should not be used at a haul-by-haul (two-hourly catch reporting period) for routine analysis given uncertainties in the methods implemented to allocate catches to two-hourly catch reporting by continuous vessels.

2.50 The Working Group noted that in the context of:

(i) CM 23-06 (closure of the fishery), the reporting procedures do not impact on CCAMLR management of the vessel catch and the overall krill fishery

(ii) CM 21-03 (two-hourly catch reporting by continuous vessels) the method used to estimate the catches (holding tank krill depth) is considered appropriate but requires standardisation, in terms of an agreed protocol that is consistent across vessels and in its application on the vessel.

2.51 The Working Group noted that the sampling of fish by-catch by observers takes place before the catch enters the holding tank as described in WS-SISO-17/11 and agreed that the methodology was appropriate. Based on the findings in WG-SAM-18/22 that the geographic distribution of reported catches showed minor deviances, the georeferencing of length-frequency distribution would not be impacted. However, linking of these samples to the overall vessel catch during a specific two-hourly catch reporting period may not be possible for existing data and requires an agreed standard approach for future data collection. This will ensure that finer-scale raising of by-catch sample data to total catch can be applied in future data collection. This may require amendment of instructions to observers and crew, as well as the relevant recording form.

2.52 Dr O.A. Bergstad (Norway) reported that consistency has been achieved between vessels and skippers in the procedures for estimation of 2-hourly catches. It would seem difficult to improve the precision further with the current processing and operational procedures.

2.53 The Working Group agreed that analysis of the continuous trawl data, particularly CPUE standardisation and analysis and the investigation of krill swarm dynamics, should proceed with caution and provide clarity on the temporal scale of aggregation of the two-hourly catch reporting periods. The Working Group therefore recommended that the Scientific Committee provide advice on appropriate advice to accompany data extracts.

2.54 The Working Group noted Norway's intention to pursue other options, in particular the acoustic recording and quantification of catches in the trawl mouth. There are actions to implement and develop such methods, and Norway would report on progress in due course.

Data layers from the krill fishery

2019 large-scale survey in Area 48

3.1 The Working Group considered papers concerning the proposed 2019 large-scale survey (WG-EMM-18/08, 18/12 and 18/23). The Working Group was reminded of the primary scientific objectives that were proposed by Norway in late 2017:

(i) to derive an estimate of abundance for Antarctic krill in the survey area, i.e. the subarea recognised as the primary distributional range of krill within Area 48

(ii) to compare and contrast density distribution patterns of krill between the surveys in 2000 and 2019

(iii) to compare distributions of krill and other biota in relation to oceanographic conditions, with particular focus on potential effects of climate variation and change

(iv) to enhance spatially and temporally relevant knowledge on interactions between krill and apex predators and the potential impacts of krill fishing.

3.2 WG-EMM-18/08 expanded paragraph 3.1(iv) and presented a project aimed at developing knowledge on the marine environment essential for the implementation of a feedback management (FBM) system. Data supporting FBM as an integral part of the broader management strategies of the krill fisheries within Domain 1 are critical if the fishery is to be managed by an empirical understanding of krill density, distribution, availability and predator needs. A future developed FBM system, as presented in SC-CAMLR-XXXVI/BG/20, requires acoustic data to be collected, processed and reported continuously during the fishing season as a measure of the available prey field. This information can be integrated with finer-scale knowledge of krill predator feeding strategies and updated through specific scientific studies at regular (multiyear) intervals. The FBM process studies will take place during the austral summer 2018/19 in association with the large-scale survey planned for Area 48.

3.3 WG-EMM-18/12 and 18/23 were presented to the Working Group in response to feedback on SG-ASAM-18/07 presented during SG-ASAM-18 in Punta Arenas, Chile. SG-ASAM-18/07 described plans for the execution of the multinational large-scale krill survey in Area 48 during 2019. The 2019 large-scale survey is coordinated by Norway working with international partners and CCAMLR scientific working groups to endorse methodology that has used the CCAMLR-2000 Survey as the basis for the survey design and sampling protocols. SG-ASAM-18/07 was endorsed by SG-ASAM, but that Subgroup recommended additional description of the implementation of technical issues to the survey be presented to WG-EMM.

3.4 WG-EMM-18/12 described acoustic procedures, the acoustic reporting procedures, analysis procedures and contingency plans, also with appendices containing acoustic sampling protocols and lists for the dedicated transect allocations of individual vessels. The survey summarises the collaborative efforts of Norway, the Association of Responsible Krill harvesting companies (ARK: companies from Norway, the Republic of Korea, China and Chile), the UK, Ukraine, Korea and China, all of whom have confirmed a commitment of survey ship time. With these commitments it is feasible to implement all transects and stations occupied during the CCAMLR-2000 Survey. A survey coordination group is established and has progressed substantially during the planning time; it was announced that it is still open for additional members.

3.5 WG-EMM-18/23 presented a protocol for sampling of biological data and hydrographic data for the survey. The aim is to facilitate a joint understanding of the field and laboratory work for participants that carry out the survey to standardise equipment and methods. The net sampling and laboratory protocols are based on the protocols developed for the CCAMLR-2000 Survey. Notably, the sampling locations will be the same stations as those undertaken during the CCAMLR-2000 Survey.

3.6 The Working Group welcomed the Norwegian-led initiative as proposed and noted the major commitments already made by several Members and the industry facilitating a synoptic sampling of all major fishing areas as well as the remainder of relevant areas of Area 48.

3.7 The Working Group also noted that the progress plan for developing the survey as a CCAMLR activity was presented with the first draft plan. WG-EMM welcomed the formation of a survey coordination group, which met at WG-EMM, building on previous work undertaken by correspondence since SG-ASAM. The Working Group agreed that many of the SG-ASAM recommendations had been addressed, and that that work is continuing. It emphasised the need to schedule further meetings and the pre-survey meeting early in order to ensure relevant participation.

3.8 The Working Group noted that while the 2019 large-scale survey protocols were based on the CCAMLR-2000 Survey acoustic, net and oceanography protocols, some differences were identified:

(i) net types used differed between vessels, and also differed from the single RMT8+1 used in 2000

(ii) the acoustic sampling will occur through day and night, compared with only daytime sampling undertaken in 2000

(iii) stratified net sampling stations would be undertaken at variable times of day/night (compared with fixed midnight and midday timings in 2000).

3.9 Dr Krafft identified that all the nets mentioned in WG-EMM-18/23 were approved by CCAMLR to sample Antarctic krill, that their selection properties can be calculated and that results can be used to look at inter-net selection variability of sampling of Antarctic krill. In addition, it was noted that more than 70% of the biological sampling stations would use the same trawl type.

3.10 The Working Group further noted that the spatial extent of the survey and time allocated by contributing vessels meant acoustic surveying would have to occur throughout the 24 hour period, different from the CCAMLR-2000 Survey. It also highlighted that in Subarea 48.1, alternative sampling platforms such as moorings and gliders would provide detailed information on the diurnal pattern of krill distribution that could be used to interpret diel variability and would be advantageous to a daytime-only view of krill distribution.

3.11 It was also noted that due to limited available resources (ship time), it will not be possible to carry out the same biological sampling strategy as in 2000 with regard to station timing. In 2019, station work will be performed at the same geographic locations as in 2000, but not at midnight and midday.

3.12 The Working Group discussed whether the intended coordinated meeting of SG-ASAM, WG-EMM and WG-SAM planned for 2019 to discuss survey design could be an opportunity to consider a strategy for the frequency of large-scale surveys, or whether science should focus on regional variability. The Working Group recognised that the results from the 2019 large-scale survey would be compared with the estimate from 2000 and it needed to be confident that methodological differences were understood. The Working Group was reminded of the annual national krill surveys (e.g. in Subareas 48.1, 48.2 and 48.3), that could be used to interpret differences between the two point measurements.

3.13 The Working Group agreed that the 2019 large-scale survey will provide a framework for studies into FBM. It recommended that the mesoscale transect components of the CCAMLR-2000 Survey were aligned with the long-term national surveys, particularly in the Bransfield Strait where fishing activities have shifted geographic location since 2000.

3.14 It was highlighted that the 2019 large-scale survey would provide a wealth of new observations from Area 48 and that appropriate data stewardship and sharing strategies should be established. During WG-EMM-18 the survey coordination group identified that a data management plan would be developed, led by Dr G. Macaulay (Norway) (acoustic) and Dr Krafft (biology) and supported by Drs Fielding and Hill. This would include common cruise reports and outline station reporting requirements.

3.15 The Working Group considered plans for post-processing and analyses. It agreed that acoustic data processing should, where possible, be undertaken during the survey (on board the vessel) using the swarms-based approach to determine krill density. It reminded the group that the appropriate software template and R markdown script describing the methods were available from https://github.com/ccamlr/CCAMLREchoviewR and Members should use the supporting documentation within the SG-ASAM reports (SC-CAMLR-XXXVI, Annex 4 and Annex 4). It was agreed to support SG-ASAM's suggestion for a survey analysis workshop in 2019.

3.16 The Working Group recommended that the 2019 large-scale survey dataset be used to further examine the performance of swarms-based methods over different temporal and spatial scales by also calculating krill density distribution using the two-frequency identification method.

3.17 Dr Kasatkina emphasised that the CCAMLR-2000 Survey was strongly standardised in terms of acoustic data collection and analysis using the multi-frequency acoustic method to identify krill, accompanied by biological sampling with standard research trawl and data collection during the daytime. The timeline for each transect was determined in advance of the survey and was monitored. The 2019 large-scale survey will be carried out by vessels that collect acoustic data during day and night with krill identification undertaken on a single frequency using the swarms-based approach. She highlighted that the multi-frequency identification method should be applied to the data. In addition, biological sampling will be undertaken using both commercial and research trawls. She noted that results of the 2000 and 2019 surveys of krill distribution patterns and biomass estimates will be estimated using different techniques that may not be comparable.

3.18 Dr Kasatkina outlined the necessity to clarify differences in the 2019 survey. In particular, how to establish the baseline acoustic data by summarising data from each vessel and whether these data are accompanied by different sources of uncertainty and how to assess this uncertainty in density estimates. She stressed that clarity regarding these issues raised would facilitate both clarity regarding the practical utility of expected outcomes from the 2019 survey as well as the development of survey design and methodology.

3.19 The Working Group summarised the expected outcomes of the 2019 large-scale survey as:

(i) provide an overall reference, in terms of abundance and distribution, to krill assessments in the fishing areas and provide an indication of biomass within the survey area

(ii) analyse large-scale distribution in relation to environmental conditions to inform analyses of impacts of climate change

(iii) evaluate and develop survey strategies incorporating the future utilisation of fishing vessels

(iv) undertake a synoptic assessment of biomass, distribution and population characteristics in those areas currently fished

(v) provide information pertinent to the development of risk assessment, FBM and the spatial management considerations in Domain 1

(vi) provide ocean-scale opportunity for sampling of krill biology and other taxa.

2019 krill Survey in Division 58.4.1

3.20 WG-EMM-18/17 described the revised proposal for a dedicated krill survey for Division 58.4.1 during 2018/19 carried out by the *Kaiyo-maru*. The survey will follow the BROKE transects, use multifrequency narrowband acoustics, and a number of different net types. The survey will include both national and international participants.

3.21 The Working Group identified that the BROKE transects were being repeated and queried whether knowledge gained and other survey efforts in the area undertaken since 1996 could be used to inform different survey designs, particularly within neritic regions. The Working Group noted, however, that the Japanese vessel is not ice-strengthened and survey efforts will be limited to the ice edge or the 200 m isobath.

3.22 The Working Group noted that SG-ASAM had also considered papers outlining the *Kaiyo-maru* survey in Division 58.4.1 and endorsed the method outlined to determine krill density and distribution (SC-CAMLR-XXXVI, Annex 4, paragraphs 5.1 to 5.3 and Annex 4, paragraphs 5.16 and 5.17). It had focused its discussion and recommendations around the novel wideband acoustic methodology to be employed during the survey.

Krill survey in Subarea 48.2

3.23 WG-EMM-18/P03 presented the activities and preliminary results from the annual (since 2011) krill and ecosystem monitoring survey conducted during February 2018 at the South Orkney Islands. This year the FV *Juvel* was provided by the fishing company Aker Biomarine AS and acoustic information was recorded using three frequencies (38, 70 and 120 kHz), trawl hauls were made every 25 n miles along the transect lines. Catches were weighed and sorted by taxonomy. A conductivity temperature depth probe (CTD) with a fluorescence sensor was attached to the trawl to obtain profiles of hydrography. Systematic sightings for seabirds and marine mammals were carried out along the transects during daylight hours. Data from echosounder and acoustic doppler current profiler moorings deployed in 2017 were recovered and the moorings were redeployed programmed for logging until recovery in 2019.

3.24 Dr Krafft noted that the vessel was unable to trawl during the survey within the South Orkney Islands southern shelf marine protected area (MPA). The Working Group recalled that CM 91-03 identifies that fishing activity is prohibited with exception of research activities in the South Orkney Islands southern shelf MPA. The Working Group recommended that Norway consider how this annual survey could contribute to the RMP of the South Orkney Islands southern shelf MPA and submit a proposal outlining this for approval.

Acoustic data methods and analysis

3.25 WG-EMM-18/15 presented a new drone technology available through a Sailbuoy concept, which offers new opportunities for an industry–science partnership in collecting environment and krill distribution data independent of vessel availability. This concept has demonstrated robustness and reliability under other rough conditions and will be tailored to support data for FBM and for a more environmentally efficient fishery in the Antarctic. The system can be equipped with echosounders and environmental sensors to feed science and industry with data in near-real time. The system does also have the possibility to collect data from moorings through underwater communication using an acoustic modem. The first test is planned for 2019 and the goal of the paper is to establish interaction with potential users to ensure that the tailored system includes most of their requirements.

3.26 WG-EMM-18/11 provided an update on the Antarctic Wildlife Research Fund (AWR) project 'Rapid unsupervised automated krill density estimation from fishing vessels' (Rapid-Krill), which aims to summarise acoustic data to krill density information in near-real time on board research and fishing vessels. The project has been building the CCAMLR acoustic protocols in the open-source software Python, building on a wider community effort to develop open-source acoustic processing tools. It showed the output of a two-frequency (120-38 kHz) identification technique undertaken in Python. The alternative swarms-based approach for krill identification in acoustic data has yet to be implemented.

3.27 The Working Group noted that the swarms-based approach, agreed by SG-ASAM, can operate using single-frequency data (120 kHz) and is used to identify krill in swarms, whilst a multifrequency identification method is required to estimate krill not contained within swarms and recommended that the Rapid-Krill project should facilitate either method.

Marine mammal surveys

3.28 WG-EMM-18/33 introduced two concepts for observing pelagic predators from fishing vessels, including specific questions that can be addressed with different data collection and sampling methods:

(i) using SISO observers to collect data to establish potential interactions and competition of the krill fishery and krill-dependent predators during fishing operations, as identified by WG-FSA-16 (SC-CAMLR-XXXV, Annex 7, paragraph 6.14) and WG-EMM-17 (SC-CAMLR-XXXVI, Annex 6, paragraphs 2.11, 2.25 and 2.26)

(ii) the use of trained marine mammal observers to collect data on abundance and distribution of marine mammals during surveys and transects using krill fishing vessels.

3.29 The Working Group noted that whilst the CEMP land-breeding higher predator monitoring was well developed, there is no similar program for pelagic krill predator observations within CCAMLR. The Working Group commended the outline of pelagic predator observations possible from krill fishing vessels in WG-EMM-18/33 and highlighted the potential use of krill fishing vessels as a platform for these observations.

3.30 With respect to using SISO to collect data for understanding potential interactions and competition of the krill fishery and krill-dependent predators during fishing operations, the Working Group acknowledged that there is little information on pelagic predators in comparison to land-based krill predators. As cetaceans are major krill predators, an understanding of how they overlap with the krill fishery is of relevance to the work of WG-EMM and should be considered further.

3.31 The Working Group encouraged Members to undertake experiments or designs of a feasibility study (see also WS-SISO-17/05) noting the concerns about whether the krill fishery observers had the time, alongside their existing responsibilities, to undertake additional marine mammal observations during fishing operations as described in WG-EMM-18/33.

3.32 Regarding wider ecosystem monitoring through surveys and transects by krill fishing vessels, WG-EMM highlighted that marine mammal observations require appropriate training to ensure quality of recorded observations, and this required consideration as well. The Working Group noted that WG-EMM-18/33 included specific methods for marine mammal observations and identified that greater interaction with the International Whaling Commission (IWC) would enable wider exploration of the suitability of krill fishing vessels for cetacean surveys.

3.33 Dr Kasatkina noted that observations from krill commercial vessels do not provide information on marine mammal or other pelagic predators in relation to their biology, feeding and krill consumption. Therefore, it is possible to study only the spatial overlap between the foraging zones and the fishing grounds. To assess the degree of this overlap, information is needed regarding the number and biology of the observed predators relative to the abundance and population structure of their colonies. Some errors in the counting of predators from the vessel cannot be excluded, in particular, bearing in mind the possibility of re-registration of the same predator from neighbouring vessels.

Ecosystem monitoring and observation

CEMP data

4.1 WG-EMM-18/44 summarised the data submitted to CEMP for the 2017/18 season. Eleven Members working at 18 sites in Areas 48, 58 and 88 contributed data for 13 CEMP parameters on six species of krill-dependent predators.

4.2 The Working Group welcomed Cape Hallett as a CEMP site operated by the Republic of Korea and the planned contributions of monitoring at Cape Hallett to contribute to the research and monitoring plan (RMP) of the Ross Sea region MPA (RSRMPA).

4.3 The Working Group noted that the CSI analysis of the CEMP data had been updated to compare patterns of interannual variability of predator performance in Area 48. The CSI analysis indicated an increase in synchrony of the site-specific CSIs within subareas in recent years. Such concordant responses of CEMP indices suggested that predator performance is tracking similar processes on a regional scale. There was no indication of an overall trend in predator performance, but substantial interannual variation that warrants continued research.

4.4 The Working Group considered two papers that suggested updates to several CEMP e-forms. WG-EMM-18/46 provided a rationale for updates to the e-forms for CEMP parameters A3 (breeding population size) to request only data on occupied nests and for A8 (penguin diet) to facilitate submission of krill length-frequency data obtained from predator diets. WG-EMM-18/27 reviewed the type of data available from nest camera images and described their relationship to the CEMP parameters A3, A6 (breeding success) and A9 (breeding phenology) and potential application to A2 (incubation shifts) and A5 (trip durations). The paper proposed minor revisions to the CEMP data forms A3, A6a, A6b and A6c and A9 to accommodate camera-derived data streams.

4.5 The Working Group recalled prior analyses (Lynch et al., 2009; Southwell et al., 2010) that explored how nest camera data can be used to correct off-peak census data.

4.6 The Working Group recommended that the proposed changes to the CEMP e-forms be implemented to increase data provision to CEMP and to progress the use of camera data in the collection of multiple CEMP parameters.

Nest cameras

4.7 The Working Group considered WG-EMM-18/26 and 18/P01 that presented results from validation studies to compare ground and nest camera observations of breeding chronology and success of *Pygoscelid* penguins. The observations demonstrated a correspondence of major phenological events observed directly or with nest cameras to within 1–2 days. The Working Group noted the utility of repeating validation studies as a means to test the robustness of new methods. The Working Group also noted the clear progress made in the development and uptake of camera-based monitoring of seabirds by many Members.

4.8 The Working Group noted that the R code published in the appendix of WG-EMM-18/P01 is accessible to Members as an R Shiny application (available at: https://jefferson.shinyapps.io/photor2). The application is designed to assist with summarisation of nest-camera data to populate CEMP e-forms for parameters A6b (breeding success) and A9 (breeding chronology).

4.9 The Working Group agreed that such applications are useful tools to provide consistent analysis techniques with utility that could extend beyond camera-based analyses. For example, applications could be built for estimation of foraging trip duration (CEMP parameter A5). Such methods may help ease the provision of CEMP data to the Secretariat. The Working Group welcomed future coordination with the Secretariat to develop capacity to utilise such methods.

Diet studies

4.10 The Working Group discussed WG-EMM-18/29 and 18/45 that introduced new methods to collect penguin diet data. The Working Group recalled that penguin diet is a CEMP parameter. Given the current reduction in lavage sampling, it is important to identify and assess alternative, less invasive methods as potential supplementary approaches for studying penguin diet.

4.11 WG-EMM-18/29 provided results to compare stomach lavage techniques and faecal DNA analysis using Adélie penguin samples collected from Signy Island during two seasons. Both methods produced a similar pattern of penguin diet, with a shift from almost exclusively krill in 2014/15 to a mixture of fish and krill in 2015/16.

4.12 The Working Group welcomed this new approach to estimate diet composition but noted several trade-offs with such approaches. While stomach flushing is invasive, it allows, inter alia, prey size, frequency of occurrence and meal mass information to be collected. Alternatively, faecal prey DNA is non-invasive, simple to collect, and provides a more comprehensive sampling of diet composition. The Working Group recalled that the percent occurrence of prey items estimated by both methods were not directly comparable and that further work is needed in this sense.

4.13 The Working Group noted that to consider faecal DNA diet analysis as a CEMP monitoring tool, future requirements need to be considered, such as validation of the technique, sample standardisation and costs of implementation for national programs. The Working Group noted a CEMP review in the near future could be helpful for including these considerations.

4.14 WG-EMM-18/45 reported the results of a pilot study conducted at Esperanza Station during the 2017/18 breeding season. Data on diet composition and krill length were obtained from collecting samples of 'krill spill', which come from regurgitation during chick feeding. The krill length frequency of the krill spill sample (N = 145) was compared to data collected utilising the A8 (chick diet) standard methods (N = 632 krill for 'A8 guard stage' and N = 1 568 krill for 'A8 crèche stage'). The authors identified trade-offs with taking this specific opportunistic approach to data collection, namely that the samples will be much smaller, that samples can be heavily digested and that setting a minimum standard required for analyses may not be possible. The authors concluded that while the length frequencies were similar, more opportunistic data must be collected alongside routine A8 monitoring.

4.15 The Working Group noted that this is a useful approach and encouraged those Members already collecting this data to undertake similar analyses. The combination of two non-invasive methodologies, faecal analysis and krill spill, may help reducing some of the limitations of the DNA faecal analysis method.

4.16 The Working Group noted that krill length distribution between samples from regurgitation and krill spill appears to be different, but preliminary bootstrapping analysis suggests that the overlapping distribution shows that they belong to the same population.

4.17 The Working Group recalled the use of predators as samplers of krill and the use of such data to parameterise target strength calibrations in acoustic analysis (see Reid and Brierley, 2001) to estimate krill biomass noting that such data would be helpful for the analysis of acoustic data collected from autonomous acoustic platforms.

4.18 The Working Group noted that additional species can provide information for management purposes that have not yet been considered as CEMP species, as for example the long-term diet data series from icefish from South Georgia.

Population census

4.19 The Working Group noted WG-EMM-18/25 that provided a thorough description of the topographical characteristics, geographic locations and estimated abundances of *Pygoscelid* penguins at breeding colonies near the Ukrainian Antarctic station Vernadsky during the 2017/18 austral summer. Within the study region, gentoo penguins were the most abundant (13 320 breeding pairs in 14 colonies), followed by Adélie penguins (5 300 nesting pairs in

8 colonies) and chinstrap penguins (16 nesting pairs in 1 colony). The authors report on a gentoo colony with 17 nests on the northwest coast of Green Island (65°19'S 64°09'W) possibly representing the southern-most colony established by this species.

4.20 Routine CEMP monitoring near Vernadsky Station is currently conducted primarily on Galindez and Petermann Island, but the Working Group noted that monitoring of other colonies would be welcome given the importance of the region for the expanding gentoo population. Ice conditions in the region have prevented the development of monitoring, however, the Working Group noted that deployment of nest cameras may be a useful approach to expand routine monitoring in this study area.

4.21 The Working Group discussed WG-EMM-18/38 that reported on the use of unmanned aerial hexacopters to census large penguin colonies and monitor habitat conditions at Cape Hallett in the Ross Sea. The Working Group welcomed the updated census of Adélie penguins breeding at Cape Hallett, noting that continued monitoring will be useful for the RMP of the RSRMPA.

4.22 The Working Group also noted the general utility of drones for monitoring and research and that their use is likely to increase. The Working Group recalled that guidelines for the use of drones in Antarctica have been developed by the Committee for Environmental Protection (CEP) (Resolution 4 (2018)) and supported by active research to quantify the effects of drones on wildlife.

4.23 The Working Group noted that traditional aerial methods (e.g. helicopter surveys) will remain viable alternatives in many cases. In particular, to ensure continuity in data streams, comparisons of data from traditional aerial census methods with drone-based census methods would be desirable in areas where methods transition from one to the other.

4.24 The Working Group noted that the imagery collected during the survey of Cape Hallett were very useful for identifying human-generated debris (e.g. plastic, wood, and metal). Aerial drone surveys that use photography or hyperspectral/multispectral imaging to locate and identify such debris have potential to enhance information on marine debris and terrestrial management efforts.

Reports by CEMP Special Fund projects

4.25 The Working Group received reports from two CEMP Special Fund projects that were funded in 2015/16.

4.26 WG-EMM-18/24 provided an update on an overwinter penguin tracking project. The data-collection phase is complete and analysis of the data in underway.

4.27 Based on the preliminary analyses in WG-EMM-18/24, the Working Group noted that the environmental characteristics of the habitats occupied by gentoo penguins, traditionally considered a more temperate species relative to the more polar chinstrap and Adélie penguins, was unexpected. The Working Group recalled that gentoo penguin populations in Subarea 48.1 are increasing and expanding their range southward (paragraph 4.19), in contrast to the other *Pygoscelid* penguin populations in the region. The Working Group encouraged further research on their habitat characteristics during winter and potential interactions with other penguin species in the region.

4.28 The Working Group noted that sample sizes used in this tracking study were similar to other tracking programs in the region. The Working Group agreed that the collected data would therefore be representative for achieving the goals outlined in the project (see WG-EMM-17/07).

4.29 WG-EMM-18/28 provided an update on the software developed for assessing nest camera images through the CEMP Special Fund project 'Developing an image processing software tool for analysis of camera network monitoring data'. The nest camera image software was developed for the purpose of assessing time series of images from fixed cameras established overlooking a cluster of nests for surface-nesting seabirds.

4.30 The Working Group noted the significant progress towards finalising the nest camera image software so that it is available for the broader camera network community. The Working Group agreed that it would be useful for the broader nest camera user group to trial the software on test data to provide feedback tailored for finalising the software in time for the meeting of the Scientific Committee where a presentation of the software can be provided.

CEMP review

4.31 The Working Group noted management strategies for Antarctic marine living resources are diversifying to include spatial management, risk assessments and FBM. For such strategies, the necessary data to meet the objectives of the Commission may extend beyond the current CEMP framework.

4.32 The Working Group recalled the objectives of CEMP to:

(i) detect and record significant changes in critical components of the marine ecosystem within the Convention Area, to serve as a basis for the conservation of Antarctic marine living resources

(ii) distinguish between changes due to harvesting of commercial species and changes due to environmental variability, both physical and biological.

4.33 While the CEMP effort is currently focusing on krill-dependent predators, there remains a broader set of ecosystem monitoring data that are required by CCAMLR for, inter alia, krill fishery management and MPA RMPs.

4.34 The Working Group recommended that the Scientific Committee consider a review of the ecosystem monitoring requirement of CCAMLR, given the current priorities of the Scientific Committee, in which the current CEMP would be one important component.

4.35 This review should consider a change in emphasis from only having a set of standard-method-based approaches, to an approach that incorporates more data to address the objectives set out above. This change should be accompanied with appropriate metadata to allow the evaluation of its utility in a particular monitoring application.

4.36 To facilitate a review of the ecosystem monitoring requirement of CCAMLR, draft terms of reference are to:

(i) review objectives for ecosystem monitoring within CCAMLR with reference to Article II

(ii) review the current scope of CEMP with reference to the objectives identified in term of reference (i) and the priorities of the Scientific Committee by:

(a) reviewing current CEMP data holdings to ensure that relevant data are collected to achieve the objectives established under term of reference (i)

(b) identifying other methodologies of relevance to CCAMLR ecosystem monitoring

(c) identifying how the integrity of time series should be maintained when methods change

(d) reviewing how monitoring data can be used in the priority work of the Scientific Committee

(e) compiling a list of relevant data sources and the methods to access them within and beyond CCAMLR

(iii) advise on priorities for expanding CEMP to achieve the objectives identified in term for reference (i) and the priority work of the Scientific Committee.

4.37 The Working Group discussed if a review of the current CEMP would be appropriate, given the current priorities of the Scientific Committee. In this respect, the Working Group noted concerns about how to best constrain the scope and duration of a review so that advice to the Scientific Committee could be focussed and timely.

4.38 The Working Group suggested that the scope of the review could be made manageable by adopting a two-part process to first review the current CEMP framework and then consider the broader ecosystem monitoring requirements of CCAMLR.

4.39 The Working Group noted that a review of CEMP is linked to other priority work of the Scientific Committee, particularly the development of FBM and MPA RMPs. The Working Group encouraged the voluntary work of Members to reflect on and improve upon the current CEMP framework.

Ecological interactions: predators

4.40 WG-EMM-18/03 presented foraging data from Antarctic shags (*Phalacrocorax bransfieldensis*) breeding at Harmony Point, Nelson Island, during the 1995 and 1996 summer seasons. Prior to egg laying, individuals conducted one foraging trip per day. In contrast, when rearing chicks, breeding adults increased the number of foraging trips and the time spent foraging relative to the number and age of chicks in individual nests. The authors suggested that Antarctic shags invest time in activities that buffer variability in energetic demands of nestlings, and further highlighted the possibility of using foraging parameters in ecosystem monitoring programs.

4.41 The Working Group noted that non-krill eating species are also monitored as part of CEMP, and that these data have been, and are continuing to be, collected and will be made available to the Secretariat in due course.

4.42 WG-EMM-18/04 used dietary data from nine bird and two seal species collected each austral summer between 1996 and 2000 at the South Orkney Islands to characterise interspecific trophic relationships among top predators in the area. Prey re-occurrence in diets was intermediate and consisted mainly of krill, fish or penguins. Most frequent reoccurrences reported were notothenids as well as the myctophid *Electrona antarctica*. Predators foraging in the water column had yearly variable diets that were most likely related to fluctuations in krill availability, with switches to notothenids in periods of low krill abundance. The authors discussed the recovery of *Gobionotothen gibberifrons* stocks around the South Orkney Islands and highlighted the potential for interspecific trophic competition between predators under scenarios of decreasing krill availability.

4.43 The Working Group welcomed the multispecies approach. It was noted that the *G. gibberifrons* abundance estimates from the recent Chilean survey around the South Orkney Islands represented the second-highest biomass estimate of all fish species observed, and that these biomass estimates in particular contrasted sharply with those in the South Shetlands Islands where *G. gibberifrons* populations appear to continue to decline.

4.44 WG-EMM-18/10 utilised data on migrating adult male Antarctic fur seal abundance coupled with published energetics models to estimate the removal of approximately 86 500 tonnes of krill in the South Orkney Islands area. The authors suggested this is likely an underestimate and provided several caveats including population size increases of Antarctic fur seals over the preceding 30 years and consumption estimates above those predicted by energetic models due to animals recovering body condition.

4.45 Dr Lowther indicated that recent tracking work of adult male Antarctic fur seals from the South Orkney Islands suggested that their post-breeding foraging behaviour in the Bransfield Strait where it overlapped with the foraging distribution of breeding chinstrap penguins (*Pygoscelis antarcticus*) at the same time.

4.46 The Working Group noted that diet data from WG-EMM-18/04 from the same population used to estimate abundance during (part of) the years might be useful in refining consumption estimates in the current paper.

4.47 The Working Group discussed the similarity in movement strategies between adult male Antarctic fur seals and the fishery, but noted that the majority of individuals instrumented with satellite tags at the South Orkney Islands did not remain in the area for long and transited into the Bransfield Strait within several days of arriving.

4.48 The Working Group further noted that, given the consumption estimates provided in the paper, it would be useful to collate data on the historical trends in adult male Antarctic fur seal arrivals into the Bransfield Strait to better understand their potential competition with breeding krill-dependent predators in the area.

4.49 WG-EMM-18/40 showed the preliminary analysis of tracking studies of gentoo and chinstrap penguins at Devil's Point, Byers Peninsula, and Vapour Col, Deception Island, between December 2016 and January 2017. At-sea location data collected from breeding adult birds were used to generate basic foraging behaviour parameters including trip length, maximum distance and trip duration.

4.50 The Working Group noted the novel data from the area and supported further work that was being planned, including increased coordination and collaboration with the forthcoming multination survey effort in 2019. The Working Group agreed that such work would be useful to test recently developed penguin foraging habitat models (WG-EMM-17/34), and the authors confirmed that future studies will also include dietary information to further characterise diurnal variability in foraging trip durations and corresponding diets identified in other regions. The Working Group further agreed that this data can be useful for the supporting information for the MPA in Planning Domain 1 (D1MPA) proposal.

4.51 WG-EMM-18/P09 outlined the at-sea movement behaviour of four instrumented leopard seals (*Hydrurga leptonyx*). Tracking data, ranging from 142 to 446 days, showed seasonal migratory behaviour between the pack-ice and South Georgia and an increased propensity for undertaking longer haul-outs during the summer. The authors highlighted that peak haul-outs were around midday between October and April, which may have implications for visual surveying efforts. Furthermore, the authors suggested that, given the movement of individuals between, and subsequent behaviours within, areas important to breeding populations of birds and other seals, further consideration of leopard seal ecology is vital in the context of Southern Ocean sustainable management.

4.52 WG-EMM-18/P12 presented tracking data from pre-moult Adélie and chinstrap penguins breeding on the South Orkney Islands. The authors showed that Adélie penguins foraged throughout their foraging trip, more frequently in close proximity to sea-ice, on which they subsequently moulted. In contrast, chinstrap penguins remained over shallower shelf waters to forage and returned to land to moult. Models derived from the data had low predictive power, and the authors highlighted that additional empirical data is required to improve predictability and further understanding of the impacts of climate change and fishing.

4.53 The Working Group noted that similar areas in the Weddell Sea are used by juvenile and pre-moult Adélie penguins tracked from the South Shetland Islands, and agreed that areas to the south of the current South Orkney Islands southern shelf MPA may also be important. The importance of this area to leopard seals reported in WG-EMM-18/P09 was noted. The Working Group discussed the utility of satellite-based detection of Adélie penguins whilst moulting on the sea-ice, and agreed that this may have the potential to more readily characterise moulting areas.

4.54 WG-EMM-18/P13 reported on a project examining Adélie and gentoo penguin breeding chronology and success at islands across the Wilhelm Archipelago via data collected by remote cameras since 2016, established as part of the CEMP camera network. These data are reviewed in the context of a dataset collected on gentoo penguins at Petermann Island between 2003 and 2017.

4.55 The Working Group thanked the authors for the continued development of a time series of breeding success data, and commented on general trends in breeding success decline with decreasing latitude. The Working Group also agreed that such studies contributed greatly to characterising potential climate change impacts across latitudinal clines.

4.56 WG-EMM-18/P14 presented tracking data on chinstrap penguins from southern Powell Island in the South Orkney Islands during the austral summers of 2014 and 2016. The authors noted that the second season coincided with one of the largest El Niño events ever recorded. High-resolution global positioning system (GPS) data were used to characterise significantly longer foraging trips and more pelagic foraging behaviour in the latter season, contrasting strongly with more coastal shelf water foraging detected in 2014. Using in-situ collected weather data, the authors identified a signal of strong coastal downwelling that was temporally concurrent with the extension of foraging trips by individual penguins and suggested that this event likely displaced krill away from coastal areas into the open ocean which penguins subsequently followed. Remotely sensed climatology failed to resolve the same downwelling signal, and the authors cautioned using insufficiently resolved environmental covariates to explain predator foraging behaviour.

4.57 Some participants of the Working Group noted that there was a strong teleconnection between the south tropical Pacific Ocean and the west Antarctic Peninsula in the context of El Niño events, and it was noted that local-scale results presented in WG-EMM-18/P14 were detected at Area 48 scale in the CEMP CSIs (WG-EMM-18/44). The Working Group highlighted the need to take advantage of multiple datasets to better characterise the response of predators to such changes.

Other monitoring data

4.58 WG-EMM-18/02 described research conducted during New Zealand's 2018 voyage to the Ross Sea region, and gave notice of a second cruise in 2019. The 2018 cruise had seven objectives, and all were achieved. Four berths were allocated to international collaborators on the 2019 cruise. Colleagues are also invited to collaborate on post-cruise data analyses and interpretation. The draft objectives for the 2019 cruise are to:

(i) recover oceanographic and acoustic moorings deployed in 2018

(ii) undertake oceanographic and atmospheric observations of the Southern Ocean

(iii) study the structure and function of marine microbial planktonic communities in the Southern Ocean

(iv) survey benthic and demersal habitats and fauna of the southern Ross Sea shelf and slope

(v) carry out a demersal trawl survey of the Ross Sea slope to provide information relevant to estimating abundances and distributions of grenadiers and icefish

(vi) study the distribution and abundance of mesopelagic fishes and zooplankton in the Ross Sea region of the Southern Ocean.

4.59 The Working Group welcomed New Zealand's invitation for scientific collaboration during and after the 2019 cruise. Further details on cruise dates etc. are provided in Table 1.

Toothfish

4.60 SC-CAMLR-XXXVII/01 summarised outcomes from the Workshop for the Development of a *Dissostichus mawsoni* Population Hypothesis for Area 48 (WS-DmPH-18), which included development of three population hypotheses for Antarctic toothfish

(*Dissostichus mawsoni*) in Area 48 and recommendations for data collections and analyses that might resolve which hypothesis is most likely (also see Annex 7 for further discussion on outcomes from the WS-DmPH).

4.61 The Working Group noted that data collected during research and monitoring activities customarily considered within its agenda may be informative about stock hypotheses for *D. mawsoni* in Area 48. For example, toothfish eggs and larvae might be caught during the conduct of krill research (e.g. in under-ice trawls), and juvenile and adult toothfish might occur in the diets of seabirds and pinnipeds (e.g. macaroni penguins (*Eudyptes chrysolophus*) and Weddell seals (*Leptonychotes weddellii*)). Members were encouraged to report such observations to the Development of a *D. mawsoni* Population Hypothesis for Area 48 e-group for further consideration.

4.62 Mr D. Di Blasi (Italy) summarised plans for research on *D. mawsoni* in the Ross Sea region; Mr Di Blasi is a recipient of the CCAMLR scholarship. Mr Di Blasi and colleagues intend to further develop a non-extractive technique for studying *D. mawsoni* using baited underwater video cameras deployed through the sea-ice. The work will include application of a quantitative approach to estimating the local abundance of *D. mawsoni* from videos collected by a small array of such cameras. The proposed research demonstrates that non-extractive techniques can be used to study toothfish within the general protection zone (GPZ) of the RSRMPA. The research is being developed in the context of the RSRMPA RMP and will be further presented to WG-FSA.

4.63 Mr Di Blasi's research was welcomed, and the Working Group provided several suggestions for further developing his work. These suggestions mostly related to analysis and interpretation of the data that will be collected by the cameras and include accounting for tides, territorial 'guarding' of baits by large toothfish, and fish that may swim in and out of the field of view.

Cetaceans

4.64 WG-EMM-18/16 presented new results on the abundance and trends of Type B killer whales around the western Antarctic Peninsula. The authors used satellite telemetry to study movements and photo identification to estimate the abundances of Types B1 and B2 killer whales. Type B1 whales primarily forage on pinnipeds, and their range extends further south along the Peninsula than Type B2 whales, which are thought to forage on fish and penguins. Both ecotypes are coastally distributed, and individuals occasionally migrate to and from warmer subtropical waters. During the period from 2008/09 to 2013/14 the abundance of Type B1 killer whales was estimated to be stable with an average of about 50 whales (95% credible interval, 39–53). Type B2 whales were likely increasing in abundance during this period, with estimates ranging from 181 to 299 individuals coming from a larger population of about 502 (95% credible interval, 434–662).

4.65 The Working Group acknowledged the importance of the results in WG-EMM-18/16, which will be valuable for understanding trophic dynamics in the western Antarctic Peninsula. When considered in combination with results from WG-EMM-17/49 (which reported on the distribution and abundance of Type A killer whales that eat Antarctic minke whales (*Balaenoptera bonaerensis*) and southern elephant seals (*Mirounga leonina*) in the same region), it appears that the overall abundance of this suite of apex predators has recently increased along the Peninsula.

4.66 WG-EMM-18/18 reported on genetic analyses that aim to investigate the breeding-group provenance and individual identity of southern right whales distributed throughout the Indian Ocean sector during summer. This study was based on 157 biopsy samples collected during IWC and Japanese sighting surveys. The study assesses site-fidelity and sex-specific ranges of whales on the feeding grounds. The main findings were that southern right whales in the Indian Ocean sector have a genetic correlation with individuals from the southwest Australian calving ground. Both sexes returned to the same feeding area every year, but the longitudinal range used by females was smaller than that used by males. The authors are interested in investigating the diet of southern right whales in the Indian Ocean sector using stable isotope analysis in the near future.

4.67 WG-EMM-18/18 also provided a preliminary estimate of the abundance of southern right whales in the Indian Ocean sector using a genetic mark–recapture analysis and compared this to estimates from previously published sightings data. For the period from 1993/94 to 2007/08 the two methods indicate similar increasing trends, and the most recent abundance estimate from both approaches is similar, about 1 500 animals. The Working Group noted that the trends in abundance indicated in WG-EMM-18/18 are similar to those estimated on the calving grounds off southwest Australia.

4.68 WG-EMM-18/43 presented preliminary results on the distribution of fin whales around the northern Antarctic Peninsula. Results from line-transect surveys undertaken by the Brazilian Antarctic Program from 2013 to 2018 indicate that the species is mainly sighted near Elephant Island and in Bransfield Strait. The authors highlighted that data since 1998 are available and might be considered in further analyses. The paper was presented by Ms Seyboth, a recipient of the CCAMLR scholarship scheme for the 2018/19 term, who thanked Dr Watters (her mentor) and his team for their support and contributions to the analysis. She also acknowledged CCAMLR for the scholarship, which is allowing her to pursue this research and is also allowing her and other early career researchers to have enriching experiences while contributing to CCAMLR's needs.

4.69 Ms Seyboth also introduced WG-EMM-18/P15, which was recently submitted to the peer-reviewed literature. The main aim of the study was to analyse the correlation between the reproductive success of those humpback whales (*Megaptera novaeangliae*) from breeding stock G that use the southwest coast of Ecuador and krill biomass in feeding grounds around the northern Antarctic Peninsula using data from 2004 to 2010. A positive and significant cross-correlation with a one-year lag was found between an index of calf production and krill biomass, which may indicate that the food supply may affect either gestation or lactation of humpback whales reproducing off the coast of Ecuador.

4.70 The Working Group welcomed the paper. It was recommended that the authors weight the correlation by the inverse of the coefficients of variation in the krill density data. It was also noted that authors might consider whether data collected near Ecuador are representative of the breeding stock G as a whole. The same consideration should be given to the feeding area, as the authors focused on krill biomass data from Bransfield Strait and some individuals from breeding stock G may migrate to other feeding areas or even not migrate at all.

Climate change and associated research and monitoring

5.1 WG-EMM-18/14 summarised the objectives of the Australian-led initiative to produce a Marine Ecosystem Assessment for the Southern Ocean (MEASO), and provided a timetable to produce a first MEASO by June 2019. Initial discussions were held at a conference in Hobart, Australia, in April 2018. The organisers thanked participants, noting substantial input from members of CCAMLR working groups. They encouraged participation in the development of the first MEASO (by contacting measo2018@acecrc.org.au) and noted that while the geographical scope will be circumpolar, further aspects of its scope are under development.

5.2 The Working Group noted that MEASO aims to generate a useful assessment of ecosystem status given the resources available within the proposed timescale. MEASO might be a conduit by which the expertise of the wider scientific community can feed into the work of CCAMLR, especially by providing information on ecosystem status and trends.

5.3 WG-EMM-18/P02 described simulation modelling, using Foosa (Watters et al., 2013), to investigate how potential climate change impacts on krill growth (Hill et al., 2013) might affect populations of krill-dependent predators in Subareas 48.1 to 48.3, and whether stopping krill fishing can offset climate change impacts on predators. The projections suggested that the magnitudes of climate change impacts on predators are likely to vary between small-scale management units (SSMUs) and predator taxa, with penguins being the most strongly effected group, especially under severe warming (representative concentration pathway (RCP) 8.5). Although impacts on krill are likely to be most severe in Subarea 48.3, projected impacts on penguins also occurred in Subareas 48.1 and 48.2. Climate change impacts under RCP8.5 are likely to be more severe than the impacts of fishing alone. Nonetheless, cessation of fishing slightly reduced the projected overall impact on penguins. The authors concluded that targeted spatial controls on fishing might be necessary to protect vulnerable predation populations.

5.4 The Working Group recalled that penguins, as represented in the current Foosa parameters, have depensatory dynamics which tend to amplify perturbations (Watters et al., 2013; Hill and Matthews, 2013) and noted that care is needed in interpreting such projections. There may be other potential mechanisms by which climate change might influence krill availability to predators, such as by modifying aggregation characteristics. Nonetheless, a strength of the approach in WG-EMM-18/P02 is that it quantified the impact of a single clearly defined process, allowing the community to assess whether that process is likely to be an important influence that merits more investigation.

5.5 Dr Kasatkina noted that there has been a significant decline in macaroni penguin abundance from 3 million pairs in the 1980s to 1 million pairs in 2003 (Trathan et al., 2012). There was a substantial change in krill catch at South Georgia over this time period with catches greater than 100 000 tonnes in the early years and about 40 000 tonnes more recently. She pointed out that at the same time a number of marine mammal populations have recovered, or are beginning to recover. Therefore, competitive relationships between krill-dependent predators may be important mechanisms that influence penguin populations. Dr Kasatkina suggested that modelling considerations should include competitive relations, particularly as krill consumption by penguins and other krill predators is far greater than the annual krill catch in Subarea 48.3.

5.6 The Working Group noted that Foosa incorporates competitive interactions between predator groups and that such simulations are useful to the work of CCAMLR. The Foosa approach can be adapted to consider different spatial units and scales, and different groups of predators, for example by providing more resolution of penguin groups (WG-EMM-08/51). Other complementary approaches such as Ecosim can also be used.

5.7 WG-EMM-18/P17 provided a review of the energetic density of zooplankton and nekton species in the Southern Ocean based on a new publicly available database compiling the results of previous studies. Energy densities are mainly based on whole animals, including the exoskeleton. The authors noted that information on the seasonal and regional variability in energy densities is limited for most species but that such information is necessary for the improvement of bio-energetic and food-web models. The authors encouraged further contributions to the database.

5.8 The Working Group thanked the authors for this valuable resource and noted that forthcoming surveys may be useful for collecting samples to address some of the data gaps. The authors were encouraged to provide advice on the collection, storage and analysis of relevant samples.

5.9 WG-EMM-18/P19 provided a summary of knowledge about climate change impacts on Southern Ocean marine fisheries, as part of the Food and Agriculture Organization of the United Nations (FAO) global report on impacts of climate change on fisheries and aquaculture. The Southern Ocean is characterised by complex interactions between climate change and natural variability. While climate change may impact the productivity of fished stocks in the long term, there may be shorter-term effects on fishing effort distribution as a result of changes to sea-ice. Although there are no concerns about local livelihoods, the underexploited Antarctic krill fishery could be important for future global food security. The existence of CCAMLR and its approach, including ecosystem-based management and the development of a system of MPAs, provides a measure of institutional resilience to climate change.

5.10 WG-SAM-18/22 described an approach to monitoring and managing the effects of environmental change on toothfish assessments, which focuses on recording key parameters relevant to stock assessment and identifying trends in these parameters. While such trends may be related to the effects of environmental variability and change, demonstration of such relationships is not required for this understanding to be useful. The approach also identified some changes that may occur that may not be used in stock assessments, consideration may need to be given to how these may be monitored and effectively accounted for in management advice.

5.11 The Working Group noted that clear recommendations relating to this paper had been provided by WG-SAM in relation to toothfish (Annex 6, paragraph 3.4). In relation to krill, the Working Group noted that long-term change may alter the value of parameters and reference points including the krill B_0 and the 75% escapement reference point. There may be a need to consider alternative reference points that take account of changing productivity of the target stock. Reference points which update as parameter estimates change are being considered for toothfish and are already used in the International Council for the Exploration of the Sea (ICES).

5.12 WS-SM-18/05 discussed the use of reference areas to assess the impacts of the krill fishery. In addition, it also considered the physical properties of the environment and highlighted that glacial retreat is more limited towards the tip of the Antarctic Peninsula (Cook et al., 2005), which is also an area of Adélie penguin concentration. This area is strongly influenced by the outflow from the Weddell Sea. Ocean dynamics at the tip of the Peninsula are a major influence on ecological dynamics in the Bransfield Strait, where krill catches have become increasingly concentrated. Understanding large-scale processes is therefore important for understanding both krill and predator processes in the Bransfield Strait.

ICED Workshop

5.13 WG-EMM-18/09 provided a preliminary report of the Integrating Climate and Ecosystem Dynamics in the Southern Ocean (ICED)–CCAMLR Projections Workshop. The Workshop brought together ecologists, physical and ecological modellers, and fisheries scientists to consider the development of projections of the impacts of climate change on krill in Area 48, and to provide advice to enable CCAMLR to plan for, and adapt to, the consequences.

5.14 The Working Group agreed that the Workshop and associated work (including jointly developing questions of interest to CCAMLR that ICED was in a position to address) had been a valuable process.

5.15 The Working Group recognised that global analyses of climate change often include a range of alternative outcomes for the Southern Ocean. The Working Group discussed the specific suggestion from the Workshop that the position of the Polar Front is highly constrained and is not expected to change in the coming century, even under the highest emissions scenario. The importance of this point to CCAMLR was emphasised.

5.16 The Working Group noted that the report emphasised that the global models can provide general scenarios but do not resolve many key regional processes and require careful interpretation for particular regions such as Area 48. It was agreed that regional investigations, comparisons and development of high-resolution models would be valuable.

5.17 The Working Group acknowledged that the RCP2.5 and 8.5 pathways are projected to diverge, and that models suggest that clear signals of divergence (e.g. of sea-ice and sea-surface temperature) are unlikely to emerge from the overall variability of the models until around 2050. It was noted that this timescale is crucial for CCAMLR (2–3 decades). Attention was drawn to the proposed future SCAR Scientific Research Programme 'Near-term Variability and Prediction of the Antarctic Climate System'(AntClimnow). This proposed new program (currently awaiting endorsement from SCAR) will focus on near-term changes (from years to multiple decades). It was also noted that the next round of the Intergovernmental Panel on Climate Change (IPCC) assessment report (AR6) will produce the next generation of climate models (CMIP6), and as such it was emphasised that this work is ongoing and iterative.

5.18 The Working Group noted that the set of summary papers provided to the Workshop are a useful source of background information, particularly for Area 48. It agreed that it would be valuable to make these more widely accessible, and suggested that the Antarctic Environments Portal could be one possible mechanism for achieving this.

5.19 Information regarding variability and climate change in the Antarctic Peninsula region is highly relevant for planning, and for contributing to the D1MPA RMP. The broader scope for ICED and CCAMLR to work together on spatial management issues was also recognised (WS-SM-18/17).

5.20 The Working Group noted the next steps and looked forward to the outcomes of an iterative process developing models and collaborations. These include:

(i) an updated ICED–CCAMLR Projections Workshop report will be submitted to SC-CAMLR-XXXVII

(ii) the results will provide clear input to IPCC (for AR6, CMIP)

(iii) field and observational studies are required to improve knowledge of key processes

(iv) systematic improvement of krill and ecosystem models will be undertaken

(v) high-resolution regional models are needed for understanding processes and regional response.

5.21 The Working Group agreed that the engagement between ICED and CCAMLR on this activity has been successful and provides a good example of engaging broader expertise in CCAMLR's work (Annex 7, paragraphs 6.12 to 6.14). The potential for future joint activities was noted, and ICED encouraged suggestions and input from the Working Group.

SOOS

5.22 WG-EMM-18/P10 presented the vision for the Southern Ocean Observing System (SOOS). The Working Group noted Figure 2 in WG-EMM-18/P10 in particular with regard to the range of instruments that SOOS is intending to deploy to create an integrated network of Southern Ocean observations. The Working Group also recognised the potential for this information to inform CCAMLR work, including marine spatial management.

5.23 WG-EMM-18/P08 highlighted the SOOS West Antarctic Peninsula regional work (part of SOOS's circumpolar initiative).

5.24 WG-EMM-18/P06 proposed that CCAMLR build even stronger links with SOOS with regard to a hierarchical approach to monitoring.

5.25 The Working Group acknowledged the range of ongoing work by SOOS. It was agreed that integrating these efforts with CCAMLR's work would be valuable, including for RMPs for spatial management.

5.26 The Working Group recalled current interactions with SOOS, including the recent SOOS Synergies Workshop (SC-CAMLR-XXXVI, paragraph 10.17).

5.27 The Working Group discussed the potential for a two-way process regarding data collection, for example, equipment on fishing vessels as a potential source of data. Consideration should be given to how such data might be integrated and used, and how to facilitate this process. Indices of krill fishery performance and CEMP metrics might be of use to SOOS. CEMP data were discussed in the SOOS Synergies Workshop, particularly with regard to access to comprehensive metadata. Coordinated publication of CEMP data in the peer-reviewed literature would also be useful to inform SOOS.

Integration of VME data into broader spatial planning data analyses

Ecoregionalisation

6.1 WG-EMM-18/19 described a modelling approach that was used to build a benthic ecoregionalisation within the French exclusive economic zone (EEZ) of Division 58.5.1 using CCAMLR's vulnerable marine ecosystem (VME) indicator taxa. The Working Group noted that this was an extract from the article 'Benthic ecoregionalisation and conservation issues in the French Exclusive Economic Zone of Kerguelen' that has been submitted for publication to *Proceedings of the Second Symposium on Kerguelen Plateau Marine Ecosystems and Fisheries*.

6.2 The Working Group noted that there appeared to be commonalities between this approach and that described in WS-SM-18/P02, although the latter was used to characterise ecoregions of demersal finfish. Mr A. Martin (France) noted that initial comparisons between the modelling approaches yielded convergent patterns, although the statistical methodologies underpinning them were different.

6.3 The Working Group noted that increasing the number of taxa used to build ecoregionalisation using this method can result in less precise and low-resolution results, and that there were benefits in using reduced datasets with this approach. The Working Group agreed that it would be useful to compare this approach to that of MARXAN, and further explore the effect of restricting relevant data groups and how this may impact results.

6.4 WG-EMM-18/20 described an application of the data acquisition protocol for benthos by-catch in the French fisheries in Division 58.5.1 previously presented at WG-EMM-17 (SC-CAMLR-XXXVI, Annex 6, paragraphs 5.15 and 5.16). The methodology was used during the POKER 4 survey to sample specimens and significantly improve the characterisation of benthic invertebrate by-catch. This, coupled with the first use of cameras mounted on the bottom trawl in this division, allowed for more complete descriptions of invertebrate communities on the seabed, as well as substrates on the northern part of the Kerguelen Plateau.

6.5 The Working Group agreed that this was a valuable approach for direct comparison of benthic communities, seafloor substrate composition, and the by-catch of invertebrates in bottom trawls. Mr Martin indicated that further work in relation to invertebrate by-catch identification from the POKER 4 survey catches and video imagery was ongoing.

Proposals for additions to the CCAMLR VME registry

6.6 WG-EMM-18/35 characterised benthic invertebrate communities and VME taxa from a series of manned submersible dives along the northern Antarctic Peninsula and South Shetland Islands in Subarea 48.1. Five sites are proposed for inclusion in the CCAMLR VME registry in accordance with CM 22-06: three based on significant VME indicator taxa abundances, one based on high density and diversity of cold-water coral taxa, and one based on rare and unique populations. Also proposed are amendments to CCAMLR's *VME Taxa Classification Guide*.

6.7 The Working Group reviewed conservation measures in force relevant to the notification process for adding VMEs to the CCAMLR VME registry from fishery-independent research activities under CM 22-06, and agreed that the information set out in WG-EMM-18/35 was properly structured in accordance with CM 22-06, Annex 22-06/B. The Working Group noted that the authors made raw footage of all dive sites available for consideration by WG-EMM.

6.8 After reviewing the characteristics of VME indicator taxa at the five sites proposed for VME registration, the Working Group recommended that four of the five sites be added to the CCAMLR VME registry as 1 n mile radius circles centred on the following midpoint locations:

Latitude	Longitude	Location
63.3861°S	56.9146°W	Hope Bay, northern Antarctic Peninsula
63.3085°S	56.5364°W	Kinnes Cove, northern Antarctic Peninsula
63.9276°S	60.6225°W	Off Trinity Island
64.3004°S	62.0014°W	Off Lecointe Island

6.9 The Working Group reviewed the fifth VME proposed in WG-EMM-18/35 that was notified on the basis of rarity and uniqueness, located in Half Moon Bay near Livingston Island. The Working Group noted that the taxa described, a tube anemone (Ceriantharia (Hexacorallia)), was not currently part of the VME indicator taxa that had been adopted by the Scientific Committee based on the recommendations at the 2009 Workshop on Vulnerable Marine Ecosystems (WS-VME-09). Although the Working Group agreed that it demonstrated attributes consistent with rarity and uniqueness (one of the seven criteria that underpin VME indicator taxa), it agreed that a fuller consideration of this taxa should be undertaken, that it be assessed against all criteria (SC-CAMLR-XXVIII, Annex 10, paragraph 3.5), formally considered for addition as a VME indicator taxa, and that this notification be submitted again for consideration. The Working Group noted that the suggestion of adding Staurozoa (stalked jellyfishes) in WG-EMM-18/35 should undergo the same process as outlined for the addition of Ceriantharia.

6.10 WG-EMM-18/36 identified high densities of pennatulaceans (Phylum Cnidaria: Order Pennatulacea) encountered at three sites on the northeastern shelf of the South Orkney Islands (Subarea 48.2) from a recent Chilean bottom trawl survey (WG-SAM-18/25), submitted in accordance with CM 22-06, Annex 22-06/B.

6.11 The Working Group noted that the three sites are in close proximity to two other currently registered VMEs, one of which was based on high densities of pennatulaceans, and that this VME indicator taxa was likely the tallest of all groups, with specimens encountered >5 m in height.

6.12 After reviewing the information of the three sites proposed for VME registration, the Working Group recommended that they be added to the CCAMLR VME registry as 1 n mile radius circles centred on the following midpoint locations:

Latitude	Longitude	Location
60.4767°S	45.0950°W	Northeastern South Orkney Islands shelf
60.5425°S	44.8150°W	
60.6108°S	44.2625°W	

6.13 The Working Group considered the benefits of creating a larger precautionary buffer region around the three proposed new VMEs (similar to that of the VMEs in CM 22-09, and the scallop beds near Terra Nova Bay), given their close proximity to other currently registered VMEs in the region. The Working Group recommended that further consideration be given to the depth distribution of pennatulaceans, as this could inform an appropriately sized precautionary VME buffer region.

6.14 The height of these pennatulaceans, and the potential for krill trawls to disturb these communities was considered by the Working Group, as it was noted that there were instances where midwater krill trawling inadvertently catches benthic organisms although the krill fishing vessels try to avoid any contact of fishing gear with the seabed. The Working Group suggested exploring existing data, which could inform potential future advice on precautionary actions.

6.15 The Working Group acknowledged that although GPZs of MPAs would prevent disturbance of VMEs from commercial activities, there remains great value in having the locations of VMEs registered, as potential future research and monitoring activities would be aware of VMEs within MPAs. Further, the Working Group noted that registered VMEs do not expire.

Other business

SCAR Krill Action Group

7.1 WG-EMM-18/01 Rev. 1 provided an overview of the proposal to create a Scientific Committee on Antarctic Research (SCAR) Krill Action Group (SKAG) (SC-CAMLR-XXXVI, paragraphs 10.9 to 10.11). Prof. Meyer provided an update to the Working Group that SCAR had agreed to create this action group.

7.2 The Working Group welcomed this update and the creation of this action group that would provide a very useful conduit between the broader krill research community and CCAMLR and recognised that it also meant that krill would be considered by scientists in SCAR.

7.3 The Working Group noted that the SKAG would have its first meeting in the week following WG-EMM and encouraged the submission of a report of this meeting to the Scientific Committee.

Dronning Maud Land research

7.4 WG-EMM-18/13 provided an overview of planned research activities to be conducted by Norway in Dronning Maud Land, including research directed on Antarctic toothfish, krill and predators. Dr Lowther informed the Working Group that as part of this cruise, Norway also proposed to conduct research in the north of Subarea 48.6 near Bouvet Island and near the Antarctic Polar Front.

7.5 The Working Group welcomed this proposal, noting that relatively limited research had been conducted in this region, and looked forward to receiving the results from this in the future.

Indian research proposal

7.6 Dr S. Bal Raj (India) informed the Working Group that India was preparing to undertake research in the Indian Ocean sector on krill-based ecosystem processes in 2019 and that when plans were finalised there would be opportunities for collaboration. She invited interested scientists to contact her for further details.

7.7 The Working Group welcomed this news from India and looked forward to receiving further news about the Indian research program.

Proposal for an MPA in Argentine Islands

7.8 The work presented in WG-EMM-18/32 provided a comprehensive overview of research that Ukraine has developed in the Wilhelm Archipelago area, Antarctic Peninsula, including underwater and acoustic surveys, chemical analyses of bottom sediments and soils of nearshore areas. Importantly, Ukraine has been undertaking research on Adélie and gentoo penguins at the same area since 2003, including the establishment of remote cameras in 2016, as part of the CEMP camera network (WG-EMM-18/P13 and 18/26). In relation to this, the Working Group agreed that such studies contributed greatly to characterising potential climate change impacts across latitudinal clines.

7.9 The Working Group recalled the advice of Scientific Committee (SC-CAMLR-XXXVI, paragraphs 5.36 and 5.37) that it may be useful to coordinate spatial planning efforts around in the Wilhelm Archipelago area around the Argentine Islands with those efforts supporting development of the D1MPA. The Working Group encouraged the authors of WG-EMM-18/32 to work with the D1MPA Expert Group as this site could form one of the potential reference areas for assessing the effects of climate change on benthic communities and penguin populations and distribution, noting that the D1MPA proposal is a wider process.

Acoustic backscatter

7.10 WG-EMM-18/P06 and 18/P07 described the collection and modelling analysis of acoustic backscatter on latitudinal transects from New Zealand to the Ross Sea. The data were collected from a variety of vessels, including longline fishing vessels, and the results showed a decrease in deep mesopelagics with increasing latitude.

7.11 The Working Group welcomed these papers as together they demonstrated that quality scientific acoustic data could be collected from fishing vessels and how these data can be used to provide biologically useful information.

Interaction with the IWC

7.12 The Working Group recalled previous proposals for a Joint SC-CAMLR–IWC Workshop on multi-species models (SC-CAMLR-XXXV, paragraphs 10.16 to 10.18 and SC-CAMLR-XXXVI, paragraph 13.7). Dr Kawaguchi informed the Working Group that the steering group had been through a number of iterations and he recalled that the Scientific Committee had indicated that the proposal for a workshop should be considered in the context of demands and priorities of the Scientific Committee. The Working Group agreed that, based on the advice of the Scientific Committee, the priority for this workshop had been de-emphasised.

7.13 The Working Group noted the increase in discussion of cetacean research in its meeting this year, including through the CCAMLR scholarship scheme, and agreed that where there were areas of mutual interest with the IWC, including, for example, guidelines for cetacean surveys, that it was important to maintain a mechanism for interaction and engagement (see paragraph 3.32).

CEMP Special Fund

7.14 The Working Group noted the excellent progress made on research supported by the CEMP Special Fund (paragraphs 4.25 to 4.30).

7.15 Drs C. Cárdenas (Chile) and Santos (Co-Chairs of the CEMP Special Fund Management Committee) reported to the Working Group that the management group had undergone a large change of personnel and had been working on a revision to the terms of reference to clarify the application criteria, eligibility and reporting requirements associated with the CEMP Fund. They informed the Working Group that the revised terms of reference would be circulated to all Members.

7.16 The Working Group noted the success of the camera network supported by the CEMP Fund and suggested that the Scientific Committee consider a mechanism for ongoing funding to support camera refurbishment and battery replacement to maintain the network.

Future work

Future research cruises

8.1 The Working Group noted the large number of research cruises planned for 2018/19 that have objectives relating to krill and the pelagic ecosystem, across a wide geographic range within the Convention Area and collated these in Table 1.

Priorities and approaches for the Working Group

8.2 Dr Belchier noted the breadth of material that had been submitted for consideration by the Working Group but that in many cases it was not clear how the discussion contributed to the core work of CCAMLR or the priorities of the Scientific Committee. He further noted that one of the key roles of WG-EMM remains to provide advice to the Scientific Committee to manage the krill fishery and that is was important to ensure that this remained a core element of its role.

8.3 The Working Group recalled the discussion at WG-SAM on the priorities for its work (Annex 6, paragraphs 7.1 to 7.7) and noted in many of the generic issues faced by the two working groups were very similar. In particular, the Working Group agreed in general that:

(i) there was a lack of time to discuss issues in detail due to the large amount of material submitted to the Working Group

(ii) the current structure of the working groups may be limiting flexibility in the prioritisation of issues for which the Scientific Committee has requested advice

(iii) the use of workshops to consider specific items may be a more efficient mechanism to facilitate the attendance of subject matter experts

(iv) the relative status of workshops and working groups in providing advice to the Scientific Committee should be clarified, including the process and format for reporting and the implications for attendance by Members at multiple meetings.

8.4 The Working Group agreed that it was important to be inclusive but that time allocated to the consideration of items should be directed to issues relevant to CCAMLR's objectives and priorities and recognised that some issues that may be scientifically interesting in the context of Southern Ocean ecosystems might not be a priority for the Working Group.

8.5 The Working Group reviewed the establishing terms of reference www.ccamlr.org/node/74341 in which the Scientific Committee had requested the group to:

(i) assess status of krill

(ii) assess status and trends of dependent and related populations, including identification of information required to evaluate predator/prey/fisheries interactions and their relationships to environmental features

(iii) assess environmental features and trends which may influence abundance and distribution of harvested, dependent, related and/or depleted populations

(iv) identify, recommend and coordinate research necessary to obtain information on predator/prey/fisheries interactions, particularly those involving harvested, dependent, related and/or depleted populations

(v) liaise with WG-FSA on stock assessment related matters

(vi) develop further, coordinate the implementation of, and ensure continuity in CEMP

(vii) taking into account assessments and research carried out under terms of reference (i) to (v) above, develop management advice on status of Antarctic marine ecosystems and for management of krill fisheries in full accordance with Convention Article II.

8.6 The Working Group noted that, as indicated on the webpage that includes the terms of reference, addressing these terms of reference is the core work of WG-EMM which now includes providing advice on aspects of spatial protection, including MPAs and VMEs.

8.7 The Working Group agreed that overall the terms of reference remained appropriate and that, should the Scientific Committee undertake to review the terms of reference of its working groups, the following be taken into consideration:

(i) in term of reference (i) definition of krill stocks and regular advice on their status is vital for ensuring that CCAMLR can meet its objectives, especially in the context of climate change. The trigger level approach taken by CCAMLR means that the status of krill stocks at the large scale does not have to be assessed annually. The development of a krill assessment model that makes use of available data from small-scale surveys and length-frequency data from the fishery and from predator diet studies would also need to include a spatially explicit krill stock hypothesis

(ii) in term of reference (iv) coordination of research between Members has resulted in positive examples such as the CEMP camera network, but this term of reference could also refer to coordination with other bodies for which an engagement strategy should be developed

(iii) term of reference (v) refers only to WG-FSA and should be updated to include WG-SAM and SG-ASAM

(iv) in term of reference (vi) replace 'ensure' with 'promote' noting that the proposal for a review of CEMP would directly address this term of reference

(v) in the context of term of reference (vii) work on spatial management is not in the original terms of reference and only appears as commentary on the work that the group now undertakes, however, this topic has formed the majority of the advice to the Scientific Committee from WG-EMM in recent years.

8.8 The Convener of WS-SM-18 reported on discussions at WS-SM-18 on mechanisms to progress future work on spatial management, (Annex 7, paragraphs 6.6 to 6.8). The Working Group discussed possible mechanisms to enable spatial management issues to be considered, including the possible creation of a new working group or further spatial management workshop(s) and recommended that the Scientific Committee consider how such work should be progressed in the context of its other priorities.

Priorities for the next meeting

8.9 The Working Group discussed the priority issues for consideration in 2019 and requested that the Scientific Committee consider these when agreeing the priorities for its subsidiary meeting:

(i) The Working Group noted that in the five-year plan for the work of the Scientific Committee (SC-CAMLR-XXXVI/BG/40) the priority for WG-EMM in 2019 included (under the theme of Ecosystem-based management of Southern Ocean krill resources) using geospatial data and analysis to examine krill flux and spatial structure.

CM 51-07

(ii) The Working Group recalled that in CM 51-07 there was a requirement for the Scientific Committee to provide advice to the Commission on progress towards the development of the risk assessment framework, FBM and the spatial allocation of catch no later than the annual meeting in 2019 and that this conservation measure would need to be replaced or updated no later than the end of the 2020/21 fishing season.

(iii) Given this schedule, the Working Group agreed that the issue of risk assessment framework, FBM and the spatial allocation of catch should form a key part of the agenda of the Working Group in 2019.

Krill surveys

(iv) The Working Group noted that the five-year plan for the work of the Scientific Committee (SC-CAMLR-XXXVI/BG/40) also included a proposal for a joint workshop of SG-ASAM, WG-EMM and WG-SAM to develop acoustic survey methods and design to facilitate FBM.

(v) The Working Group noted that while the results of the large-scale survey in Area 48 being conducted in 2019 would contribute towards this work, the time between the end of the survey and the meeting of WG-EMM meant that it was unlikely that the full set of results from the survey would be available for consideration in 2019.

CEMP review

(vi) The Working Group noted the proposal for a review of CEMP (paragraphs 4.31 to 4.39).

Other workshops

8.10 Dr P. Trathan (UK) recalled the proposal to hold an intersessional workshop to advance technical discussions related to FBM (SC-CAMLR-XXXVI, paragraph 13.8) noting a planning meeting had been scheduled to develop the terms of reference.

Advice to Scientific Committee

9.1 The paragraphs containing the advice of the Working Group to the Scientific Committee are summarised below; these advice paragraphs should be considered along with the body of the report leading to the advice:

(i) changes to logbooks for krill fishery observers (paragraph 2.14)

(ii) advice on appropriate temporal scale of aggregation of the two-hourly catch reporting periods continuous trawl data (paragraph 2.53)

(iii) changes to the CEMP e-forms (paragraph 4.6)

(iv) recommendation for a review of the ecosystem monitoring requirement of CCAMLR (paragraphs 4.34 to 4.39)

(v) proposals for addition of eight sites be added to the CCAMLR VME registry (paragraphs 6.8 and 6.12)

(vi) consideration of the terms of reference of the Working Group (paragraph 8.7)

(vii) possible mechanisms to enable spatial management issues to be considered (paragraph 8.8)

(viii) priority issues for consideration by the Working Group in 2019 (paragraph 8.9).

Close of meeting

10.1 Dr Belchier thanked all participants for their perseverance and engagement in the meeting that had made his position as temporary Convener very enjoyable. He particularly thanked the Secretariat, both at the meeting and in Hobart, and the local BAS hosts, in particular Dr Grant and Ms Pilvi Muschitiello, who had ensured the smooth running of the meeting.

10.2 On behalf of the Working Group, Dr Watters thanked Dr Belchier for stepping into the Convener role at such short notice and doing such an excellent job. Dr Jones also thanked Dr Belchier and thanked BAS for hosting the meetings.

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Table 1: Planned research cruises (noting that details may change) in the Convention Area during the 2018/19 season, with objectives relevant to the work of WG-EMM.

Subarea(s)	MPA planning domain(s)	Expedition/project	Vessel	Geographic focus	Members involved[1]	Summary/objectives (reference)	Gear type(s)	Dates
48.1	1	OPERANTARXXXVII/ Projects Interbiota, Baleias and Nautilus	*Alte. Maximiano* (Brazilian Navy)	Northern Antarctic Peninsula (Bransfield and Gerlache Straits, northwestern Weddell Sea – if the ice margin does not block our way to this last one)	Brazil	• Hydrography (CTD castings and seawater sampling: physical, chemical and biogeochemistry measurements) • Continuous CO_2 surface sampling and carbonate system parameters measurements • Phytoplankton sampling • Zooplankton sampling • Microplastic sampling • Line-transect cetacean survey • Whale biopsies • Fin whale tagging	• CTD Rosette • CPR (Continuous Plankton Recorder) • Manta net • Bongo net • Cross-bowls • Satellite transmitters	Jan 2019 (exact dates to be confirmed)
48.3	2	Western Core Box	*RRS Discovery*	South Georgia	UK	Annual marine ecosystem assessment (krill density, ocean acidification, plastic marine debris, carbon cycling)	• CTD, MOCNESS, MAMMOTH, RMT8+1, BONGO, possibly RMT25, EK60 (18, 38, 70, 120, 200, 333 kHz)	02/Jan/2019 – ~20/Jan/2019
48.4	2	South Sandwich Island krill survey	*RRS Discovery*	South Sandwich Islands	UK	Marine ecosystem assessment (krill density, plastic marine debris)	• CTD, MOCNESS, MAMMOTH, RMT8+1, BONGO, possibly RMT25, EK60 (18, 38, 70, 120, 200, 333 kHz)	21/Jan/2019 – 10/Feb/2019

(continued)

Table 1 (continued)

Subarea(s)	MPA planning domain(s)	Expedition/project	Vessel	Geographic focus	Members involved[1]	Summary/objectives (reference)	Gear type(s)	Dates
48.1, 48.2, 48.3, 48.4	1 and 2	Multinational large-scale krill synoptic survey in CCAMLR Area 48 and assay of ecosystem processes for the development of feedback management (FBM) of the krill fishery	• RV *Kronprins Haakon* (Norway) • FV *Cabo de Hornos* (Chile) • FV *Kwangjaho* (Korea) • FV *Fu Rong Hai* and FV *Long Teng* (China) • FV *More Sodruzhestva* (Ukraine)	Area 48	Norway Chile Korea China Ukraine UK South Africa USA Germany	1. Provide an indication of krill biomass at the larger scale 2. Consider the relationship between preferred fishery areas and the larger scale. 3. Ecosystem assessment of the marine environment essential for the development of the risk assessment, feed-back management (FBM) and spatial planning	• Trawl • Plankton nets • Moorings • CTD • ADCP • Acoustic sensors	Nov 2018–Mar 2019
48.6	3 and 4	ECOgaps survey cruise to inform spatial planning in CCAMLR	RV *Kronprins Haakon*	Astrid Ridge Fimbulisen (and the shelf area between) Maud Rise	Norway	Conduct a multidisciplinary survey across the trophic spectrum including benthic and pelagic biogeochemistry, oceanography and higher trophic ecology (WG-EMM-18/13)	• Acoustics, pelagic and benthic sampling, ROV, research fishing longlines	26/Feb/19 – 14/Apr/19
48.5 48.6	3 and 4	PS117	*Polarstern*	Weddell Sea	Germany	Hybrid Antarctic Float Observing System (HAFOS)	• ?	15/Dec/18 – 07/Feb/19
48.5	3	PS118	*Polarstern*	Weddell Sea	Germany	Larsen ice-shelf region bathymetry, ecology	• Hydrosweep, ROV, misc	09/Feb/19 – 10/Apr/19

(continued)

Table 1 (continued)

Subarea(s)	MPA planning domain(s)	Expedition/project	Vessel	Geographic focus	Members involved[1]	Summary/objectives (reference)	Gear type(s)	Dates
58.4.1	7	Dedicated krill survey for CCAMLR Division 58.4.1 during 2018/19 season by the Japanese survey vessel, *Kaiyo-maru*	RV *Kaiyo-maru*	Full longitudinal range of 58.4.1 (80°E–150°E) to the south of 63°S	Japan China EU USA	1) Estimation of krill biomass to update B_0 in Division 58.4.1 based on the CCAMLR standard method 2) Oceanographic observations in Division 58.4.1 to detect long-term changes if any 3) Multidisciplinary approach to elucidate current state of the ecosystem in the Division (SG-ASAM-18/02, SG-ASAM-18/05 and WG-EMM-18/17)	• Quantitative echosounder (EK80 with 38, 70, 120 and 200 kHz) • SADCP (Ocean Surveyor with 38 kHz) • LADCP (Ocean Surveyor with 300 kHz) • RMT1+8 for meso- and microzooplankton • SUIT for meso- and microzooplankton • Small ringed net for mesozooplankton • CTD (Seabird with various sensors) • Water sampling for biological, chemical and physical oceanographic studies • XCTD	12/Dec – 11/Jan (Leg 1) 26/Jan – 25/Feb (Leg 2)

(continued)

Table 1 (continued)

Subarea(s)	MPA planning domain(s)	Expedition/project	Vessel	Geographic focus	Members involved[1]	Summary/objectives (reference)	Gear type(s)	Dates
							• Free drifting float/buoys (Argo floats, DeepNinja, DeepApex and SOCCOM floats, and CO_2 buoy) • Multi-Excitation Fluorometer • Opportunistic sighting survey (marine mammals, seabirds and surface swarm of krill) • Video recording of behaviour of biological organisms using drifting camera, drop camera and drone	

(continued)

Table 1 (continued)

Subarea(s)	MPA planning domain(s)	Expedition/project	Vessel	Geographic focus	Members involved[1]	Summary/objectives (reference)	Gear type(s)	Dates
58.5.1 58.4.4b 58.5.1 58.5.2 58.6	5 and 6	OBSAUSTRAL with 4 scientific programs REPCCOAI (Réponses de l'Écosystème Pélagique aux Changements Climatiques dans l'Océan Austral – Indien) THEMISTO (Towards Hydroacoustics and Ecology of mid-trophic levels in Indian and Southern Ocean) OISO (Océan Indien Service d'Observation) OHASISBIO (Observatoire hydroacoustique de la sismicité et de la biodiversité)	*Marion Dufresne*	From the subtropical to the Antarctic waters (56°S) and from Crozet to Kerguelen and St Paul and New Amsterdam	France	• Oceanography and biogeochemistry including pCO2 • Continuous acoustics measurements (plankton and micronekton) • Biogeography of plankton (mesozooplankton, macroplankton) and micronekton (mesopelagic fish) • Ecophysiology of different euphausiids species (stress towards temperatures) • Acoustics moorings for seismicity and biodiversity (cetaceans)	• CTD, NISKIN bottles, continuous surface measurements, acoustics, WP2, IKMT, CPR, acoustic moorings (seismicity and whales)	5/Jan/19 to 15/Feb/19

(continued)

Table 1 (continued)

Subarea(s)	MPA planning domain(s)	Expedition/project	Vessel	Geographic focus	Members involved[1]	Summary/objectives (reference)	Gear type(s)	Dates
58.6	5	Prince Edward Islands summer survey 2019	SA *Agulhas 2*	Prince Edward Islands	South Africa (others to be confirmed)	1) Survey of top predators (seals and seabirds) at the island 2) Survey of the terrestrial biodiversity of the island 3) Undertake oceanographic and atmospheric observations 4) Study the structure and function of marine planktonic communities	• PTTs and helicopters • CTDs • Full-depth CTD casts and vertical Multinet (type Midi)	Oct/Nov 2019
88.1 58.4.1	7 and 8	The availability of Antarctic krill to large predators and their role in biogeochemical recycling in the Southern Ocean.	RV *Investigator*	South of 60°S, northward of the ice edge, and between 140°E and 175°W	Australia, UK, USA, Germany, South Africa, Argentina, New Zealand, China	• Explore relationship between Antarctic blue whales and krill swarms • Use passive acoustics to track and locate Antarctic blue whales • Study the distribution and density, and 3D structure of krill swarms • Study iron-fertilisation by whales and relationships to krill • Parameterise distance functions for passive acoustic monitoring of Antarctic blue whales	• Difar sonobuoys to detect and track Antarctic blue whales • Acoustic Recording Package + Simrad wide-band autonomous transceiver mooring • Visual observations for cetaceans (including 7 × 50 and 25 × 150 binoculars) • Cetacean photo-ID and PAXARMS biopsy	19/Jan – 5/Mar 2019

(continued)

Table 1 (continued)

Subarea(s)	MPA planning domain(s)	Expedition/project	Vessel	Geographic focus	Members involved[1]	Summary/objectives (reference)	Gear type(s)	Dates
							• Video-tracking of whales • UAS for whale photo-ID, body condition and behaviour • EK60 (calibrated), ME70 and SE90 echosounders • RMT 1+8 trawls for target trawls and live animal collection • CTDs and trace metal rosette ops to examine Fe availability, microbial production and biogenic climate gases	
88.1	8	Tangaroa Marine Environment and Ecosystem Project 2019	RV *Tangaroa*	Scott C Seamount Iselin Bank Ross Sea slope (within MPA SRZ and eastern GPZ(i)) Cape Adare	New Zealand 4 berths made available to scientists from other nations.	1) Recover oceanographic and acoustic moorings deployed in 2018 2) Undertake oceanographic and atmospheric observations	• Oceanographic moorings • Active acoustic moorings • Passive acoustic moorings • Multibeam echosounder • Underwater imagery	4/Jan – 17/Feb 2019

(continued)

Table 1 (continued)

Subarea(s)	MPA planning domain(s)	Expedition/project	Vessel	Geographic focus	Members involved[1]	Summary/objectives (reference)	Gear type(s)	Dates
						3) Study the structure and function of marine microbial planktonic communities 4) Survey benthic and demersal habitats and fauna of the southern Ross Sea shelf and slope 5) Carry out a demersal trawl survey of the Ross Sea slope to provide information relevant to estimating abundances and distributions of grenadiers and icefish. 6) Study the distribution and abundance of mesopelagic fishes and zooplankton in the Ross Sea region. WG-EMM-18/02	• Benthic and demersal trawl • MOCNESS for mesozooplankton • Midwater trawl for macro-zooplankton and mesopelagic fish • Water sampling, oceanographic and atmospheric measurements	

(continued)

Table 1 (continued)

Subarea(s)	MPA planning domain(s)	Expedition/project	Vessel	Geographic focus	Members involved[1]	Summary/objectives (reference)	Gear type(s)	Dates
88.1	8	Ecosystem structure and function of marine protected area in Antarctica (2017–2022)	RV *Araon*	Victoria Land Coast, Ross Sea (within MPA GPZ(i))	Korea	SC-CAMLR-XXXVI/BG/17 1. Biodiversity and species inventory 2. Spatial distribution of krill and mesozooplankton community 3. Food web structure and trophic level 4. Oceanographical observation	• Bongo net, Hamburg Plankton Net	5–30/Jan 2019

1 Participation of scientists from Members may not necessarily indicate Member endorsement of cruise.

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(Cambridge, United Kingdom, 9 to 13 July 2018)

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Appendix B

Agenda

Working Group on Ecosystem Monitoring and Management
(Cambridge, United Kingdom, 9 to 13 July 2018)

1. Introduction
   - 1.1 Opening of the meeting
   - 1.2 Adoption of the agenda and appointment of rapporteurs, establishment of ad hoc subgroups if necessary

2. Ecosystem impact of the krill fishery
   - 2.1 Fishing activities
   - 2.2 Scientific observation
   - 2.3 Krill biology, ecology and population dynamics
     - 2.3.1 Krill life-history parameters
     - 2.3.2 CPUE and spatial dynamics

3. Data layers from the krill fishery
   - 3.1 Fishing vessel surveys

4. Ecosystem monitoring and observation
   - 4.1 CEMP data
     - 4.1.1 Ecological interactions: predators
   - 4.2 Other monitoring data

5. Climate change and associated research and monitoring
   - 5.1 ICED Workshop
   - 5.2 SOOS

6. Integration of VME data into broader spatial planning data analyses

7. Other business
   - 7.1 CEMP Special Fund

8. Future work

9. Advice to the Scientific Committee and its working groups

10. Adoption of the report and close of the meeting.

Appendix C

List of Documents

Working Group on Ecosystem Monitoring and Management
(Cambridge, United Kingdom9 to 13 July 2018)

WG-EMM-18/01 Rev. 1	Proposal for a New SCAR KRILL Action Group B. Meyer, A. Brierley, S. Kawaguchi, C. Reiss and S. Nicol
WG-EMM-18/02	New Zealand research voyages to the Ross Sea region in 2018 and 2019 D. Bowden, R. O'Driscoll and M.H. Pinkerton
WG-EMM-18/03	Foraging patterns in the Antarctic Shag *Phalacrocorax bransfieldensis* at Harmony Point, Antarctica R. Casaux and M.L. Bertolin
WG-EMM-18/04	Diet overlap among top predators at the South Orkney Islands, Antarctica M.L. Bertolin and R. Casaux
WG-EMM-18/05	On the very high likelihood of bycatch of ice krill (*Euphausia crystallorophias*) in the present-day fishery for Antarctic krill (*E. superba*) A.S. Brierley and R. Proud
WG-EMM-18/06	Modelling Movement of Antarctic Krill (MMAK): the importance of retention, dispersal and behaviour for krill distribution – a project update S.E. Thorpe, E.F. Young, E.J. Murphy, O.R. Godø and A.H.H. Renner
WG-EMM-18/07	Improving mechanistic understanding between larval krill, krill recruitment, and sea ice B. Meyer and S. Kawaguchi
WG-EMM-18/08	Development of methods relevant to feedback management (FBM) for the krill fishery B.A. Krafft, A. Lowther, G. Macaulay, M. Chierici, M. Biuw, A. Renner, T.A. Klevjer, R. Øyerhamn, C.A. Cárdenas, J. Arata, A. Makhado, C. Reiss and O.A. Bergstad
WG-EMM-18/09	Integrating Climate and Ecosystem Dynamics in the Southern Ocean (ICED) programme: Preliminary report of the ICED–CCAMLR Projections Workshop, 5 to 7 April 2018 E.J. Murphy, N.M. Johnston, S.P. Corney and K. Reid

WG-EMM-18/10	Consumption estimates for male Antarctic fur seals at the South Orkney Islands during the post mating migration I. Staniland and S. Hill
WG-EMM-18/11	Update: Rapid unsupervised automated krill density estimation from fishing vessels (RAPID-KRILL) S. Fielding, A. Ariza, R. Blackwell, G. Skaret and X. Wang
WG-EMM-18/12	Acoustic manual for the krill synoptic survey in 2019 G. Macaulay, G. Skaret, T. Knutsen, O.A. Bergstad and B.A. Krafft
WG-EMM-18/13	Filling knowledge gaps east in Dronning Maud Land to inform MPA planning by CCAMLR (ECOgaps): Norwegian cruise to DML 2019 H. Steen, A. Lowther and O.A. Bergstad
WG-EMM-18/14	Marine Ecosystem Assessment for the Southern Ocean – Brief Report, June 2018 A. Constable
WG-EMM-18/15	"Sailbuoy for krill" – a concept for autonomous commercial and scientific monitoring of the krill fishing in Antarctica O.R. Godø, G. Pedersen, D. Peddie, G. Skaret, A. Lowther, F. Grebstad and A. Lohrmann
WG-EMM-18/16	Abundance and trends of Type B killer whales (*Orcinus orca*) around the western Antarctic Peninsula H. Fearnbach, J.W. Durban, D.K. Ellifrit and R.L. Pitman
WG-EMM-18/17	Revised proposal for a dedicated krill survey for CCAMLR Division 58.4.1 during 2018/19 season by the Japanese survey vessel, *Kaiyo-maru* H. Murase, K. Abe, R. Matsukura, H. Sasaki, T. Ichii and H. Morita
WG-EMM-18/18	Population identity, site-fidelity, movement ranges and preliminary estimates of abundance of southern right whales in the Antarctic Indian sector inferred from genetic markers L.A Pastene, M. Goto, P. Acuña, M. Taguchi, T. Hakamada and K. Matsuoka
WG-EMM-18/19	CCAMLR's Vulnerable Marine Ecosystems bioindicator taxa: a relevant tool for benthic ecoregionalisation A. Martin, E. Trouslard, M. Hautecoeur, J. Blettery, C. Moreau, T. Saucède, N. Améziane, G. Duhamel and M. Eléaume

WG-EMM-18/20	Benthos by-catch study and benthic cameras deployment during the Poker 4 fish biomass survey for habitat characterisation in the Kerguelen Plateau A. Martin, J. Blettery, N. Améziane and M. Eléaume
WG-EMM-18/21	Features of spatial and temporally distribution patterns of krill flux in the Scotia Sea: some comments on the development of a krill fishery management in Area 48 S. Kasatkina, V. Shnar and A. Malyshko
WG-EMM-18/22	Uncertainty in reported geographical distribution and weight of krill catches from Norwegian krill fishing vessels operating continuous fishing systems G. Skaret, T. Knutsen, F. Grebstad and O.A. Bergstad
WG-EMM-18/23	Protocols for trawl sampling, recording of biological data, and hydrography for the 2019 International synoptic krill survey in Area 48 T. Knutsen, B. Krafft, A. Renner, G. Skaret, G.J. Macaulay and O.A. Bergstad
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WG-EMM-18/25	*Pygoscelis* penguin colonies census in the Vernadsky Antarctic station area (Statistical Subarea 48.1) V.M. Smagol, A.O. Dzhulay, I.V. Dykyy and G.P. Milinevsky
WG-EMM-18/26	CEMP cameras data validation experiment at the Galindez Island gentoo penguins (*Pygoscelis papua*) colonies A. Dzhulay, V. Smagol, G. Milinevsky, I. Dykyy, A. Simon, M. Telipska, E. Dykyy and L. Pshenichnov
WG-EMM-18/27	Considerations for CEMP data collection and submission in relation to using nest cameras to monitor surface-nesting colonial seabirds L. Emmerson and C. Southwell
WG-EMM-18/28	Update on software development for analysing nest camera images through the CEMP Special Fund C. Southwell, H. Achurch, J. Cusick, A. Lashko, K. Newbery, A. Sikka and L. Emmerson

WG-EMM-18/29	Adélie penguin diet: a pilot study directly comparing data from stomach flushing with faecal DNA analysis B. Deagle, J. McInnes, L. Emmerson, M. Dunn, S. Adlard and C. Waluda
WG-EMM-18/30	Genetic identification of fish caught as by-catch in the Antarctic krill fishery and comparison with observer records A. Polanowski, J. Clark, D. Maschette, D. Welsford and B. Deagle
WG-EMM-18/31	Are we there yet? Evaluating and reporting progress towards a Representative System of Marine Protected Area across the CAMLR Convention Area D.C. Welsford
WG-EMM-18/32	Next steps in development of Marine Protected Area in the Argentine Islands Archipelago water area A. Utevsky, E. Sinna, D. Smyrov, M. Shrestha, Y. Gamulya, G. Ukhno, R. Khodzhaeva, Y. Utevsky, V. Levenets and S. Utevsky
WG-EMM-18/33	Approaches to data collection and analysis for detecting and quantifying functional overlap at the scale of the individual vessel M. Söffker and N. Gasco
WG-EMM-18/34	Characteristics of interannual variation in aggregation and diurnal vertical migration of Antarctic krill at South Georgia during winter T. Ichii, Y. Mori, P.N. Trathan, K. Mahapatra, M. Okazaki, T. Hayashi and T. Okuda
WG-EMM-18/35	Evidence of Vulnerable Marine Ecosystems documented via submarine in the Antarctic Sound and Gerlache Strait (Subarea 48.1) S. Lockhart and J. Hocevar
WG-EMM-18/36	High densities of pennatulaceans (sea pens) encountered at sites in the South Orkney Islands (Subarea 48.2): three potential Vulnerable Marine Ecosystems C.D. Jones
WG-EMM-18/37	An ecological risk assessment of current conservation measures for krill fishing in East Antarctica (CCAMLR Divisions 58.4.1 and 58.4.2) N. Kelly, L. Emmerson, S. Kawaguchi, C. Southwell and D. Welsford

WG-EMM-18/38	Application of aerial photography for ecological survey and habitat management of Adélie penguins J.-H. Kim, H.-C. Kim, J.-I. Kim, C.-U. Hyun, J.-W. Jung, Y.-S. Kim, H. Chung and H.C. Shin
WG-EMM-18/39	A revised Krill Trawl logbook for the 2019 season Secretariat
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WG-EMM-18/41	Spatio-temporal dynamics of the Antarctic krill fishery in Subarea 48.1 based on data collected on board FV *Fu Rong Hai* Y. Ying, X. Wang, X. Zhao, J. Zhu, G. Fan and X. Yu
WG-EMM-18/42	Spatial distribution and swarm characteristics of Antarctic krill around the South Shetland Islands X. Yu, X. Wang and X. Zhao
WG-EMM-18/43	Preliminary results on the distribution of fin whales on the northern Antarctic Peninsula E. Seyboth, L. Dalla Rosa, G. Watters and E.R. Secchi
WG-EMM-18/44	CEMP data inventory/summary and updated spatial analysis of Area 48 Secretariat
WG-EMM-18/45	Krill Spill: An opportunistic approach to collecting penguin diet and krill length data E. Grilly, M. Santos, K. Reid and A. Silvestro
WG-EMM-18/46	Proposed updates to CEMP data e-forms and a review of CEMP Standard Methods Secretariat

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WG-SAM-18/22	Monitoring and managing the effects of environmental change on toothfish assessments M. Pinkerton, A. Dunn, S. Mormede and S. Parker
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WS-SM-18/05	An experimental approach for the Antarctic krill fishery: advancing management and conservation through the use of Krill Reference Areas and Krill Fishing Areas P.N Trathan and O.R. Godø
WS-SM-18/06	Hierarchical monitoring plans to determine patterns of change in the Antarctic Marine Ecosystem P. Trathan
SC-CAMLR-XXXVII/06	Report of the Meeting of the Subgroup on Acoustic Survey and Analysis Methods (Punta Arenas, Chile, 30 April to 4 May 2018)

Annex 9

Report of the Working Group on Fish Stock Assessment
(Hobart, Australia, 8 to 19 October 2018)

Contents

Report of the Working Group on Fish Stock Assessment
(Hobart, Australia, 8 to 19 October 2018)

Opening of the meeting

1.1 The meeting of WG-FSA was held in Hobart, Australia, from 8 to 19 October 2018. 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 seeing the outcomes of the meeting being presented to the Scientific Committee and 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 (UK), C. Darby (UK), K. Demianenko (Ukraine), M. Doyle (Secretariat), A. Dunn (New Zealand), J. Fenaughty (New Zealand), I. Forster (Secretariat), N. Gasco (France), E. Grilly (Secretariat), P. Hollyman (UK), C. Jones (USA), D. Maschette (Australia), S. Mormede (New Zealand), S. Parker (New Zealand), C. Péron (France), K. Reid (Secretariat), G. Robson (UK), R. Sarralde (Spain), S. Somhlaba (South Africa), S. Thanassekos (Secretariat) and P. Ziegler (Australia).

Review of data available

Illegal, unreported and unregulated (IUU) fishing activity

2.1 The Secretariat presented an update on illegal, unreported and unregulated (IUU) fishing activity and trends in 2017/18 (CCAMLR-XXXVII/12) and highlighted that there were no reports of IUU vessel sightings in the Convention Area in 2017/18 and there were only three reports of gear recovered by Members. The Working Group agreed that, while the trend in IUU vessel sightings in the Convention Area (Figure 1) is a very welcome indication of a decline in IUU fishing activity, it noted that, with the information currently provided to the Secretariat, it is not possible to be definitive as the trend is not corrected for changes in surveillance effort.

2.2 With respect to the three reports of unidentified gear reported by Members, the Working Group noted that:

(i) the gillnet recovered from research block 486_3 was from the same location as previously recovered gillnet and may be the legacy of previous IUU fishing, rather than reflecting ongoing IUU fishing in 2017/18

(ii) the Spanish longline reported in Division 58.4.2 was described as having encrusting organisms attached which is potentially consistent with it being lost in the 2008–2010 period when Spanish longline gear was last used in the regulated fishery in the division

(iii) the description of the state of the gear recovered in Subarea 88.1 in November 2017 indicated that it had been deployed within five days of the recovery suggesting that fishing had occurred immediately prior to the start of the fishing season.

2.3 The Working Group highlighted that fishing prior to the start of the fishing season would negatively affect the ability to manage the fishery sustainably and would also have a negative impact on the collection of data required for the assessment for this fishery and considered that the particular circumstances of this gear recovered should be considered by the Standing Committee on Implementation and Compliance (SCIC).

2.4 The Working Group also considered an analysis of IUU fishing activities in Division 58.4.1 during 2013/14 and in Division 58.4.3b during 2014/15 (paragraphs 4.93 to 4.97).

Catches in the current season

2.5 The Secretariat presented SC-CAMLR-XXXVII/BG/01 Rev. 2 that provided an update on catches in 2017/18 up to 30 September 2018. This paper also included a map of the Convention Area showing all areas for which a catch limit is in place.

2.6 The Working Group noted a number of areas/subareas where the proportion of the catch limit taken was low or zero (SC-CAMLR-XXXVII/BG/01 Rev. 2, Table 3) and requested an indication from Members of intention to fish in the periods between WG-FSA and the end of the season which would assist in the provision of advice and the review of ongoing research fishing.

2.7 The Working Group thanked the Secretariat for this update and noted that while closure notices were issued for fisheries in Subareas 88.1 and 88.2, the Secretariat had worked collaboratively with Members and vessels engaged in fisheries in other areas to ensure that the catch limits were not exceeded without the necessity of issuing a closure notice.

2.8 The Working Group requested that SC-CAMLR-XXXVII/BG/01 Rev. 1, Figure 1, be revised to indicate those areas where catch limits are set using an integrated assessment and to show existing and proposed research blocks (the revised figure is included as Figure 2 of this report).

Data management

2.9 The Executive Secretary described the proposed Secretariat Strategic Plan (CCAMLR-XXXVII/06) in which data management was identified as a key theme. He explained that to strengthen data management across the entire Secretariat, the staffing strategy accompanying the Strategic Plan included the recruitment of three new data management related positions (one each in the Science, Fishery Monitoring and Compliance and Information Systems and Data Services (ISDS) sections).

2.10 Mr T. Jones (Secretariat) provided an update on the project to develop a CCAMLR data warehouse that would consist of a set of database tables that have had a rigorous process around how they have been produced from source data, would have a stable, well-defined database infrastructure and would provide consistent, quality-assured and well-documented data. He indicated that the first phase of the project would focus on catch and effort, tagging and recapture data and length data, and would be overseen by a steering committee including section managers in the Secretariat and representatives from the Data Management Group (DMG). The Working Group was informed that elements of the data warehouse will be available by WG-FSA-19.

Data Management Group

2.11 The Working Group discussed the role on the DMG in progressing data-related issues. To support the work of the DMG, the Working Group developed a summary of its priorities for consideration by the DMG (Table 1). The Working Group further considered how engagement from the Working Group with the DMG could be improved and asked the Scientific Committee to consider ways in which continuity and information exchange between the DMG and the Scientific Committee working groups could be enhanced. The Working Group recalled that the membership of the DMG was by nomination by Scientific Committee Representatives and requested that the DMG e-group be visible to all authorised users of the CCAMLR website.

C2 form design

2.12 The Working Group noted the following issues with the current C2 form that were highlighted in WG-FSA-18/29:

(i) only one conversion factor per processing type per species, and three conversion factors per haul can be reported. This can be insufficient for fisheries where both *Dissostichus* spp. are caught, or for vessels which use separate conversion factors for different fish size classes

(ii) the inclusion of processed weight would improve evaluation of how green weights are calculated using reported conversion factors

(iii) fate descriptions do not include ‘retained for later discard’. This can cause issues with reconciling landed catch as the fate can only be currently reported as retained

(iv) the form requires modification by the vessel if more than six species are landed from a single haul, which increases the complexity of the form.

2.13 The Working Group agreed that resolving the highlighted issues would improve data quality and assist in reconciliation between landings reported in the Catch Documentation Scheme for *Dissostichus* spp. (CDS) data by product type.

2.14 The Working Group agreed that potential modifications to the C2 form may allow vessels to submit a single catch report using a new C2 form, rather than the current requirements of submitting a catch and effort report aggregated by time (either daily, five-daily or 10-daily) and haul-by-haul data (C2 form) at different reporting frequencies. The submission of a single form would reduce reporting complexity for vessels, avoid transcription errors and result in higher-resolution data being available sooner for many fisheries.

2.15 The Working Group reflected that prior to any modifications to the C2 form it was important to understand how vessels and Members completed the current forms operationally to ensure that any additional issues could be identified and to allow for ease of data transfer between vessel systems and any updates to the C2 form.

2.16 The Working Group emphasised the importance of clear instructions to vessels on how to complete the both the C2 and catch and effort forms, to ensure consistency of data reported between vessels.

2.17 The Working Group recognised that in addition to considerations of the C2 form, several other vessel operational issues had been raised in recent years e.g. data collection, e-monitoring, tagging performance and by-catch reporting, and noted that a workshop focussed on these issues, attended by a range of stakeholders including those who complete catch reporting forms on the vessels, would be beneficial.

2.18 The Working Group therefore recommended:

(i) the Secretariat initiate a consultation with all Members on how vessels record catch data, and if any issues are encountered using the current C forms, with deadline for comments by 15 March 2019

(ii) following the results of the consultation, the Secretariat will undertake a revision of the C2 form and present this through the Data Forms e-group for consideration and potential trial by Members. Results from this process will be presented to WG-FSA-19

(iii) the development of a commercial data manual by the Secretariat with clear instructions on how to achieve vessel reporting requirements using CCAMLR forms

(iv) the formation of a list of fishery data coordinators (analogous to the Scheme of International Scientific Observation (SISO) technical coordinators) to facilitate easier communication between the Secretariat and Members on vessel data issues

(v) the Scientific Committee consider holding a focussed fishing data workshop, similar to the SISO Workshop in 2017 (SC-CAMLR-XXXVI/08) attended by a range of stakeholders including those who complete catch reporting forms on the vessels, to review fishery data submission issues that have been raised in working groups

(vi) the same introduction schedule as agreed for new observer forms be applied to any new fishery data forms to allow adequate time for training and testing

(vii) clarification be provided by SCIC on how hauls that are incomplete at the end of a reporting period should be recorded in C forms.

Procedures for the use of catch and effort data in fishery management

2.19 The Working Group noted the proposal from the Secretariat on a revised approach for catch and effort monitoring, and the calculation of closure dates for the 2018/19 season in the Ross Sea (WG-FSA-18/07). The paper described a two-stage decision process that uses all available data to manage exploratory longlining in a way that provides timely updates to Members and issues closure notices according to the catch limits in place.

2.20 The Working Group agreed that the approach described in WG-FSA-18/07 would accommodate situations where the catch limit in place might be exceeded prior to sufficient catch and effort data becoming available from the fishery with which the Secretariat can advise a closure date in accordance with Conservation Measure (CM) 31-02, paragraph 2. In addition, the Working Group noted that the within season forecast process described in WG-FSA-18/07 had been used in 2017/18 to close the fishery in Subarea 88.1 south of 70°S where the catch reached 99% of the catch limit.

2.21 The Working Group recalled that the overall catch limit in CM 41-09 was based on the Ross Sea region stock assessment and that the separate area catch limits in that conservation measure are designed to create a spatial distribution of the fishery relative the distribution of the stock in the assessed area. The Working Group requested that the Scientific Committee consider the proposed amendment to CM 41-09, described in WG-FSA-18/07, as a means to achieve the aim of not exceeding the overall catch limit and the required distribution of fishing effort in a way that balances the impact of both under- and over-runs in the area north of 70°S.

2.22 The Working Group agreed that where the total potential catch of the vessels in a fishery exceeds the catch available, then this over-capacity has the potential to compromise any forecasting approach. In a management framework where such situations arise, there is the potential for this to cause a change in the behaviour of the fishery that could potentially impact on the time series of data used in assessments.

2.23 The Working Group noted that testing the algorithm for early season closure, using historic catch data for vessels in the area of the fishery immediately prior to the start of the fishery, was restricted by the requirement of CM 10-04, Annex 10-04/B, paragraph 3.6 to de-identify vessels in the vessel monitoring system (VMS) data. The Working Group agreed that this requirement may unintentionally restrict scientific analyses and requested that the ongoing need for this requirement be reviewed by the Commission (Appendix D).

2.24 The Working Group agreed that for the purpose of CM 23-07, paragraph 1, any vessel that is licenced and notified to participate in an exploratory fishery, and is the in the area of that fishery during the period that the fishery is open, should be considered to be a 'operating in an exploratory fishery' regardless of whether it is actively deploying or retrieving fishing gear. This clarification would provide vessels and the Secretariat with a greater degree of certainty on when to expect catch and effort data.

2.25 The Working Group also noted that the notification of vessel movements in CM 10-04, Annex 10-04/A, was required for movements between areas, subareas or divisions, rather than at the scale of the individual fishery areas and this meant that a vessel fishing in small-scale research unit (SSRU) 882A could move to SSRU 882H without requiring a vessel movement notification despite moving between areas where the catch limits are specified in different conservation measures. The Working Group noted that there was a proposal before the Commission to redefine the longitude of the boundary between Subareas 88.1 and 88.2 and this realignment would alleviate confusion over vessel movement reporting.

2.26 The Working Group recommended that the procedure outlined in Appendix D be used to manage the catch limits in the Ross Sea region exploratory fishery and other exploratory fisheries as appropriate. The Scientific Committee should review the application of these rules in the Ross Sea region exploratory fishery in 2019 and adjust them as necessary.

2.27 If the application of the pre-season closure process results in the northern area in the Ross Sea region exploratory fishery not being opened in a given season, then a process for managing the catch limit in the subsequent period would need to achieve the average spatial distribution of catch over a 3–5 year period.

Fishery Report updates

2.28 The Working Group noted that changes in productivity parameters may impact on assessments and management advice, and these changes may be related to long-term environmental change, shorter-term variability, or potential effects of fishing.

2.29 The Working Group recommended that Members developing updated management advice present any changes in productivity parameters used in their analyses and evaluate how these may impact the advice. The Working Group encouraged Members to collaborate to develop methods to assess changes over time, that can be used to evaluate the importance of observed changes on resulting advice using sensitivity analyses and simulations.

2.30 The Working Group recommended that WG-FSA-19 update CCAMLR's Fishery Reports to include a section on changes in model parameters and productivity assumptions, and that this section consider the impact of observed changes in biological parameters on management advice.

2.31 The Working Group recommended that key parameters could be presented in a table or as figures either in annual or five-yearly periods (see Table 2). The spatial distribution of catch and effort may also be considered, to assess if there have been distributional changes in population locations. For example, this may be shown as a plot of mean catch-per-unit-effort (CPUE) and latitude over time (see Figure 3).

2.32 The Working Group welcomed the Secretariat's intent to transform the way Fishery Reports will be published, into standardised and automated webpages. The Working Group recalled that the CCAMLR Independent Stock Assessment Review for Toothfish (Annex 5) indicated the need for standardised summaries across assessments to ease their comparison, and that such an approach would be beneficial to implement in Fishery Reports.

2.33 The Working Group recommended the establishment of an e-group to develop a standard format for Fishery Reports Stock Assessment Appendices so that they contain easily accessible summary information similar to Stock Annexes used in International Council for the Exploration of the Sea (ICES), summarising the background information leading to stock assessments. The Working Group requested that the e-group initially focusing on the toothfish fisheries to be assessed at WG-FSA-19, so that those Fishery Reports can be updated accordingly (paragraph 3.6).

Review of updated stock assessments and provision of management advice (all fisheries)

3.1 An independent CCAMLR Stock Assessment Review was held in June 2018. The primary objective for the expert group 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 improvements to the assessment methods where appropriate (SC-CAMLR-XXXVI, Annex 9). The Stock Assessment Review (Annex 5) concluded that the CCAMLR approach to stock assessment is appropriate for the precautionary management of the toothfish stocks and consistent with CCAMLR's approach to management. The CCAMLR stock assessments use a single modelling framework across stocks, based on surveys, catch, and a comprehensive annual tagging program across the fisheries, and the applied uncertainty in parameters and assumptions. The review highlighted the importance of the tagging data and long-term standardised surveys to index recruitment and noted that CCAMLR was leading in the development of tag-based integrated assessments. It further noted the need to reduce the differences in tag-survival and tag-detection rates between vessels, and to investigate statistics and methodologies to account for the variation in spatial distribution of fishing between years. The report also recommended future generic and assessment-specific work.

3.2 The Working Group thanked the Convener, Dr C. Reiss (USA), the expert group and the participants for the thorough review. It noted that valuable lessons were learned with regard to preparing for reviews and, in particular, the need for standardised documentation of inputs to, and outputs from, stock assessments. The Working Group further noted that topic-specific workshops with invited experts were a useful process to progress CCAMLR's work program, including how to best conduct assessments and provide catch advice in data-poor fisheries.

3.3 The Working Group recommended that the report of the independent Stock Assessment Review be made publicly available, for example, as an appendix to the WG-FSA-18 report.

3.4 The Working Group noted that such a publicly available report could include in an appendix a list of the papers and the presentations presented to the review panel that could be made available upon request to the Secretariat under the same process as for CCAMLR working group papers. The Working Group requested that the Secretariat work with the Members that presented assessments to facilitate this.

3.5 In particular, WG-FSA noted the expert group's conclusions that:

(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) overall, CCAMLR applies assumptions in the stock assessments in a precautionary manner, when there is uncertainty in parameters and assumptions. Management of the fisheries is consistent with CCAMLR's precautionary approach and Article II

(v) in most instances examined, appropriate practices are being followed and the assessments continue to adapt to new standards. 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 expert group was presented with many instances where the assessment scientists considered spatial structure in fishing and population dynamics, indicating a high level of understanding of the importance of this component to the assessment of these fisheries in the future.

3.6 The expert group made a number of recommendations which WG-FSA agreed should continue to be evaluated in future research and presented to the appropriate working group. The expert group recommendations and the target group, priorities and timelines suggested by WG-FSA are presented in Table 3. The Working Group further recommended that an intersessional e-group be created to develop a standardised format for a stock assessment annex to be added to the Fishery Reports.

Champsocephalus gunnari

C. gunnari in Subarea 48.3

3.7 The fishery for mackerel icefish (*Champsocephalus gunnari*) in Subarea 48.3 operated in accordance with CM 42-01 and associated measures. In 2017/18, the catch limit for *C. gunnari* was 4 733 tonnes. At the time of the meeting, no fishing had taken place in Subarea 48.3; vessels were expected to start fishing in October. Details of this fishery and the stock assessment of *C. gunnari* are contained in the Fishery Report (www.ccamlr.org/node/75667).

3.8 The Working Group agreed that the catch limit for *C. gunnari* in Subarea 48.3 of 3 269 tonnes, for 2018/19, in Conservation Measure 42-01 remain in place.

C. gunnari in Division 58.5.1

3.9 No papers were tabled under this item, and the Working Group provided no new management advice for this fishery.

C. gunnari in Division 58.5.2

3.10 The fishery for *C. gunnari* in Division 58.5.2 operated in accordance with CM 42-02 and associated measures. In 2017/18, the catch limit for *C. gunnari* was 561 tonnes. Fishing was conducted by one vessel and the total reported catch up to 28 September 2018 was 523 tonnes. Details of this fishery and the stock assessment of *C. gunnari* are contained in the Fishery Report (www.ccamlr.org/node/75667).

3.11 The results of a random stratified trawl survey in Division 58.5.2 undertaken in April 2018 were summarised in WG-FSA-18/55. 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.

3.12 Based on data gathered during the survey, an assessment for *C. gunnari* using the generalised yield model (GYM) was presented in WG-FSA-18/56. The one-sided bootstrap lower 95% confidence bound of total biomass of age 1+ to 3+ fish from the 2018 survey and fixed model parameters was estimated at 2 964 tonnes. Estimates of yield indicate that a catch limit of 443 tonnes of *C. gunnari* in 2018/19 and 320 tonnes in 2019/20 would satisfy the CCAMLR decision rules.

3.13 The Working Group also suggested further investigations to understand why the projected biomass estimate for this stock was above their respective 95% confidence interval in some years. The Working Group noted that the biomass estimate was consistent with that of the previous year and thanked Drs T. Earl (UK) and R. Sinegre (France) and Mr Maschette for developing diagnostic plots.

3.14 The Working Group recommended that the diagnostic plots be included in the annual fishery reports for icefish and that Members continue to work to standardise the information presented in the assessment papers and fishery reports.

Management advice

3.15 The Working Group recommended that the catch limit for *C. gunnari* should be set in 2018/19 at 443 tonnes and at 320 tonnes in 2019/20 in Division 58.5.2.

Dissostichus spp.

3.16 WG-FSA-18/02 presented a review of variability in the Patagonian toothfish (*Dissostichus eleginoides*) biological parameters in longline fishery catches in Subarea 48.3. Analysis was based on WG-FSA reports, documents and Fishery Reports. The authors noted declines in the length and weight at first maturity of females and males, increases in the proportion of immature fish and a reduced number of large spawning fish in historic catches from 1985 to 2004. The authors also noted that despite an increase in fishing depth from 2002 to 2004, young fish remained predominant in catches in Subarea 48.3. The authors further noted that unstandardised length frequency of toothfish in the catches in South Georgia for the period 2008–2017 showed an apparent decline in the mean length of fish in the catch in the more recent years (Fishery Report 2017).

3.17 The authors of the paper advocated that the *D. eleginoides* population in Subarea 48.3, which has been fished for more than 40 years, requires protection via the imposition of restrictions on fishing and changes to conservation measures, because CCAMLR's precautionary approach to the management of this resource has not been likely effective and asked if the changes discussed in WG-FSA-18/02 were consistent with the CCAMLR precautionary approach to stock management. As a consequence, the authors proposed a range of management changes for the *D. eleginoides* in this subarea, namely a minimum size limit of 90 cm in catch, restricting fishing to depths greater than 1 000 m, a reduction in the catch limit to 500 tonnes in depth ranges from 1 000 to 2 250 m and a closure of the fishery from 2020 onwards until a review has taken place based on international surveys.

3.18 The Working Group noted that the exclusive use of unstandardised 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. In particular, the Working Group considered that the authors have apparently misunderstood that the CCAMLR decision rule accounts for expected catch-at-length in the fishery, such that the long-term objective is likely to be achieved even if a proportion of the catch are juveniles.

3.19 The Working Group noted that *D. eleginoides* stocks in this area are characterised by maturing fish (60–90 cm in length) throughout the depth profile. Larger fish are increasingly caught at depth, but the immature length ranges are also present in the catches. Moving fishing to deeper waters does not reduce the proportional abundance of the maturing fish substantially. The Working Group further noted that the analyses of maturity trends presented in the paper were collected over a short historic time period and had not been standardised for effects such as sample size, sampling location and time, length distribution and depth which are key processes that will impact on the interpretation of these data. The Working Group noted that standardisation carried out by the UK showed no trend, and recommended such standardisation be presented in 2019 to WG-FSA.

3.20 The Working Group noted that *D. eleginoides* in Subarea 48.3 was assessed biennially with an integrated stock assessment. This assessment is reviewed by WG-FSA and additionally in 2018, was reviewed by an independent expert review panel (Annex 5). The review panel considered that the assessment was appropriate for the precautionary management of the stock and consistent with CCAMLR's approach to management. The assessment showed that fits to the observations which incorporated information on catch at length data, including changes over time, were adequate. The conclusions drawn from the information presented in WG-FSA-18/02 were therefore not consistent with the results of the agreed CCAMLR assessment which uses all available information.

3.21 The Working Group noted that 2018 was an intersessional year for the biennial integrated stock assessment in Subarea 48.3. It recalled advice from the Commission for a biennial assessment in this area unless WG-SAM recommended new methods for use in the stock assessment, parameters in the stock assessment were revised significantly, or a large IUU catch occurred (not included in the assessment) (CCAMLR-XXVI, paragraph 4.57). The Working Group concluded that a biennial assessment was still appropriate in this instance.

3.22 On the basis of these discussions, the Working Group agreed that its management advice for *D. eleginoides* in Subarea 48.3 remains unchanged for 2018/19.

Dissostichus spp. in Subarea 48.4

3.23 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 2017/18 was 37 tonnes of which 20 tonnes were taken in the fishery. An additional 18 tonnes were allocated as an upper catch limit for the effort-limited research survey to the south of the fishery outlined in WG-FSA-16/40 Rev. 1, of which 5 tonnes were taken (www.ccamlr.org/node/75667).

3.24 WG-FSA-18/26 presented an annual tag-recapture biomass estimate for the area that was conducted following the agreed procedure from SC-CAMLR-XXXV, Annex 7, paragraphs 3.29 to 3.31. The Chapman biomass estimate in 2018 was 982 tonnes and applying a harvest rate of 0.038 resulted in a yield of 37 tonnes, unchanged from 2017.

3.25 The Working Group noted that the confidence intervals were calculated analytically and that bootstrapping to estimate uncertainty could be used to better describe the variability in the data, especially with low numbers of recaptures. The Working Group noted that vessel and gear effects were likely to have a small effect on the Chapman estimate, with similar effective tagging survival and tag detection rates between vessels and similar catch length frequencies across different gear types.

3.26 The Working Group further noted that CPUE by vessel was showing a decreasing trend over time, which the authors attributed to vessels starting fishing later in the season. The Working Group noted the duration of fishing had also changed and suggested further analyses be conducted to assess the effects of changes of the timing of the fishery on CPUE.

Management advice

3.27 The Working Group recommended that the catch limit for *D. mawsoni* in Subarea 48.4 be set at 37 tonnes for 2019/20 based on the results of this assessment, and that a stock hypothesis continue to be developed for that area.

Research to inform current or future assessments in 'data-poor' fisheries (e.g. new fisheries, activities in closed areas, areas with zero catch limits and in Subareas 48.6 and 58.4) notified under Conservation Measures 21-01, 21-02 and 24-01

Generic issues

Trend analysis and setting catch limits

4.1 WG-FSA-18/12 updated the estimates of local biomass with uncertainty for *D. mawsoni* and *D. eleginoides* in research blocks in Subareas 48.6 and 58.4 as agreed by the Scientific Committee (SC-CAMLR-XXXV, Annex 5, paragraph 2.28).

4.2 The Working Group recalled the advice of WG-SAM-18 (Annex 6, paragraphs 4.1 to 4.7) to use the linear trend method for the estimates of local biomass in research blocks in Subareas 48.6 and 58.4. The trend analysis decision rules developed by WG-FSA-17 (SC-CAMLR-XXXVI, Annex 7, paragraphs 4.28 to 4.33) were applied to provide catch limits for 2018/19. The only research blocks in which there were adequate tag recaptures were 486_2, 486_3 and 486_4. However, as the trend in all three of these research blocks was declining, the revised catch limit is determined as 0.8 times the existing catch limit. The revised catch limits for all but one of the research blocks was determined by the requirement that the absolute change in the existing catch limit should not exceed 20%.

4.3 The Working Group recommended updating the decision rules to account for situations when CPUE data were declining, but the tag-recapture data were not adequate to inform a trend. The revised decision rules are given in Figure 4.

4.4 The Working Group recommended that the trend analysis be based on data from the past five years only, so that the method would be responsive to recent trends in the biomass indices. The Working Group welcomed the use of the inverse variance weighting in the regression as an appropriate method to account for the different levels of uncertainty in the biomass estimates used in the regression analyses, although the Working Group noted that the effect of using this regression method had little impact on the resulting catch limits.

4.5 The Working Group recommended that catch limits for the research blocks be as determined using this method, and these are given in Table 4.

4.6 The Working Group noted that while the method is suitable for providing interim management advice, further work was required to fully account for the uncertainty in the estimates of mean trend. The Working Group noted that the linear trend method was likely to be precautionary, however, it also noted that additional simulation and evaluation of the method were required in order to fully test it against the CCAMLR decision rules.

4.7 The Working Group noted that the method was considered an interim measure for the calculation of precautionary catch limits in research blocks. The Working Group noted that other methods could replace the linear trend method in each area as the research programs in those areas progressed.

4.8 The Working Group recommended that research plans provided for research blocks by Members include additional milestones for undertaking further method development and simulation analyses to ensure the removals under these research plans are consistent with Article II.

Tagging performance

4.9 WG-FSA-18/48 Rev. 1 presented on improvements to the tagging procedure on the Spanish FV *Tronio* using a cradle to lift and lower toothfish that are tagged and released. The method was trialled in 2017/18. The modifications were trialled to optimise the handling of the cradle, achieve rapid retrieval to minimise hauling downtime, minimise handling and time out of the water of the fish and use the cradle to release the fish. The authors reported that the modification achieved most of these objectives, with room for some further suggested alteration to further improve the system.

4.10 The authors noted that they observed reduced instances and severity of injury to the mouth of the toothfish when using the cradle, particularly for fish longer than 115 cm in length. They reported that the use of the cradle and winch did not affect the hauling rate of toothfish and had little impact on the efficiency of the vessel's fishing operations.

4.11 The Working Group welcomed the paper and noted that the improvements would likely result in a higher likelihood of survival of released toothfish and encouraged further development of the procedure. The Working Group requested that the authors make the plans and design of the cradle available to other Members so that they could consider the use of the cradle on other vessels.

4.12 The Working Group recalled the advice from WG-SAM to request vessels to record the use, characteristics and water flow of holding tanks for toothfish as a part of the tagging procedure as this may assist in understanding variability between vessels.

4.13 The Working Group recalled that there can be a high level of variability between vessels in the rates of tagged fish survival and tag detection, and recommended that the procedure used on vessels for tagging fish and for recording tagged fish be documented by observers so that a more complete understanding of the variability of effective tag survival and tag detection between vessels can be documented.

4.14 The Working Group noted the request by the Scientific Committee to develop a tagging pro forma for the purposes of collecting information describing the mechanisms used to train people tagging toothfish, the tagging facilities on board vessels, and the actual practices used on board, so that tagging effectiveness by vessels can be comprehensively reviewed (SC-CAMLR-XXXVI, paragraphs 3.127 to 3.130).

4.15 The Working Group considered that ongoing collection of data describing tagging practices could be useful in future analyses to understand the differences in tagging performance between vessels and may also be useful for improving future training materials for the people that are using them.

4.16 Noting the discussion from the Commission regarding alternatives to vessels supplying tagging information (CCAMLR-XXXVI, paragraphs 5.38 and 5.39), the Working Group developed a survey form intended for use by SISO observers to collect information about tagging facilities and practices on board toothfish longline vessels (Appendix E).

4.17 The Working Group recommended:

(i) the Secretariat circulate the survey form to Members' observer technical coordinators and lodge a copy of the form on the SISO section of the CCAMLR website for use by observers in exploratory fisheries and for toothfish research conducted under CM 24-01 in the 2018/19 season (Appendix E)

(ii) the Observer Scheme Program Coordinator at the Secretariat collate data collected through the survey, liaising directly with observer technical coordinators and observers if any responses describing the tagging procedures require clarification

(iii) the Secretariat present the results of the survey at WG-FSA-19 for consideration.

Transitioning from area biomass estimates to integrated stock assessments

4.18 The Working Group considered the general issues arising from WG-FSA-18/37, 18/58 Rev. 1, 18/66 and 18/72 on transitioning from area biomass estimates to integrated stock assessments. The Working Group noted that in progressing from research in research blocks and developing advice using integrated assessments, research would need to:

(i) consider different assumptions of stock structure and how these impacted the advice

(ii) develop simulations and analyses that evaluated different assumptions and their impact on the advice

(iii) develop methods that incorporate changes in spatial overlap of tag releases and recaptures to evaluate spatial and temporal bias in the interpretation of tag-recapture biomass estimates

(iv) incorporate the individual vessel effects into the analyses to account for different vessel-specific CPUE, gear, tag-release survival and tag-detection rates, or other confounding factors

(v) develop or continue to develop toothfish habitat models that extrapolate from fished areas within research blocks to account for the stock that may be outside the research blocks, including methods to validate the estimates from habitat models for extrapolated areas

(vi) provide estimates of biological parameters (for example, age structure, maturity, and growth rates) and validated age data that can be used in analyses and integrated assessments

(vii) undertake sensitivity analyses of current and historical IUU catch to account for uncertainty in catch histories

(viii) develop intermediate assessment methods to facilitate the transition from CPUE by seabed area and Chapman estimates to integrated assessment methods, noting that WG-FSA-18/58 Rev. 1 includes examples of each step

(ix) develop methods to fully include uncertainty within the estimates used to develop advice.

4.19 The Working Group noted the previous discussion on the revision of the regulatory framework (CCAMLR-XXXIV/17 Rev. 1), and requested that the Scientific Committee and the Commission clarify the objectives, priorities and definitions of data-poor exploratory fisheries.

Process for reviewing research proposals

4.20 The Working Group recalled the advice from the Scientific Committee (SC-CAMLR-XXXVI, paragraph 3.74) that WG-SAM and WG-FSA should evaluate and provide comment on proposals submitted by the submission deadlines for these meetings. The submitted proposals, together with comments by the working groups, should then be forwarded to the Scientific Committee for consideration.

Review of requirements for plans in CM 21-02

4.21 The Working Group noted that currently CM 21-02 requires a data collection plan, a fishery operation plan and a research plan for notifications for exploratory fisheries in areas included in paragraph 6(iii). The Working Group recommended that the Scientific Committee review the need for the data collection plan and the fishery operation plan for such notifications as all of the information requested in these plans was now provided in the research plan.

Management area research reviews and management advice

4.22 The Working Group reviewed research plans involving toothfish, using the summary table format with the criteria set out in WG-FSA-17 (SC-CAMLR-XXXVI, Annex 7, paragraph 4.7), and using the recommendations from WG-SAM-18 (Annex 6, paragraphs 6.1 to 6.3).

4.23 The Working Group also noted that there was considerable variability in the timeframes over which future research programs were notified. The Working Group requested that the Scientific Committee consider how research timeframes could be standardised.

4.24 The Working Group noted that a considerable amount of the time of WG-SAM and WG-FSA was spent reviewing research proposals for research fisheries limiting their ability to address other priorities, and that there were examples of research plans that were successfully delivering on their on- and off-water milestones which could be used as examples to emulate in developing research plans.

4.25 The Working Group noted advice on how to prepare research plans has been extensively progressed by WG-SAM and WG-FSA since 2011 and therefore asked that the Scientific Committee consider whether, given this progress, research plans still need to be reviewed twice each year or if a single review in WG-FSA would be sufficient (Annex 6, paragraphs 7.1 and 7.2) and advise the Commission accordingly.

4.26 The Working Group noted the advice from WG-SAM that recognised the potential for differences in the interpretation of the need for an exemption from conservation measures under CM 24-01 for different research fishing activities. The Working Group requested that the Scientific Committee review the objectives and provisions of CM 24-01 and provide clear guidance to Members on appropriate criteria for the application of this measure.

Research standardisation

4.27 Whilst reviewing a number of research plans the Working Group recalled previous discussions about gear selectivity and standardisation of effort between different types of longlines (SC-CAMLR-XXXVI, Annex 7, paragraphs 4.19 and 4.20). The Working Group recalled that the effect of gear type will depend on the research question asked, for example questions regarding stock hypotheses such as life stages in areas, biological parameters or spatial distributions may not be affected by gears, whereas catch rate analyses or tag-release performance may be.

4.28 Dr S. Kasatkina (Russia) noted that at present a variety of evidence regarding the longline type impact on catch rate, the size and species structure of the catches, mark-recapture results were revealed by documents of CCAMLR Working Groups (Kasatkina 2016, 2017; Yates et al., 2017; Eleaume et al., 2018). Dr Kasatkina expressed the need to clarify the potential effects of different types of longlines on outcomes from multivessel research with focus to their efficiency including the quality of the results obtained and the achievement of the objectives.

4.29 The Working Group noted that the standardisation of a parameter adjusts for, and removes the impact of, confounding factors other than that of interest, and recommended that it should include the following steps:

(i) define the question or hypothesis

(ii) data exploration, such as:

(a) visualising the data, e.g. with bi-plots for potential factors and mapping for spatial and temporal overlap

(b) summarising any decisions in relation to data cleaning

(c) summarising the data, such as number of hauls by year and area

(iii) model exploration, such as:

(a) considering appropriate model and error structures based on the data exploration taking into account the question asked and data complexity

(b) exploring alternative models in a stepwise manner for candidate explanatory factors and complexity in statistical approaches (e.g. GLM, GAM, GLMM or GAMM), avoiding over-parameterisation of the models

(c) showing stepwise comparisons from initial and final models

(d) presenting diagnostic table and plots, showing the fit and predictive ability of the model.

4.30 The Working Group also recalled its advice (SC-CAMLR-XXXVI, Annex 7, paragraph 4.20) that Members develop methods towards the following issues regarding the characteristics of different gears:

(i) design-based versus model-based approaches to gear standardisation

(ii) performance of tag releases and recaptures associated with gear type

(iii) approaches to consolidate effort between different gear types for the evaluation of CPUE, length distribution, species composition and other parameters

(iv) characterisations of gear types, such as bait types or hook types and line length and number of hooks.

Dissostichus spp. in Area 48

4.31 The Working Group noted SC-CAMLR-XXXVII/01, the report of the Co-conveners of the CCAMLR Workshop for the Development of a *D. mawsoni* Population Hypothesis for Area 48 held from 19 to 21 February 2018 in Berlin, Germany. The Working Group thanked the Co-conveners, Drs Darby and Jones, and all participants for their valuable contributions to the Workshop and, in particular, Dr M. Söffker (EU) for her major contribution in preparing WG-SAM-18/33 Rev. 1 synthesising extensive background information and including summaries of available data, developed through the Development of a *D. mawsoni* Population Hypothesis for Area 48 e-group.

4.32 The main outputs of the Workshop were three alternative stock hypotheses which are provided in WG-SAM-18/33 Rev. 1. The Working Group noted that some of the outcomes from the Workshop had already been incorporated in the current work of research plans.

4.33 The Working Group noted that there is little information on early life stages and stock connectivity of toothfish available at the moment, and that climate change in particular is likely to affect the early life stages of toothfish. Data on early-life stages could be collected, for example through targeted plankton sampling.

4.34 The Working Group noted there were a number of research plans across different subareas in Area 48 and Subarea 88.3, and that these research plans provide the opportunity to examine the stock connectivity of *D. mawsoni* populations between those subareas.

4.35 The Working Group noted that scientific activities outside CCAMLR, for example through the Scientific Committee on Antarctic Research (SCAR) and the Southern Ocean Observing System (SOOS), could assist in developing and testing the alternative stock hypotheses.

4.36 Dr Kasatkina noted that in her view the fragmented nature of available biological data at all stages of *D. mawsoni* life cycle were revealed by the Workshop. The latter is especially important considering interannual variability in environmental conditions in Subareas 48.5 and 48.6.

4.37 At the time of adoption, Dr Kasatkina proposed that conducting a large-scale multivessel toothfish survey in Area 48 would collect sufficient data to develop a population hypothesis for toothfish (*D. mawsoni*) and facilitate a stock assessment in Area 48.

4.38 The Working Group recommended that future research in the region should address the data gaps highlighted at the Workshop for the Development of a *D. mawsoni* Population Hypothesis for Area 48 (WS-DmPH-18) to further develop and test stock hypotheses in Area 48. The Working Group also recommended that considerations of climate change, which is likely to affect the early life stages of toothfish, be included in such work.

Subarea 48.1

4.39 WG-FSA-18/45 presented an analysis of the spatial distribution and population structure of juvenile *D. mawsoni* that had been sampled on random stratified bottom trawl surveys from 2001 to 2007 around the South Shetland Islands in Subarea 48.1.

4.40 The Working Group noted that information on catch locations for *D. mawsoni* from Subarea 48.1 trawl surveys had been provided at WS-DmPH-18, and that this analysis was undertaken to fill in data gaps identified at WS-DmPH-18. Specifically, juvenile development stages and durations, growth changes with latitude, condition indices, and age and growth of *D. mawsoni* in Subarea 48.1. The Working Group agreed that this information will contribute to evaluating the alternative stock hypotheses developed at WS-DmPH-18.

4.41 WG-FSA-18/20 presented a research proposal by Ukraine to carry out a scientific survey of *Dissostichus* spp. by bottom longline in the eastern part of Subarea 48.1 under CM 24-01. Revision 1, submitted during the meeting at the request of the Working Group, contained an additional map showing the proposed fishing locations based on the coordinates presented in WG-FSA-18/20 Rev. 1, Table 1, and a reformatted table of the proposed research milestones.

4.42 The Working Group noted that this proposal, on request by WG-SAM-18, now incorporated information that simplified the evaluation of the proposal against the criteria set out in Table 5, and information to take account of CM 24-05. The Working Group also welcomed the trial of monitoring the hauling and tag and release processes using video cameras.

4.43 The Working Group noted that Ukraine has proposed to conduct research in Subareas 48.1 (WG-FSA-18/20 Rev. 1), 48.2 (WG-FSA-18/49) and 88.3 (WG-FSA-18/16 Rev. 1). The Working Group noted the large amount of data and sample analysis activity that would be required to achieve all research objectives, including ageing the required number of otoliths across multiple subareas. It was noted that an overarching strategy or scheme of prioritisation for research undertaken by Ukraine would assist the Working Group to provide advice on whether the respective research plans are likely to achieve the objectives. The Working Group also recalled the advice from SC-CAMLR-XXXVI, paragraph 3.64, that priority should be given to the completion of research programs already in place over new research proposals.

4.44 The Working Group noted that the survey design focuses only on a relatively narrow range of fishing depth and recommended that it should also include hauls from shallower and deeper habitat to achieve the objective of determining distribution and abundance of *D. mawsoni* in the area.

4.45 The Working Group noted that plankton sampling in the upper layer of the investigated area and measurements of oceanographic parameters was planned during the survey to confirm the hypothesis of the distribution of *D. mawsoni* larvae in Subareas 48.1 and 48.2. The Working Group noted that the sampling was not designed to test a particular stock hypothesis and may not achieve its objective to collect eggs and larvae since toothfish spawn in winter during August–September while the survey was planned to be completed in the austral summer. The Working Group also noted that the ocean circulation patterns in this area are complex, and obtaining new oceanographic and biological data will provide a better understanding of the ecosystem structure in this area.

4.46 The Working Group also noted that several expeditions with research ice breakers had been carried out in the area proposed by Ukraine, including the CCAMLR krill survey with RV *Polarstern* in March and April 2018. This meant that data and information on several biological and environmental parameters were already available.

4.47 The Working Group noted that, if possible, more than 10 specimens of any by-catch species should be collected and analysed to achieve the objective of evaluating the by-catch distribution and trophic relationships and ecosystem function.

4.48 WG-FSA-18/01 provided an analysis of ice condition in the research area proposed by Ukraine in WG-FSA-18/20 Rev. 1, using the modelling method presented in WG-SAM-18/01. The results indicated that the mean sea-ice concentrations range from 50% to 100% and mean repeated accessibility was between 0% and 60%, especially in the southern parts between 64°S and 65°S of the proposed research area from January to April when the survey was planned to be carried out.

4.49 The Working Group noted that while fishing vessels may be able to navigate through waters with 60% sea-ice concentration, fishing activities were usually limited to a maximum of 20% sea-ice concentration.

4.50 Based on the results of this sea-ice model, the Working Group noted that the proposed sampling locations in the central and southern part of the research area had a likelihood of below 50% to be accessible for fishing at least twice within the three-year time span proposed in the Ukrainian proposal (Figure 5).

4.51 The Working Group noted that an important aspect of the Ukrainian research plan was to repeatedly access the research area, and it was concerned that the objectives of the research plan may not be achievable due to high sea-ice concentration in some proposed sampling areas.

4.52 Dr Demianenko welcomed the presented sea-ice analysis, noting that it provides important information for the successful realisation of the research plan. However, he noted that the preference of the Ukrainian research team was to test the real sea-ice conditions during the first year of the research plan, in particular in the southern area (research block 3), which has the highest sea-ice concentration. The research plan could then be modified for the subsequent years depending on the actual sea-ice conditions. The Ukrainian research team considers that it would be very useful to collect different types of data in this area which has not been observed regularly. Dr Demianenko noted that Ukraine would be happy to take into account the discussions and advice of WG-FSA, to make sure that this research plan in Subarea 48.1 could be realised.

4.53 Dr Demianenko noted that the area of research block 3 as shown in Figure 10 in WG-FSA-18/20 Rev. 1 could be excluded from the research proposal for Subarea 48.1 to increase the likelihood for completing the 3-year research plan. The research plan would remain the same for research blocks 1 and 2.

4.54 The Working Group evaluated the research proposal in WG-FSA-18/20 Rev. 1 against the criteria set out in SC-CAMLR-XXXVI, Annex 7, paragraph 4.7 (Table 5).

Subareas 48.2 and 48.4

4.55 WG-FSA-18/49 provided a progress report on the research from 2014/15 to 2017/18 for *Dissostichus* spp. in Subarea 48.2 by Ukraine and a notification to continue research in 2018/19, the final year of a two-year research plan extension.

4.56 The Working Group noted that a number of recommendations by WG-SAM-18 (Annex 6, paragraph 6.17) had not been addressed completely, namely:

(i) detailed studies of by-catch species, seabirds and mammals observed during the research as indicated in the original proposal

(ii) specific recommendations on reporting (SC-CAMLR-XXXVI, Annex 7, paragraphs 4.45 to 4.49) from this research plan

(iii) length-frequency data in research reports should be catch-weighted if not every fish is measured from the catch

(iv) that the CCAMLR geographic information system (GIS) could be used to present maps of sampling stations.

4.57 The Working Group expressed concerns that the number of sampling stations in the southern research blocks had continuously increased over the last three years, while the catch rates had declined over the same period. The Working Group noted that Ukraine had increased the number of sampling stations to increase the likelihood to recapture tagged toothfish and increase the information from the southern part of the research area.

4.58 The Working Group welcomed that a number of fish had been aged, and the number of aged fish has increased in recent years. However, it noted that the number of aged fish per year was still too small to estimate robust age–length keys (ALKs) for an assessment, and that the current sampling protocol would not provide sufficient otoliths to achieve robust ALKs.

4.59 The Working Group welcomed efforts of the Ukrainian research team to collect additional data on the hydrobiology and oceanography from the research area and noted that this could be useful for broader assessments of structure, status and trends of the ecosystem in this region (paragraphs 4.235 to 4.240 and WG-FSA-18/04 and 18/19).

4.60 The Working Group evaluated the research proposal in WG-FSA-18/49 against the criteria set out in WG-FSA-17 (SC-CAMLR-XXXVI, Annex 5, paragraph 4.7) (Table 5). The Working Group noted that Ukraine had other research plans proposed (in Subareas 48.1 and 88.3) and recommended that this existing research plan should have priority over new proposals. However, the Working Group noted that 2018/19 was the final year of this research plan and that there was a large amount of research outstanding to achieve the objectives of the research plan. It expressed concerns that the intended development of an integrated stock assessment for this area next year may not be achievable.

4.61 The Working Group recommended that the existing 75 tonne catch limit be applied as the precautionary catch limit for the research proposed by Ukraine in Subarea 48.2.

4.62 WG-FSA-18/35 presented results from the second year of a three-year survey by the UK into the connectivity of toothfish species in Subareas 48.2 and 48.4. The focus for the second year was to further investigate availability of fishable grounds, update information for toothfish species and non-target species in this region, continue temperature data collection on longlines, focus on vulnerable marine ecosystem (VME) indicator species information and review survey station locations.

4.63 The Working Group noted that the deployment of satellite tags and benthic cameras had been delayed, and that no ageing had been done yet but that otolith reader training was in progress.

4.64 WG-FSA-18/31 provided an outline for the third year of the three-year longline survey by the UK to determine toothfish population connectivity between Subareas 48.2 and 48.4.

4.65 The Working Group noted that the survey design in WG-FSA-18/31 had been adjusted to provide a greater spatial overlap between the fishing activities of the two vessels that are part of the proposal, by allocating stations to vessels *a priori* randomly, however, adjusting station allocations where necessary to minimise travel between stations.

4.66 The Working Group welcomed that plan for the refinement of the stock hypothesis in Area 48, which is scheduled as part of this research plan for 2020 and 2021, to combine information on tag recaptures, genetic stock connectivity, otolith microchemistry and environmental measurements.

4.67 The Working Group evaluated the research proposal in WG-FSA-18/31 against the criteria set out in WG-FSA-17 (SC-CAMLR-XXXVI, Annex 7, paragraph 4.7) (Table 5).

4.68 The Working Group recommended that the existing catch limits of 18 tonnes for hauls in Subarea 48.4 and 23 tonnes for hauls in Subarea 48.2 be applied as the precautionary catch limit for the research proposed by the UK.

4.69 The Working Group welcomed the overall summary report of the activities conducted independently within Subarea 48.2 by Ukraine and the UK (WG-FSA-18/52). The report provides an area overview of the research and objectives of the independent research programs, as outlined in the proposal submitted by Ukraine in WG-FSA-18/49, and the UK in WG-FSA-18/31.

Subarea 48.5

4.70 WG-FSA-18/06 reported biological data on a few sub-adult *D. mawsoni* collected by research bottom trawling carried out by the RV *Polarstern* in the southern Weddell Sea (Subarea 48.5). The Working Group thanked the authors for providing this information on request by WS-DmPH-18 and noted that more information from research cruises by the RV *Polarstern* is available and will be tabled to future WG-FSA meetings which can address some of the identified data gaps.

Subarea 48.6

4.71 WG-FSA-18/72 provided an annual report of research fishing operations in Subarea 48.6 in 2017/18. As the research operation was still in progress at the time of the WG-FSA-18 meeting, the reported data was incomplete.

4.72 The Working Group noted that catch rates had declined in research block 486_3 between 2013 and 2016 but then stabilised over the last three years. Fishing effort had been concentrated on two small areas within the research block. The Working Group also noted that IUU vessels had been active in this research block until last year. The Working Group noted that standardised catch rates show a similar trend to the nominal CPUE as described above.

4.73 The Working Group noted that research block 486_5 had only been fished in three seasons, including 2017/18, and that high sea-ice concentration had prevented fishing in the other seasons. Catch rates had been high in this research block in all fished seasons, possibly as the result of large toothfish being caught in this area. Prior to this fishing season, there had only been two within-season recaptures. Dr T. Okuda (Japan) notified the meeting that there have been six recaptures in the 2017/18 season, one which had been released in 2011 and five which had been released in 2017. These recaptures will contribute to the stock assessment and to further develop the stock hypothesis for the area.

4.74 The Working Group requested that the Scientific Committee consider the viability of future research in research block 486_5 which is inaccessible due to sea-ice in many years in evaluating the research proposed in this block.

4.75 The Working Group noted that there was no report of ageing which was a milestone of this research plan for this year. Mr Somhlaba informed the Working Group that South Africa had conducted some otolith ageing but had not yet validated these age readings. Ongoing otolith ageing and validation was being performed using the reference collection from New Zealand and otolith microchemistry work was being done in collaboration with China.

4.76 The Working Group noted that estimating population productivity parameters is crucial for the development of a stock assessment and was a milestone for this research plan. The Working Group noted that while sufficient data had been collected to estimate maturity ogives in this subarea, no such estimation had been conducted recently.

4.77 The Working Group noted that five pop-up satellite archival tags (PSATs) had been released from the *Shinsei Maru No. 3* in July 2018, but no data had been recovered from these tags. The PSATs had been programmed to pop-off after one month, and as a result, they may have been trapped under sea-ice during winter or fish may have moved deeper than the maximum depth tolerated by the PSATs, preventing the transmission of data.

4.78 WG-FSA-18/75 presented an analysis of the microchemistry of *D. mawsoni* otoliths collected in research blocks 486_2, 486_3 and 486_4. The analysis showed no significant differences in the chemistry within either the nucleus or edge sections, but differences between the nucleus and edge sections. Based on these results, the authors concluded that while the *D. mawsoni* specimens may have the same hatching grounds and that the habitat was consistent between the three research blocks, the habitat may change with ontogeny between hatching ground and the area that the fish were captured. The ongoing analysis further indicated there was a significant difference in trace elements of *D. mawsoni* otoliths between Subareas 48.6 and 88.1.

4.79 The Working Group noted that the uptake of the investigated trace elements is species-specific and may change with fish age and water temperature, and that other biological processes may have contributed to the observed differences between nucleus and edge other than ontogenetic movement.

4.80 The Working Group noted that analysing the microchemistry across the entire otolith, combined with information from ageing, tag-recaptures and genetic analysis, may help to provide further insights into the stock structure and connectivity in Area 48. The Working Group noted that there was an international collaboration in place between South Africa, New Zealand, the Republic of Korea and China to address this issue, and encouraged this international collaboration to be extended to Japan and other Members.

4.81 WG-FSA-18/66 outlined the early developments of stock assessment work that has been conducted in Subarea 48.6 since 2012, possible methods for assessing the stocks given the amount of information that has been collected, experiences in progressing data-poor assessments into integrated assessments from other areas of the Convention Area, and uncertainties introduced by IUU activities that have taken place in this subarea.

4.82 WG-FSA-18/72 provided the preliminary results of an integrated stock assessment for research block 486_2 using CASAL. The model fitted a single-sex age-structure population model to tag-release data, catch-at-age and catch rates from 2012 to 2017, assuming catch data from 2006 to 2017 but not considering IUU removals.

4.83 The Working Group noted that the model needed careful consideration of data weighting since the maximum posterior density (MPD) estimate for B_0 showed a strong conflict between tagging data and catch-at-age. Tagging data indicated a low B_0 while catch-at-age data indicated a very large B_0. As a consequence, the MPD model fit was poor for tagging data, with higher numbers of observed than expected recaptures for all release years.

4.84 The assessment model assumed a closed population in research block 486_2. The Working Group noted that given the stock hypotheses in Area 48, this assumption was unrealistic. In addition, using a dome-shaped selectivity function was likely to inflate the estimate of B_0 in this case, and tag-recaptures with a time of liberty of longer than one year should be used in the model.

4.85 The Working Group recommended that the assessment model for Subarea 48.6 be further developed and presented to WG-FSA-19 to address issues on data weighting and stock hypotheses and to consider different levels of IUU catches in sensitivity runs.

4.86 WG-FSA-18/34 provided a proposal for the continuation of a multi-Member longline survey on *D. mawsoni* in Subarea 48.6 in 2018/19 by Japan, South Africa and Spain. A collaborative research plan has been undertaken by Japan and South Africa since 2013, but based on the recommendation by WG-SAM-18 (Annex 6, paragraph 6.29), Spain has joined this research plan. Data and investigations about the population structure and various demographic parameters of *D. mawsoni* using trotline by the Japanese and South African vessels and Spanish longline by the Spanish vessel, established tagging techniques, pop-up tags and genetic analysis are planned to provide the basis for the development of spatial population models and assessments by 2021/22.

4.87 The Working Group noted that this is a continuation of an existing research plan (WG-FSA-16/32 Rev. 1 and WG-FSA-17/10) with a scheduled end date of 2021. Some of its milestones in the plan have not been reported in the annual progress report for the 2016/17 and 2017/18 fishing seasons, including the estimation of growth, population structure and reproduction.

4.88 The Working Group noted that original milestones have been delayed and extended in WG-FSA-18/34, with now 2022 as the final year of the research plan.

4.89 The Working Group also noted that milestones focused on data collection instead of outcomes from data analyses, with little information provided on planned data analyses. The Working Group recommended that the research plan provide more details on:

(i) the milestones to estimate natural mortality using tagging data which is a complex task and difficult to achieve

(ii) how video data will be analysed to evaluate the impact of different fishing gear types on the benthic habitat

(iii) how the addition of Spanish line to this research plan would affect catch rates and the tagging program

(iv) analyses to evaluate the likelihood of achieving the milestones (e.g. given the spatial and temporal overlap of vessels, what is the likelihood to estimate the vessel tagging performance in Subarea 48.6).

4.90 The Working Group noted that there are three stock hypotheses developed by WS-DmPH-18 which should be incorporated into this research plan.

4.91 The Working Group evaluated the research proposal in WG-FSA-18/34 against the criteria set out in WG-FSA-17 (SC-CAMLR-XXXVI, Annex 7, paragraph 4.7) (Table 5).

4.92 The Working Group noted that catch limits were calculated for Subarea 48.6 using the trend analysis rules (paragraphs 4.1 to 4.5) and recommended they be applied as shown in Table 4.

Dissostichus spp. in Area 58

4.93 The Working Group reviewed WG-FSA-18/60 on analyses of data of IUU fishing activities in Division 58.4.1 during the 2013/14 season and Division 58.4.3b during the 2014/15 season. This analysis had been conducted upon request from SC-CAMLR-XXXVI (Annex 7, paragraph 2.16) based on data from Division 58.4.1 provided by Spain following Operation Sparrow 2, and data from Division 58.4.3b collected by a non-governmental organisation (NGO) vessel from five recovered IUU gillnets.

4.94 The paper concluded that the daily catch rates of IUU vessels using gillnets were similar to those of authorised fishing vessels using longlines, total removals by IUU vessels during the 2013/14 season were much higher than those of an authorised vessel fishing (up to seven times) in the same season in Division 58.4.1, that IUU removals may have impacted on research in this area, and that the presence of authorised vessels did not seem to deter IUU fishing.

4.95 The Working Group noted that the IUU catch concentrated outside research blocks in an area east of research block 5841_2 but also overlapped with research blocks 5841_2 and 5841_3 and 5841_4.

4.96 The Working Group noted that given the similarity in daily catch rates between IUU vessels and authorised vessels, there was the potential to estimate total IUU removals across the CAMLR Convention Area given existing sightings of IUU vessels. The Working Group recommended that the Scientific Committee develop a workplan to provide these estimates.

4.97 The Working Group noted the proximity of the FV *Tronio* to one of the IUU vessels for a number of days and requested that the Scientific Committee and SCIC evaluate if authorised vessels are an effective deterrent to IUU vessels. In addition, the Working Group requested the Scientific Committee provide advice on data collection protocols to report effort, catch and biological data for IUU fishing gears recovered in the future.

4.98 The Working Group considered WG-FSA-18/22, which reported the results from five PSATs which provided data out of 13 deployed on *D. mawsoni* between 2014 and 2017 from a study in the Mawson Sea in Division 58.4.1. All tagged fish were recovered within a distance of 183 km between release and recapture site and remained in a depth range between 326 and 1 824 m for the majority of time at liberty. Based on data from an entire year at liberty, one tagged toothfish showed a distinctive behaviour during the month of September when it ascended to depths around 500 m and a number of short vertical ascents and descents returning to the same depth that could be related to spawning behaviour. Dr S.-G. Choi (Republic of Korea) informed the Working Group on a plan to deploy 10 MiniPATs on *D. mawsoni* in Division 58.4.1 during the 2018/19 season and to deploy 50 PSATs on *D. eleginoides* in FAO Area 41 to better understand stock structure in that area.

4.99 The Working Group noted that the vertical movement could be associated with spawning behaviour due to the time of year it occurred, as the behaviour pattern has been noted in other perciform fishes, however, it could also be associated with feeding behaviours targeting species that aggregate at that time of year such as Antarctic silverfish (*Pleuragramma antarctica*). The Working Group note that depending on the questions to be addressed by the research, the use of magnetometers could help to estimate the tag location during deployment, and accelerometers can indicate changes in speed during vertical movements. The Working Group recommended analyses to identify temporal patterns (such as biological rhythms), especially in association with other environmental factors, could help to understand the fish behaviour recorded by the tags.

4.100 WG-FSA-18/24 presented an analysis on diet composition and feeding strategy of *D. mawsoni* collected from longlines in Areas 58 and 88 between 2014 and 2018. The results indicated that *D. mawsoni* is an opportunistic predator that feeds mainly on other fishes from all size classes with a narrow trophic niche width. Small quantities of other preys as molluscs, crustaceans, anthozoans, echinoderms, eggs, birds and mammals have also been found. Macrourids were the main fish in the diet in Area 58 while macrourids and the icefish *Chionobathyscus dewitti* were found in similar proportions in Area 88. Ontogenetic changes were observed where small size classes of *D. mawsoni* seem to feed mainly on *C. dewitti* while large size fish feed more on macrourids, however, this may be confounded by spatial distribution of samples collected.

4.101 The Working Group noted that because toothfish are generalists, a time series of toothfish diet composition could be used as a monitoring index for the effects of climate change on species distributions. The Working Group encouraged continuing this work to investigate potential differences between subareas or with depth, and to integrate these analyses with genetic studies, as presented in a companion paper (WG-FSA-17/P03).

4.102 The Working Group considered WG-SAM-18/65 which analysed the reproductive ecology of *D. mawsoni* in Areas 58 and 88 from gonad samples collected in 2016 and 2017 using histological analysis. The average gonadosomatic index of the fish in Area 58 was higher than in Area 88. Maturity in females was between 120 and 130 cm and all females were mature at a size of 170–180 cm. The authors hypothesised that the main spawning season starts in the month of May and suggested sampling all year around to test this hypothesis.

4.103 The Working Group noted the importance of validating the macroscopic stage data with histological analysis, especially in samples collected during non-spawning seasons. The Working Group noted that there are many fishery observations of maturity stage, gonadosomatic index (GSI), and sex available for several years and areas and recommended that these observer biological sampling data be requested from the Secretariat to be integrated into these analyses to derive maturity ogives and other biological parameters for each stock sampled.

4.104 WG-FSA-18/54 Rev. 1 described the progress in age determination of otoliths from *D. mawsoni* collected in Division 58.4.1, including a comparison of otolith readings from four age readers from Spain and two from Australia. The results showed that the agreement on ages varied among readers, that some reader comparisons indicated a bias between readers in either young or old fish, and that the overall coefficient of variation (CV) was typically >9%, which was likely a result of small sample sizes in the comparisons.

4.105 The Working Group welcomed the progress in age validation. The Working Group noted that the CV threshold used for acceptable reference set reads in the Ross Sea was 5%, and that further development and testing was needed to improve the CVs in the comparisons with reference sets. The Working Group noted that the goal of the age determinations was to provide an unbiased ALK for use in assessment and that the tests for bias and changes in reader performance through time were important as the uncertainty in age is included in the integrated assessment models.

4.106 The Working Group also noted that the preparations and viewing configurations used by the readers (e.g. bake and embed, thin sections, monitor viewing, dissecting scope and optical quality) can affect the precision of reading and should be considered in comparisons.

4.107 WG-FSA-18/58 Rev. 1 presented the results from the final year of the multi-Member research plan by Australia, France, Japan, Republic of Korea and Spain in Divisions 58.4.1 and 58.4.2. The Working Group noted that a summary on fishing activities, presented in a standardised report format using R markdown, had already been presented in WG-SAM-18/17. The Working Group noted that all the comments raised by review at WG-SAM had been addressed and noted the development of case-control tagging performance statistics, improvements to a habitat model presented in WG-FSA-17/16, and progress in developing a CASAL model for *D. mawsoni* in these divisions (paragraph 4.18).

4.108 The Working Group noted that structured fishing in the research blocks in addition to that provided by the initial catch allocation among Members could be used to support data collection for case-control comparisons of effective tagging survival and tag-detection rates to improve the development of the stock assessment as presented in WG-FSA-18/58 Rev. 1.

4.109 SC-CAMLR-XXXVII/BG/23 questioned the performance of the multi-Member research plan by Australia, France, Japan, Republic of Korea and Spain in Division 58.4.1 arguing that the different gear types of longline gear and configurations used by the different vessels prevented data collected on CPUE, size composition, or mark-recapture results from being summarised and used as a time series to estimate abundance. The paper indicated that the effect of longline gear type is reflected in length composition, age composition, ratio of mature fish and mark-recapture results should be summarised and used as a time series to understand abundance (Kasatkina, 2017, 2016; WG-FSA-17/16).

4.110 The authors emphasised that understanding abundance dynamics and trends requires separating the effect of gear type from the spatial and temporal variability of toothfish compositions. Dr Kasatkina noted that it is necessary to develop approaches for summarising data obtained with different fishing gears and that the methodology should provide an opportunity to assess the quality of the results based on the application of diagnostics to determine the effectiveness of the methods and models used. Dr Kasatkina noted that an alternative approach for implementation of a multivessel program is to use standardised gear.

4.111 The Working Group noted that a number of standardisation methods exist and are used routinely within CCAMLR working groups to control for the potential effects of gear type, vessel, area, depth and other variables associated with the variable of interest (e.g. catch rate, fish size) as presented in WG-FSA-17/07 and 17/16 (paragraphs 4.27 to 4.30 standardisation discussion). Methods have also been developed to standardise differences in tagging programs, such as the case-control analysis (WG-SAM-14/30), and these data have been used in integrated stock assessments.

4.112 The Working Group noted that these types of standardisation analyses apply to research in many areas and are not specific to Division 58.4.1. Some of these standardisation methods have been applied to Division 58.4.1, including standardisation of catch rates, mean length, the proportion of mature females and sex ratio (WG-FSA-17/16), trends in by-catch abundance (WG-FSA-17/23, WG-FSA-18/28), vessel effective tagging survival and detection rates (WG-FSA-18/58 Rev. 1).

4.113 The Working Group encouraged additional analyses of the potential for gear type to affect indices of by-catch composition, or effective tagging survival and detection rates, and recalled previous advice that the appropriate analysis will depend on asking clear questions, developing hypotheses to test, and conducting an appropriate analysis and diagnostics (paragraphs 4.43 to 4.46) (SC-CAMLR-XXXV, Annex 7, paragraphs 3.90 and 3.91).

4.114 WG-FSA-18/59 presented a new four-year research proposal by Australia, France, Japan, Republic of Korea and Spain in Divisions 58.4.1 and 58.4.2. Based on the outcomes of a review of the locations of research blocks (WG-SAM-18/17), the new research plan proposed to retain the research blocks in their same locations as the previous research plans, but to remove a fine-scale research grid from research block 5841_2.

4.115 Dr Kasatkina expressed concern about the calculation of the catch limit for the researches in Division 58.4.1, given that a different gear types have been used in the research blocks in different years, there is also a low level of tag recapture in this area. Analysis of the impact of gear type in the regression technique used to set research block catch limits and the sensitivity to the level of tag recapture, has not been performed and this uncertainty may impact the precautionary catch limit advice to the Scientific Commission.

4.116 The Working Group noted that the fine-scale research grid had originally been designed around the locations of depletion experiments conducted by Spain in 2015 to recapture tagged fish that had been released as part of that experiment. While the fine-scale grid may be useful for inter-vessel comparisons, data from such a small area could create a bias in the biomass estimates using tag-recapture data. The Working Group therefore supported the removal of the grid in the research proposal.

4.117 The Working Group noted that the habitat model for *D. mawsoni* in this area, including a standardisation of catch rates, will be updated as part of this research plan, and that more detailed sampling of VME by-catch was part of the data collection plan.

4.118 The Working Group evaluated the research proposal in WG-FSA-18/59 against the criteria set out in SC-CAMLR-XXXVI, Annex 7, paragraph 4.7 (Table 6).

Management advice

4.119 The Working Group noted that the catch limits for Division 58.4.1 and 58.4.2 were calculated using the updated trend analysis rules and recommended they be applied as shown in Table 4.

Division 58.4.3a

4.120 WG-FSA-18/50 presented the 2017/18 results of the research plan by France and Japan in Division 58.4.3a. Only the *Mascareignes III* fished in that season, taking 2.5 tonnes of the 38 tonne catch limit in 16 sets with three recaptures of tagged fish. The other fishing vessel, the *Shinsei Maru No. 3* did not participate in the research due to engine failure.

4.121 The Working Group noted that the research results had been reported only for the current season. Since fishing activities by the Japanese vessel were still in progress at the time of the last WG-FSA meeting, these activities had not been reported to WG-FSA-17 and were not part of this report either. The Working Group therefore recommended that these research reports include data from more than one season.

4.122 The Working Group expressed concern about the lack of progress in this research plan and failing milestone achievements, including no new age readings since 2015, no update on the estimation of biological parameters, and no further development of a preliminary CASAL stock assessment. The Working Group noted that there is no stock hypothesis developed for this area and recommended some further work towards this objective.

4.123 The Working Group noted that due to the lack of significant catch taken for many years, the number of releases and recaptured fish over time has degraded such that only two fish in 2017 and three fish in 2018 were recaptured. The Working Group noted that these numbers of tag-recaptures could be too small to develop a stock assessment in such a way that it could be used to provide catch management advice using the CCAMLR decision rules.

4.124 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 also noted that 320 of 1 570 skates caught (20%) were reported as lost at the surface.

4.125 WG-FSA-18/61 presented a proposal to continue research in Division 58.4.3a by Japan and France in 2018/19. The Working Group noted that there had been no clear start or end date of this research plan, the presentation of future milestones lacked due dates and that some milestones had been simply delayed as few data were being collected to conduct required analyses. The Working Group also noted that if a large number of tags were not released in the upcoming year, then there would be little prospect of any tag-recaptures by 2020/21.

Management advice

4.126 The Working Group evaluated the research proposal in WG-FSA-18/61 against the criteria set out in SC-CAMLR-XXXVI, Annex 7, paragraph 4.7 (Table 6).

4.127 The Working Group noted that the catch limits in Division 58.4.3a were calculated using the updated trend analysis rules and recommended they be applied as shown in Table 4.

4.128 The Working Group requested that the Scientific Committee consider the prospect of this research plan being successful given the low catches and hence low numbers of fish being tagged since 2014, low numbers of recaptures, low catch yielding low numbers of otoliths available for ageing and ageing not being progressed, and the high proportion of by-catch.

Division 58.4.4b

4.129 WG-FSA-18/67 presented the 2017/18 results of the research plan by France and Japan in Division 58.4.4b. Only the *Ile Bourbon* fished in that season, taking 1.6 tonnes of the 28 tonne catch limit in 18 sets with no recaptures of tagged fish (three recaptures of tagged fish occurred but were not included at the time of the data extract). Similar to Division 58.4.3a, the other fishing vessel, the *Shinsei Maru No. 3* did not participate in the research due to engine failure.

4.130 The Working Group noted low catch rates with a declining trend in CPUE in research block 5844b_2 and suggested further work to standardise this time series for spatial and vessel effects.

4.131 The Working Group also noted that despite an extensive dataset of length, weight, maturity data and otolith samples that have been taken, model parameters related to productivity have not been updated since 2015.

4.132 The Working Group discussed the reported decline in killer whale sightings and depredation recalling its comments from 2016 (SC-CAMLR-XXXV, Annex 7, paragraph 4.138). No recent work has been reported to quantify depredation or develop photographic reference sets.

4.133 The Working Group expressed concern that the research plan is in a closed area, the spatial fishing grid pattern of the proposal is not being implemented, a tag-recapture time series to estimate stock abundance is not being developed, and some milestones are not achieved.

4.134 In discussion of the revised research proposal (WG-FSA-18/44), the Working Group noted that the research plan in this area has been in place since 2010 but that many of the milestones have been delayed either due to lack of catch and tagging data, or lack of processing and analysis of collected samples and data. The Working Group further noted that some milestones in the progress table (e.g. killer whale depredation) had no completion date, but that experts in the field of photo ID (e.g. in Australia, France and USA) would be available to assist in this.

Management advice

4.135 The Working Group evaluated the research proposal in WG-FSA-18/44 against the criteria set out in SC-CAMLR-XXXVI, Annex 7, paragraph 4.7 (Table 6).

4.136 The Working Group noted that the catch limits for research in Division 58.4.4b were calculated using the updated trend analysis rules and recommended they be applied as shown in Table 4.

4.137 The Working Group noted that this is a closed area and requested that the Scientific Committee consider the viability of this research plan and the sustainability of this stock given: (i) that proposed research designs have not been implemented, (ii) low and declining catch rates, (iii) low numbers of historical tag recaptures, (iv) low expected numbers of future recaptures due to low catches, and (v) limited milestone achievement.

4.138 Dr Kasatkina expressed concern about the calculation of the catch limit for the researches in Division 58.4.1, given that different gear types have been used in the research blocks in different years, there is also a low level of tag recapture in this area. Analysis of the impact of gear type in the regression technique used to set research block catch limits and the sensitivity to the level of tag recapture, has not been performed in this area and this uncertainty may impact the precautionary catch limit advice to the Scientific Commission.

D. mawsoni in Area 88

Capacity

4.139 WG-FSA-18/15 updated the metrics of capacity and capacity utilisation presented in WG-SAM-14/19 and WG-FSA-15/09 to monitor trends in capacity in exploratory toothfish fisheries in Subareas 88.1 and 88.2. The updated metrics showed a high CPUE in the Ross Sea fishery in 2016/17 and highlighted that the indices from 2017/18 should be interpreted in the context of the changes in the spatial distribution of the fisheries resulting from CM 41-09 and CM 41-10 in 2017/18.

4.140 The Working Group noted that the uncertainty associated with the closure of the northern Ross Sea in 2017/18 arose directly as a result of a large number of vessels notifying to fish in Subarea 88.1, although some moved straight through to the southern area without fishing in the north (WG-FSA-18/07, see also paragraphs 2.19 to 2.25).

Winter survey

4.141 WG-FSA-18/40 presented a proposal for a winter survey in the north of Subareas 88.1 and SSRUs 882A–B; previously presented as WG-SAM-18/09 which describes the research objectives.

4.142 The Working Group noted that WG-SAM had requested the addition of a milestone table which was included in the revised report.

4.143 The Working Group recommended that the survey catch should be taken from the Ross Sea north area.

4.144 The Working Group requested that the Scientific Committee consider whether to allocate the catch from the Ross Sea northern catch limit of the next season and then adjust the catch limit of that season by the actual catch taken during the survey.

4.145 The Working Group noted that the catch limit had been based on the previous survey catch rates in the area and the number of research blocks and number of stations within research blocks planned for the research to obtain information on catch composition and biological parameters over a broad spatial distribution. The Working Group noted that power analyses could be performed to determine the samples necessary to estimate key parameters from the survey.

4.146 The milestone table was reviewed by WG-FSA which then evaluated the research proposal in WG-FSA-18/40 against the criteria set out in SC-CAMLR-XXXVI, Annex 7, paragraph 4.7 (Table 7).

Shelf survey

4.147 WG-FSA-18/41 presented a proposal for a continuation of the Ross Sea shelf survey. The Working Group noted that the survey contributes information on the relative magnitude of recruitment year classes in the toothfish stock assessment of the Ross Sea Region.

4.148 The Working Group noted that the Independent Review Panel (Annex 5) had commented on the importance of developing time series of standardised surveys such as this one which contribute to reducing the uncertainty of recruitment estimation in assessments (Table 3).

4.149 Dr Kasatkina noted that the catch for the next year survey should be derived from the special research zone (SRZ) rather than being allocated from the Olympic fishery catch allocation in the Area south of 70°S outside the marine protected area (MPA) (CCAMLR-XXXVI, paragraphs 8.25 and 8.26).

4.150 The Working Group noted that the Commission had agreed in 2017 on the basis of advice from the Scientific Committee (SC-CAMLR-XXXVI, paragraphs 3.138 and 3.139) that the catch should be allocated from the total catch limit (CCAMLR-XXXVI, paragraphs 5.35 and 5.36). Consequently, in the absence of a scientific rationale for changing the previous advice the Working Group recommended that the survey catch be allocated from total stock catch limit.

4.151 The Working Group evaluated the research proposal in WG-FSA-18/41 against the criteria set out in SC-CAMLR-XXXVI, Annex 7, paragraph 4.7 (Table 7).

Fishery monitoring

4.152 WG-FSA-18/46 summarised the toothfish fishery in the Ross Sea region (Subarea 88.1 and SSRUs 882A–B) together with biological characteristics of the catch of Antarctic toothfish through the 2017/18 season.

4.153 The Working Group noted that despite 2017/18 being the first year of implementation of the Ross Sea region MPA (RSRMPA), most of the fishing effort was carried out in the historically fished areas. There was a small amount of effort in the northern area of SSRU 882A, which was opened to the exploratory fishery for the first time with the introduction of the RSRMPA.

4.154 The Working Group noted that the annual review would form an important source of information in monitoring the changes in behaviour of the fleets and catch rates required to provide advice on the impact of the MPA measures.

SRZ survey

4.155 WG-FSA-18/33 Rev. 1 presented a proposal for a research survey to be conducted by four vessels within the SRZ of the RSRMPA. The proposal was previously considered by WG-SAM (WG-SAM-18/07).

4.156 The research program has the objectives of investigating 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 within SSRU 882A.

4.157 Dr Kasatkina noted that the proposal includes research considered a priority within the research and monitoring plan for the RSRMPA and that the proposal would provide information on regional catch rates and migration, and toothfish and by-catch species diet studies and biological parameters.

4.158 The Working Group welcomed the link of the outcomes of this research with the topics from the research monitoring plan (RMP) (SC-CAMLR-XXXVI/20) presented in the proposal, and also noted recommendations from WG-SAM and Workshop on Spatial Management (WS-SM-18) regarding guidelines for fisheries research conducted in the MPA (Annex 6, paragraphs 6.45 to 6.47 and Annex 7, paragraph 6.2).

4.159 WG-FSA noted that WG-SAM-18 had requested further information on:

(i) the rationale for the change to the catch limits in the revised proposal

(ii) the alternative stock hypothesis that the proposal is trying to test

(iii) why a CASAL assessment or Chapman biomass estimate is required for a subregion within the Ross Sea, when there is an assessment conducted for the wider area

(iv) how the research can be conducted without interaction with the SRZ Olympic fishery.

4.160 In response to the WG-SAM questions the proponents noted that:

(i) The derivation of the catch limits was outlined as being based on an analysis of the Russian research survey conducted within the area in 2011

(ii) The survey will monitor the dynamics of the trends in local biomass within the SRZ resulting from the changes to fishing pressure resulting from the MPA.

(iii) The survey objectives were changed to provision of standardised data on length and age structure to the current CASAL assessment; similar to that provided by the Ross Sea shelf survey. It will allow monitoring of the local dynamics of the toothfish in this area which represents a link between Subareas 88.1 and 88.2. The survey would also provide local biomass trends within the surveyed part of the SRZ to compare with trends in the open areas outside the MPA.

(iv) The proponents advocated reducing interactions with the Olympic fishery by conducting the survey after the Olympic fishery in the SRZ had been closed.

4.161 The Working Group noted that, while the SRZ general objectives are outlined within CM 91-05, there is no mechanism to separate effects of the Olympic fishery and structured research plans and asked the Scientific Committee to consider how this can be achieved.

4.162 The Working Group expressed concerns that a vessel with negligible recaptures of tags was considered for delivering the research objectives of this proposal.

4.163 The Working Group noted that the current design of the survey, in which four vessels fish in four 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.

4.164 The Working Group recalled that WG-FSA-17 and WG-SAM-18 had noted that a systematic survey design was a suitable approach to develop time series of monitoring information from the SRZ, although systematic designs used on fixed stations can be impacted by high sea-ice concentrations, which is a particular problem in this area. The Working Group therefore recommended that a more flexible random stratified design be considered.

4.165 However, the Working Group also noted that the systematic design of the survey 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.

4.166 Dr Kasatkina, noted that the vessel gears would be standardised, as far as possible, by using autolines with 5 000 hooks per line set on 6 km lines with hook spacing of 1.2 m and that, subsequent to a review of the results from the first year of the survey, the survey stratification would be designed with input from WG-FSA and WG-SAM to ensure a survey distribution, by vessel, which permitted testing of vessel effects.

4.167 The Working Group discussed past research by Russia noting that previous surveys had not completed the research program and also outstanding analyses in other areas were yet to be completed.

4.168 The Working Group evaluated the research proposal in WG-FSA-18/31 against the criteria set out in SC-CAMLR-XXXVI, Annex 7, paragraph 4.7 (Table 7).

The CCAMLR scholarship recipient

4.169 Dr D. Di Blasi (Italy), a recipient of the 2018 CCAMLR scholarship, summarised plans for research on *D. mawsoni* in the Ross Sea region (WG-FSA-18/62). The research intends to further develop a non-extractive technique for collecting time series of abundance and investigating size distribution of *D. mawsoni* in areas or seasons not accessible to fishing vessels using baited underwater video cameras deployed through the sea-ice in the Ross Sea.

4.170 The Working Group noted that the research design had previously been presented at WG-EMM-18, which had also provided feedback on developing the experimental design. The Working Group discussed the use of different lighting colours and switching the lights on and off to examine whether lights act as a deterrent, as well as considering examination of fish behaviour in response to guarding the bait.

4.171 The Working Group encouraged future feedback to WG-FSA on the results as non-extractive sampling is of particular interest in monitoring within an MPA.

Subarea 88.2

4.172 WG-FSA-18/36 presented a review of the fishery in the Amundsen Sea region in which the toothfish fishery has operated since 2003. In 2015, a research plan was developed to estimate the toothfish biomass in the area.

4.173 The Working Group noted that few age data are currently available from otoliths collected after 2014 and recommended that further ageing of toothfish be made a priority by Members who have collected otoliths in this area (SC-CAMLR-XXXVI, Annex 7, Table 1) to develop annual ALKs. The Working Group noted previous attempts to encourage the provision of data for this region from the Members fishing there; particularly ageing. Dr Ziegler informed the Working Group that Australia had aged some otoliths from 2015 (WG-FSA-17/15) and just recently finished ageing otoliths collected in 2017.

4.174 The Working Group noted that the current research plan and catch limit distribution by area had advanced the information required for the assessment of the stock, but further development of the stock assessment is needed and relies heavily on adequate mark-recapture and ageing data. 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.

4.175 The Working Group discussed the distribution of fishing effort in the south of Subarea 88.2 across the four research blocks, noting that effort in research blocks 2 and 3 had been consistent recently and that tag recaptures in research block 2 had contributed to local population abundance estimates. However, the allocation of a catch limit to the whole area, and not individual blocks, has resulted also in the majority of the catch being taken in research blocks 2 and 3 and not distributed across all blocks because some areas are not accessible until after the catch limit has been reached in other areas.

4.176 The Working Group recommended that in the south of Subarea 88.2 individual catch limits be applied to each research block.

4.177 The Working Group reviewed the application of the data-limited trend analysis rules (SC-CAMLR-XXXVI, Annex 7 paragraph 4.33) to this region, as applied to the offshore area SSRU 882H and the four inshore research blocks independently.

4.178 The Working Group recommended that the trend analysis rules should be applied independently for each research block in the southern Subarea 88.2 and SSRU 882H consistent with its advice for other areas, based on the analysis presented in WG-FSA-18/36.

4.179 The Working Group noted the development within WG-FSA-18/36 of a sensitivity analysis for the Chapman population estimation process by application of effective tag release and recaptures (to account for different levels of tag survival and tag detection by individual vessels; see WG-SAM-14/30). Using effective tag releases and tag recaptures for the area resulted in a substantial reduction in the Chapman estimated population abundance (11 759 tonnes reduced to 4 419 tonnes); the lower value was more consistent with the CPUE by seabed area estimates.

4.180 Adequate numbers of recaptures were available from research block 882_2 and SSRU 882H for the Chapman method to be used in the trend analysis rule. When applying this rule for research block 882_2, the recommended catch limits were the same when using all or only the effective tag survival and detection rate. However, for SSRU 882H, the recommended catch limits increase to 240 tonnes when using all tag recaptures, while they decrease to 177 tonnes when using only effective tag recaptures.

4.181 The Working Group agreed that further evaluation was required concerning the application of the effective tagging weighting within the Chapman method as, although its application within CASAL assessments has been reviewed and agreed by WG-SAM, WG-FSA, the Scientific Committee and the Independent Review Panel, its application within the Chapman method has not been reviewed.

4.182 The Working Group recommended a review of the application of the effective Chapman biomass calculation method in research blocks in the subsequent application of the trend analysis approach.

4.183 The Chapman estimates for SSRU 882H used the same R code (BERT package) to derive the estimates using a single year at liberty, which is consistent with the approach taken in Subarea 48.6 for seamount research blocks (486_2 and 486_3). The results are presented in Table 8.

Subarea 88.2 stock assessment

4.184 WG-FSA-18/37 presented progress towards an integrated stock assessment model for *D. mawsoni* in the Amundsen Sea region, defined here as SSRUs 882C–H. The region is modelled as two areas: the North (SSRU 882H) comprising large mature fish, and the South (SSRUs 882C–G) comprising a mix of large mature fish and small immature fish.

4.185 Two-area stock assessment models were first developed for the region in 2014 and refined in 2015 and 2016. Results showed the need to collect mark-recapture data in the South to inform the estimation of biomass in the South. Simulation work undertaken in 2017 showed that if tag recaptures continued in the south, and were spread among research blocks, a model may be developed for management advice.

4.186 In 2018, the assessment models were fitted to the proportions-at-age in the catch, and the mark-recapture data from the two areas. The results suggest that data from the research plan are starting to inform the model, especially with respect to the size of the population in the south and migration rates between areas.

4.187 The Working Group noted that at this stage the model should only be used as indicative of the current status and trends in the stock due to issues including poor fit to the age data in the south, the lack of year-specific age frequency data to inform these fits, the lack of observed tag recaptures which have moved from north to south, and the limited spatial overlap of fishing effort and available tags in the south.

4.188 While noting the caveats concerning the fit of the model, the Working Group agreed that the current management advice is precautionary considering the yield associated with the fitted model for the southern research blocks is consistent with the proposed catch limit in the fishery.

Subarea 88.3

Ukraine

4.189 The Working Group considered a new research proposal for *Dissostichus* spp. in Subarea 88.3 by Ukraine outlined in WG-FSA-18/16 Rev. 1 (previously presented as WG-SAM-18/12). The proposed research will conduct analysis on the life cycle of *D. mawsoni* by fishing at a range of depths across the area. Associated research included conducting conductivity temperature depth probe (CTD) and plankton sampling, which would be analysed by the University of British Columbia. The vessel had been equipped with full electronic monitoring for monitoring catch and by-catch.

4.190 The Working Group noted that there were insufficient details in the proposal to conduct a full evaluation of the recommendations made by WG-SAM-18 (Annex 6, paragraphs 6.74 to 6.76). Particularly, the Working Group considered that there was uncertainty around:

(i) the process by which the Ukrainian proposal could be integrated with the existing research proposals from the Republic of Korea and New Zealand

(ii) standardisation of the research results given the proposed research blocks were not overlapping to allow calibration between vessels

(iii) what the added value of an additional vessel would bring to the research, particularly given that Ukraine was committed to delivering many milestones across a number of proposals.

4.191 WG-FSA recommended that Ukraine should continue efforts to coordinate its research efforts with Korea and New Zealand.

4.192 Dr Demianenko noted that Ukraine considered that the proposal would add value to the New Zealand and Korean research by enabling better coverage of the area and provide valuable oceanic and plankton data for the region.

4.193 The Working Group evaluated the research proposal in WG-FSA-18/16 Rev. 1 against the criteria set out in SC-CAMLR-XXXVI, Annex 7, paragraph 4.7 (Table 7).

Korea and New Zealand

4.194 WG-FSA-18/42 presented a proposal by Korea and New Zealand for an additional three years of research, in Subarea 88.3, during 2018, 2019 and 2020, that is designed to continue Korea's previous research. The study would focus on research blocks where tagged fish have previously been released on the slope, whilst also sampling two of the northern seamount complexes and two boxes on the southern shelf, where little or no fishing has occurred to inform stock structure hypotheses.

4.195 The main objective of the proposal is to determine the abundance and distribution of Antarctic toothfish in Subarea 88.3. Secondary objectives are to improve the understanding of stock structure of toothfish in this area, to carry out calibration trials between the two vessels, to collect data on the spatial and depth distributions of by-catch species, and to trial electronic monitoring using video cameras.

4.196 The Working Group noted that:

(i) the New Zealand vessel did not complete the survey because the vessel could not access the southern research blocks due to heavy sea-ice conditions and safety considerations and this had delayed the achievement of the milestones

(ii) no toothfish had been recaptured during the survey and this was likely due to the low catches and ice/weather conditions.

4.197 The Working Group recognised that aggregating length distributions across research blocks can create bimodal length distributions which can impact tag overlap statistics. The Working Group recommended that the tag-size overlap should be considered for each block separately in order to ensure that a representative distribution of fish lengths is tagged (Annex 6, paragraph 6.1).

4.198 The Working Group noted that an agreement on sharing the catch limit had been in place, with unused catch from one of the vessels being made available by the second vessel through Member communication.

4.199 The Working Group evaluated the research proposal in WG-FSA-18/41 against the criteria set out in SC-CAMLR-XXXVI, Annex 7, paragraph 4.7 (Table 7).

4.200 WG-FSA-18/21 presented the results of an analysis of the trophic niche of Antarctic toothfish caught in Subarea 88.3 as inferred from fatty acids and stable isotopes. The data were collected from the muscles of toothfish in Subarea 88.3 of the Pacific Ocean sector, the Ross Sea shelf and the Indian Ocean sector of the Convention Area during 2012–2017.

4.201 The research found significant differences in size distributions of regional toothfish stocks, demonstrating an ontogenetic movement into deeper water from shelf water. The relative fatty acid proportions of the Indian Ocean and Pacific Ocean stocks were similar to each other but differed from those of the Ross Sea Shelf. Isotopic differences between the shelf and slope stocks were detectable in both $\delta 13C$ and $\delta 15N$ values.

4.202 The regional variations in trophic niche were explained by different patterns in resource utilisation, which are partitioned into two prey groups (i.e. feeding on bathypelagic vs. bathydemersal organisms), between regions and toothfish size, reflecting diet shift during ontogenetic migration across the geographic range of Antarctic waters as confirmed by the combined mixing-model calculations of both trophic markers.

4.203 The Working Group noted that differences between regions in the size at which fish move to deeper water may account for some of the variation in recorded trophic niche.

4.204 The Working Group recommended that it would be beneficial to bring together information from tagging movements, diet and genetics studies in a review that would allow design of future research and sampling programs. In addition, regular monitoring could lead to a monitoring tool that could identify responses to climate change or fishing pressure.

Other fisheries research

Crabs

4.205 WG-FSA-18/32 Rev. 1 presented a revised proposal for new research on crabs in Subareas 88.2 and 88.3 to be conducted by two Russian vessels. The proposal was first submitted to WG-SAM as WG-SAM-18/06 where it was presented as a research plan under CM 24-01.

4.206 The objective of the three-year research program is to study the species composition, biology, life cycle, distribution and structure of the crab stocks to assess their fishery potential in the Bellingshausen Sea (Subarea 88.3) and Amundsen Sea (Subarea 88.2). The target species of the research is any lithodids (king crabs).

4.207 The Working Group noted the modification of the sampling design to include biodegradable escape panels and fishing effort stratified across depths, as requested by WG-SAM-18 (Annex 6, paragraph 6.66). The Working Group noted that the spatial and depth distributions of crab species were poorly known in this region and that initial exploration of the distribution of those species might benefit from substantially reducing the number of pots per line set along an isobath from the 120 pots/line proposed.

4.208 Dr Kasatkina recommended to use 120 pots per line for the first season and additionally conduct sets with reducing number of pots per line. Experience from the first season will provide actual data on number of pots per line that would be appropriate.

4.209 The Working Group was unable to evaluate an optimum number of pots per line for use in this research program and requested that the Scientific Committee consider an appropriate level and distribution of effort to conduct this research.

4.210 The Working Group noted that the distribution of crabs in the Southern Ocean was a topic of considerable scientific debate with a recently developed hypothesis suggesting that crabs may have ‘invaded’ the Southern Ocean from lower latitudes as water temperatures have increased with climate change (Smith et al., 2012; Griffiths et al., 2013; Aronson et al., 2015). The Working Group noted that the planned research may provide useful evidence to test the competing hypotheses on crabs as endemic or invasive in this region.

4.211 The Working Group noted that the crab species targeted by this research have not been studied in detail in the Pacific sector of the Convention Area, and key biological parameters such as size distribution, maturity and distribution are unknown. The Working Group recommended that a review of the scientific literature be undertaken to establish whether preliminary estimates of such biological parameters were available for related crab species in the CAMLR Convention Area or in other areas.

4.212 The Working Group noted that the aim of the research is to retain only male specimens that are above the size at sexual maturity. Since there was apparently no information on the size distribution or size at maturity for the species that may be encountered, the Working Group noted that there would be scientific benefits if samples of all catch were retained in order to estimate size at maturity for all species and both sexes. In addition, measuring all crabs would provide information on the size composition of the crab populations with depth and area and inform estimates of the size selectivity of the fishing gear. It was noted that in a previous crab fishery in Subarea 48.3 (Belchier and Peatman, 2012) the retained catch of mature males only made up a small proportion of total catch and this made the fishery commercially unviable.

4.213 The Working Group expressed concerns about the impact of the pots on VMEs. The Working Group noted that assessing the impact of pots on benthic organisms is difficult as few specimens were likely to be brought to the surface. In order to provide information on the footprint of the fishing gear, its impact on the seafloor and the habitats sampled, the Working Group recommended to use deep-water cameras such as those deployed in several CCAMLR toothfish fisheries (e.g. WG-FSA-14/P06) to assess the habitats present where fishing occurred, observed interactions and evaluate the impact of pots on benthic habitats.

4.214 The Working Group noted that tagging and releasing all toothfish caught as by-catch (above the proposed 5 tonne catch limit) could affect other research on *D. mawsoni* in Subareas 88.2 and 88.3. The Working Group noted that toothfish and other fish by-caught in pots were often preyed upon by amphipods and that this may impact on the suitability of toothfish in pots for tagging, and the ability to provide accurate estimates of quantities of by-catch. The Working Group further recommended that only toothfish assessed as suitable for tagging should be tagged and released as part of this research.

4.215 The Working Group noted that WG-SAM had requested that the Scientific Committee provide advice on the status of the proposed research and whether it should be considered as a new fishery under CM 21-01 rather than as a research proposal under CM 24-01. The Working Group recalled that the last crab fishing to take place in the Convention Area was undertaken by Russia in Subarea 48.2 in 2009.

4.216 The Working Group noted that an experimental harvest regime was utilised in previous crab fisheries in Subareas 48.2 (CM 52-02, Annex 52-02/C) and 48.3 (CM 52-01, Annex 52-01/C) that included specific requirements for effort to be placed in a grid of research blocks. It noted that these experimental research blocks were positioned across shallow shelf areas (<200 m) to slope depths in order to collect information on the spatial distribution and stock structure of crabs.

4.217 The Working Group recommended that if the Scientific Committee agreed that the research should proceed, the first season of the research should be considered as a pilot study. Detailed results would be presented to WG-FSA-19 to enable an evaluation of results, a preliminary assessment of the distribution and abundance of crabs in the region and appropriate design for further research. The Working Group also recommended that the catch and effort data be submitted according to CM 23-05 using the C5 form and that SISO data should be collected using the e-POT(2013) form.

Toothfish genetics

4.218 WG-FSA-18/64 provided an update on the *D. mawsoni* genetic connectivity project (WS-DmPH-18/08). A large number of tissue samples have been made available for this project from nine CCAMLR Members, and DNA was extracted from 761 samples with 551 samples containing sufficient quality and quantity to be sequenced. Results from this project will be presented at WG-FSA-19.

4.219 The Working Group noted that Members willing to get involved in potential future analyses, such as in Subarea 48.6 or the South Pacific Regional Fisheries Management Organisation (SPRFMO) area, were invited to send their samples and relevant biological data to the Australian Antarctic Division (AAD). The Working Group also noted that mechanisms to facilitate the linking of data for fish sampled for DNA could be developed as part of the CCAMLR data warehouse project.

Acoustic data collection

4.220 WG-FSA-18/05 presented analyses of acoustic data obtained during the austral summer of 2018 as a complement to finfish research in Subareas 48.1 (Elephant Island) and 48.2 (South Orkney Islands). The survey documented the spatial distribution of fish and Antarctic krill in the area of study. Concentrations were identified considering their bathymetric distribution, shoal shape, size structure provided by the echosounder, samples obtained with a midwater and bottom trawls and through expert judgment. The Working Group recommended stronger experimental design in future acoustic surveys and to ask SG-ASAM to review future survey designs.

4.221 The Working Group noted that acoustic monitoring is a recognised method to study fish distribution and abundance, particularly in areas closed to fishing or where trawling is banned. However, it noted that despite improved technology, quantitative analyses regarding fish or krill biomass estimates were lacking from WG-FSA-18/05. The Working Group requested that SG-ASAM provide advice on current best practise in the use of multi-frequency acoustic data to assist with the design of acoustic surveys to assess the distribution of fish in the Convention Area.

Toothfish fisheries adjacent to the Convention Area

4.222 WG-FSA-18/39 reported on an exploratory research program for toothfish in the SPRFMO Convention Area in August 2016 and September 2017. Results showed that *D. mawsoni* also spawn north of 60°S and that the sampled size composition was similar to those observed in the northern region of CCAMLR Subareas 88.1 and 88.2.

4.223 The Working Group noted that catches from the SPRFMO exploratory fishery were included into the integrated stock assessment model (CASAL model) implemented for the Ross Sea region in 2017, which was considered precautionary given the stock hypothesis in this region.

4.224 The Working Group reviewed WG-FSA-18/53 Rev. 1 which presented data about eleven *D. eleginoides* recaptures in the SIOFA management area by two Spanish vessels. These tagged fish were released in the CCAMLR management area in Divisions 58.5.1 and 58.5.2 and Subarea 58.6. The years at liberty were between 3 and 10 and 6 out of 10 fish travelled a very long distance exceeding 1 000 km. Spanish vessels have fished occasionally for toothfish and other species in the southwest Indian Ocean.

4.225 The Secretariat recalled ongoing work with the Secretariats of the Southern Indian Ocean Fisheries Agreement (SIOFA) and SPRFMO to operationalise the respective MOUs (www.ccamlr.org/node/74517) including data-sharing protocols, cooperation on tagging programs and toothfish catch reporting.

4.226 The Working Group welcomed this active cooperation between the respective Secretariats, noting that there was a need to increase integration of toothfish research and stock assessment taking account of movement of toothfish across the Convention Area's northern boundary.

4.227 The Working Group noted that most of the fish that travelled long distances were sub-adults, which was similar to findings from Subarea 48.3 (WG-FSA-14/49) and that movement frequency, directions and distances were consistent with previous movement studies conducted in Subareas 48.3 and 58.6 and Divisions 58.5.1 and 58.5.2 (e.g. WG-FSA-15/55, WG-SAM-17/11).

Research on non-target species

4.228 WG-FSA-18/47 presented a comparative morphometric analysis of sagittal otoliths of three Channichthyids (*Pseudochaenichthys georgianus*, *Chaenocephalus aceratus* and *C. gunnari*) collected during a finfish research survey in Subareas 48.1 (Elephant Island) and 48.2 (South Orkney Islands) in 2016. The Working Group noted that a feature common to all the species of icefish studied was significant asymmetry between left and right otoliths.

4.229 WG-FSA-18/74 examined the age determination and precision of age estimation on two myctophid species, *Electrona carlsbergi* and *Protomyctophum bolini* sampled from stomach contents of king (*Aptenodytes patagonicus*) and macaroni (*Eudyptes chrysolophus*) penguins on Marion Island. Results indicated that king penguins fed more on small myctophids. The authors highlighted the importance of ageing validation, particularly those age data being used for stock assessment.

4.230 The Working Group noted that investigating myctophids composition in penguin diet can provide information on ontogenetic changes in their foraging and energetics distribution through life stages and recommended that future diet analyses consider the influence of these factors.

4.231 WG-FSA-18/76 presented results on fatty acids composition of spiny icefish (*Chaenodraco wilsoni*) in the Bransfield Strait (in Subarea 48.1). This species used to be commercially fished and is currently caught as by-catch in the krill fishery.

4.232 The Working Group welcomed the study on a species that has received relatively little attention but is an important species in the regional ecosystem. The spatial variations in fatty acids composition in the study area suggested that *C. wilsoni* do not move much which could have implications for risk-based by-catch management in the krill fishery.

4.233 The Working Group encouraged biological studies on fish caught as by-catch in the krill fishery to progress risk assessment approaches for by-catch species, as discussed for toothfish fisheries under Item 6.

4.234 The Working Group noted that research on myctophids in the CAMLR Convention Area is very important given their key role in the ecosystem. The chair of Scientific Committee indicated that there had been preliminary discussion with SCAR to organise a joint CCAMLR/SCAR symposium focussing on the 'Role of fish in the Southern Ocean ecosystem'. The Working Group encouraged the development of joint meeting between SCAR and CCAMLR planned for 2020.

Zooplankton data collection

4.235 WG-FSA-18/19 presented preliminary results on mesozooplankton composition and abundances in 53 stations located in the Scotia Sea, Weddell Sea and Amundsen Sea in austral summer 2017/18. Zooplankton data were collected during research fishing from four Ukrainian vessels using vertical tows with fine mesh size (100 µm) set during daylight.

4.236 The Working Group noted that these data provided useful information on components of the pelagic ecosystem in the area and encouraged Members collecting data on zooplankton to make them available to global initiatives such as the *Biogeographic Atlas of the Southern Ocean* and through database web portals such as www.biodiversity.aq.

4.237 The Working Group noted that krill larvae had been identified in the samples and that this information should be brought to the attention of WG-EMM.

Oceanographic data collection

4.238 WG-FSA-18/04 presented a report on oceanographic data collected on longlines and plankton nets using CTD loggers on Ukrainian vessels in SSRUS 881C–I from the Ross Sea and SSRUs 882 D, E and F from the Amundsen Sea and Weddell Sea during the 2017/18 season. Some of these results were presented at WG-SAM (WG-SAM-18/27). Temperature-depth profiles from each region were compared and tables with temporal trends in bottom temperatures were presented.

4.239 The Working Group recalled previous advice from WG-SAM regarding the need for calibration of these compact CTDs to avoid misleading interpretation due to drift in sensors.

4.240 The Working Group recommended that this oceanographic data be made available to established data infrastructures such as SCAR/Scientific Committee on Oceanic Research (SCOR) through the SOOS rather than providing the data to the CCAMLR Secretariat (Annex 6, paragraph 5.12).

Scheme of International Scientific Observation (SISO)

SISO developments

5.1 WG-FSA-18/11 presented a revised SISO observer manual to the Working Group for consideration and observer metrics from an analysis of error rates during the processing of the new observer forms voluntarily trialled by some Members in the 2018 season, as well as overall observer performance in SISO.

5.2 The Working Group thanked SISO observers for their dedication and hard work in the 2017/18 season.

5.3 The Working Group welcomed the reduction in processing errors with the new logbook. The Working Group noted that it was difficult to consider objective measures of observer performance metrics as there is currently no readily available summary of how sampling and reporting requirements have changed throughout the existence of SISO. The Working Group requested that the Secretariat provide WG-FSA-19 with a summary of reporting and sampling requirement changes over time, which would also address one of the WG-FSA priorities for data management (Table 1).

5.4 The Working Group encouraged further intersessional work with Members and the Secretariat on the observer manual and recommended the following elements to guide its structure and content to ensure SISO observer sampling tasks are clear:

(i) the separation of the single manual into separate manuals for finfish and krill target species

(ii) the manual content be focussed for use by observers when at sea, rather than a comprehensive document containing all relevant CCAMLR resources (e.g. text of the Scheme of International Scientific Observation, by-catch guides), but that these other resources be made available as annexes that can be downloaded if desired

(iii) noting that standard SISO sampling requirements exist for new and exploratory *Dissostichus* spp. fisheries (www.ccamlr.org/node/81589), the Working Group further encouraged the development of standard SISO sampling requirements for other species

(iv) consider the potential addition of sampling requirement annexes for established fisheries

(v) the Secretariat present the revised observer manuals to WG-EMM-19 for discussion and endorsement.

Observer training application

5.5 WG-FSA-18/30 presented a phone application, developed based on previous work by Mr Gasco for CCAMLR (www.ccamlr.org/node/92048), aimed at improving observer identification skills. The Working Group thanked Mr Gasco for the further development and improvement of the training tool. The Working Group noted that Mr Gasco has developed, and provided CCAMLR with, several guides and tools over many years, which have improved and facilitated the work of SISO, and thanked him for his continual presentation of developments to CCAMLR designed to improve observer performance.

Non-target catch and ecosystem impacts of fishing

Fish by-catch

6.1 WG-FSA-18/14 provided an updated meta-analysis by the Secretariat of target and by-catch reported in all CCAMLR exploratory fisheries (as an update to analyses presented in WG-SAM-15/23 and WG-FSA-15/04 Rev. 1). Analyses of the number of fish belonging to target species divided by the total number of fish caught (the target catch ratio) was used as a simple metric of the relative level of target and by-catch reported for each haul. Analyses were carried out by gear type, vessel and Flag State and the results were broadly consistent with those reported in 2015 where little variation due to gear type or area was observed but apparent reporting differences between Members were evident.

6.2 The Working Group recalled that by-catch reporting is a vessel responsibility and noted that fishing gear and spatial effects on by-catch catch rates are well documented in CCAMLR fisheries. However, differences in reporting of by-catch between Members will mask these effects and make an evaluation of gear and spatial effects within the exploratory fisheries more difficult.

6.3 The Working Group recalled that for those Members reporting low by-catch (high catch ratio) in the 2015 analysis it was noted from responses to COMM CIRC 15/74–SC CIRC 15/44 that the 'observer has primary responsibility for C2 data collection'. The Working Group noted that there has been no more recent information provided by Members on how by-catch is reported by vessels. The Working Group noted that the catch ratios calculated for Spain in the current analysis were lower (higher by-catch) than those in 2015 suggesting a change in the way that by-catch was reported by this vessel. The Working Group noted that there had been no change in gear configuration used by the *Tronio* over this period so was likely to be a result of improved by-catch reporting.

6.4 The Working Group agreed that, in order to address the apparent inconstancies in the way in which by-catch is recorded between vessels, it would be useful for the Scientific Committee to further develop clear instructions to vessels on how by-catch should be reported as recommended by the Commission in 2015 (CCAMLR-XXXIV, paragraphs 3.31 to 3.35). It was noted that this could be linked to any redevelopment of the C2 forms (paragraphs 2.12 to 2.18) and associated development of guidelines for C2 form completion.

6.5 The Working Group noted that the voluntary use of electronic monitoring is now widespread across many Members' vessels and this offered a means by which by-catch reporting could be greatly improved and could allow analyses to be undertaken more frequently.

6.6 The Working Group noted that for some areas it would be possible to develop by-catch profiles similar to those presented at the meeting (e.g. WG-FSA-18/28) which could provide some bounds on the expected composition and catch rates of by-catch within an area. Interpreting such information between areas would be facilitated by the development of standard reporting metrics for by-catch and these would need to include temporal and spatial effects. The Working Group noted that a standard reporting metric, analogous to the way in which tagging performance is evaluated, could be useful in the evaluation of research proposals to assess the performance of vessel by-catch reporting.

6.7 The Working Group noted that the differences in by-catch reporting highlighted in the analyses in the exploratory fisheries meant that it may be difficult to evaluate the level of by-catch removals across a fishery. The Working Group agreed that data on by-catch in CCAMLR fisheries are fundamental to the aims of Article II of the CAMLR Convention and expressed its concern that these data were not being provided in a way that would allow by-catch levels in those fisheries to be addressed. Furthermore, the apparent lack of consistent reporting of by-catch data has implications for the application and compliance with elements of conservation measures that relate to by-catch, such as move-on rules and overall by-catch limits.

6.8 WG-FSA-18/09 provided a summary of the implementation of the by-catch move on rules in CCAMLR exploratory fisheries between 2010 and 2018, based on catch and location data prepared by the Secretariat. The Working Group noted that there had only been a small number of instances where the move-on rules (as detailed in CM 33-03) had been triggered. A post-hoc analysis of C2 data identified a very small number of incidences where the vessels did not move-on as required.

6.9 The Working Group recalled that there were two components to the by-catch move-on rules: a line-specific move-on rule triggered if by-catch of any species exceeds a tonne on a single line and a macrourid-specific cumulative move-on rule. It was noted that the chances of triggering the cumulative move-on rule, based on two consecutive 10-day reporting periods, was likely to be low in exploratory fisheries such as the Ross Sea region toothfish fishery where the catch is taken over an increasingly short period. The Working Group recalled that responsibility for implementing the move-on rules lies with the vessel.

6.10 The Working Group considered whether the current system of by-catch and move-on rules was achieving its objectives noting that it was an effective means of moving a vessel with high by-catch rates away from an area without affecting those vessels that had low by-catch rates. Move-on rules were also likely to move effort away from local regions of high by-catch density.

6.11 The Working Group noted that the catch limits for by-catch within the exploratory fisheries are based on a ratio of by-catch to target species (16%) which was derived from historical *D. eleginoides* catch to by-catch ratio from Division 58.5.2. It was noted that it was unclear whether by-catch limits that are based on a ratio of by-catch to target species are consistent with Article II, and alternative methods for setting by-catch limits may need to be developed and evaluated. These measures may include spatial management measures to reduce the impact on by-catch species in areas where they aggregate.

6.12 The Working Group noted that since the by-catch limits and move-on rules were introduced there have been considerable advances in data-limited risk assessment methods that should be considered in order to evaluate and revise the current 16% catch limit in exploratory fisheries. Data from fisheries-independent surveys of by-catch species are available for some areas (i.e. macrourids in Subarea 88.1) and this provides a means of assessing the level of risk posed to stocks of by-catch species under current rates of removals. Assessment methods could also include the use of information on changes in species ratios in the commercial catch.

6.13 The Working Group also noted that currently all by-catch limits are specified by weight rather than by number. Data on numbers of by-catch removals are available in the C2 data and this may be a more informative and appropriate measure of by-catch than removals by weight alone. The Working Group noted that there is a need to obtain more information on the dynamics of populations of by-catch species and to consider species groups at a higher taxonomic resolution.

6.14 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. However, the Working Group noted that unless the inconsistencies in the reporting of by-catch between vessels in exploratory fisheries are addressed, progress on the development of methods for providing management advice on by-catch within exploratory fisheries will remain problematic.

6.15 WG-FSA-18/28 provided a comprehensive report on fish by-catch during exploratory fishing activities undertaken in Divisions 58.4.1 and 58.4.2 from 2012 to 2018. The report presented details of temporal, spatial and bathymetric trends in species composition and CPUE. In addition, new information on the reproductive ecology and sex ratios of the most common by-catch species was presented. The Working Group encouraged Members to produce such studies on by-catch from other exploratory and research fishing activities.

6.16 WG-FSA-18/68, 18/69 and 18/70 reported on the spatial pattern of major by-catch fishes in Subarea 48.6 and Divisions 58.4.3a and 58.4.4b during 2012/13–2016/17. The Working Group noted that the research plan for these areas aims to develop estimates of key biological features of dependant species, and that there is enough information available in Subarea 48.6 to conduct estimates for the most common species listed in WG-FSA-18/70.

6.17 The Working Group noted that there were some inconsistencies between the C2 and observer datasets from Subarea 48.6 and Divisions 58.4.3 and 58.4.4 and asked for further clarification on whether the observer data was scaled-up or represented the sampling period only. The Working Group noted that in Divisions 58.4.3a and 58.4.4b the two vessels conducting research used different gear types and the effect of this on the reported distribution and density of by-catch species should be investigated further.

6.18 WG-FSA-18/25 reported on squaliform shark by-catch data between 2006 and 2016 from within Division 58.5.1. Four species of sharks were reported with *Etmopterus viator* comprising 99% of the total shark catch (by number). Catches of *Somniosus antarcticus, Centroscymnus coelolepis* and *Lamna nasus* were also reported. An abundance index (number of sharks per 1 000 hooks) was used to show differences in spatial and bathymetric distributions of these species. Biological data such as length frequency by sex were also presented for *E. viator*. A new identification sheet for sharks in Division 58.5.1 has been developed by Mr Gasco.

6.19 The Working Group thanked the authors for bringing the outcomes of these analyses to the Working Group and presenting this work as there has been little information or discussion in previous years on shark by-catch in this area.

6.20 The Working Group noted that a tagging study for *E. viator* could provide an estimate of biomass in the area if it is possible to release sharks alive and in good condition. The Working Group noted that methods have been developed to evaluate post-release survival for sharks which could be applied to *E. viator*.

6.21 The Working Group noted the presence of few localised hotspots of *E. viator* in the eastern and southeastern part of Division 58.5.1 which would need further investigation. The Working group noted that *E. viator* are small sharks and typically smaller than most toothfish caught by longline and suggested to investigate the effect of size and type of hooks on *E. viator* by-catch rate.

6.22 The Working Group noted that *L. nasus* distribution may be linked to changes in weather or sea temperature. It was also noted that catches of *L. nasus* and sleeper sharks had been reported across the Kerguelen Plateau in Division 58.5.2 as well as *L. nasus* in Subareas 48.3 and 58.7.

6.23 It was noted that *E. viator* was only described as a separate species in 2011, and that in other areas identification of several shark species groups (e.g. *Etmopterus* spp. and *Somniosus* spp.) can be difficult.

6.24 The Working Group requested that the Secretariat update the species codes used in the CCAMLR database as some species of shark (e.g. *S. antarcticus* and *E. viator*) have currently no specific codes for use in data reporting.

6.25 WG-FSA-18/63 presented a data summary of shark by-catch reported throughout the CAMLR Convention Area based on data held at the CCAMLR Secretariat to support discussions requested in CCAMLR-XXXVII/30. Shark by-catch between 1996 and 2017 by statistical subarea, Member and gear type was investigated. The paper noted that whilst there may have been an increase in the trend in shark by-catch over the last 10 years, there were substantial gaps and some inconsistencies throughout the dataset.

6.26 The Working Group noted the debate around the taxonomy of *Somniosus* spp. in the Convention Area (similar to the discussion started during WG-FSA-18/25). It was noted that the great longevity of *S. microcephalus* outlines the particular vulnerability of sleeper sharks to overfishing. It was also noted that species such as *L. nasus* are globally protected by initiatives by the United Nations General Assembly (UNGA), the 'Convention on the Conservation of Migratory Species of Wild Animals' (CMS) and the Convention on International Trade in Endangered Species (CITES).

6.27 The Working Group noted that shark species varied in their distribution range, that some have a global distribution and the Southern Ocean is likely to be at the southern limit of their range. It was noted that climate change may have an impact on species ranges, and this could be assessed by analysing changes of their biogeography and of spatial abundance data over time.

6.28 The Working Group noted that changes in by-catch reporting between vessels and over time made interpreting trends in reported shark by-catch difficult (paragraph 5.3). The Working Group noted that the CCAMLR 'data warehouse' plan and development and input from the DMG on metadata provision (Table 1) is intended to address these issues.

6.29 The Working Group suggested that the design of fishing gear such as hook size could be investigated for mitigation potential to reduce shark by-catch. The Working Group also discussed the feasibility of releasing large caught sharks (e.g. *Somniosus* spp.) alive, noting that they are sometimes dead upon hauling, wrapped in the longline. The Working Group recalled that when possible all sharks should be released alive in accordance with CM 32-18. It was also discussed that due to the size of *Somniosus* spp. and *L. nasus* it may not feasible to measure and retain them.

6.30 The Working Group noted that future studies aimed at assessing trends in shark abundance in the Southern Ocean should be considered in the context of their global biogeographic distributions. It was also recommended that biological data and genetic samples be collected where possible, as samples of rarer shark species are sought after by shark geneticists and may help resolve the species identity and stock structure of the *Somniosus* spp. caught in the Convention Area.

6.31 To assist in improving the submission of adequate and sufficient data on sharks, the Working Group recommended:

(i) consider the value of the catch information recorded as numbers in addition to weight and how it could potentially be used or improved toward understanding the status and trends of shark species in the Convention Area

(ii) to assist in species identification issues, various guides on shark ID should be collated and made available by the Secretariat to all vessels and scientific observers

(iii) a review of historical records on sharks submitted to the Secretariat should be undertaken to identify errors. Further, the Scientific Committee and Commission, working with the Secretariat, vessel operators and scientific observers, should explore mechanisms to improve the quality of future data collection on sharks

(iv) exchange of information with regional fisheries management organisations (RFMOs) adjacent to the Convention Area to facilitate the development of biogeographic analysis of present and assumed future distribution of sharks in the Convention Area and adjacent areas and to put CCAMLR fisheries shark by-catch in context.

Status and trends in finfish by-catch

6.32 WG-FSA-18/38 outlined an analysis of previous *Amblyraja georgiana* tagging within Subareas 88.1 and SSRUs 882A–B. The paper provided Chapman biomass estimations for the period 2010 to 2018 (excluding 2012) ranging between 3 257 and 11 685 tonnes with CVs between 0.32 and 0.42. Sustainable exploitation rates were estimated for both a low and a high productivity scenario and suggested that the gammas for *A. georgiana* were 1.6% and 2.8%

respectively. The estimated exploitation rate for *A. georgiana* in Subareas 88.1 and SSRUs 882A–B, based on Chapman estimates, was estimated to be between 0.2% (assuming all released skates survived) and 0.6% (assuming all released skates had 100% mortality).

6.33 The authors suggested performing a second two-year focussed tagging program within this area in the 2019/20 and 2020/21 seasons, broadly consistent with the previous tagging period in 2009 and 2010. They also suggested some additional data collection associated with the tagging, such as tag-releasing skates in all conditions but noting their injuries to estimate associated mortality rates and including an age validation study (see Gallagher and Nolan, 1999) using chemical marking of released skates. The authors further noted a large proportion (50%) of tagged skates should be marked to chemically label thorns for age validation studies (Gallagher and Nolan, 1999). Marking kits could be provided to vessels notifying to fish in the Ross Sea region for the 2019/20 fishery. At recapture, skates would be biologically sampled for disc width, sex and caudal thorns. Caudal thorns could be coordinated to be shipped to National Institute of Water and Atmospheric Research (NIWA) in New Zealand for analysis.

6.34 The Working Group noted that interpretation of ages using thorns in skates was difficult, and that skate vertebrae have also been used to determine ages. The Working Group encouraged further research to compare ageing approaches and ageing validation for skates using thorns and vertebrae.

6.35 The Working Group noted that compared to the previous tagging experiment, the fishery now has a higher proportion of effort in areas where *A. georgiana* occur. However, the Working Group noted that a large portion of this species' distribution was also within the general protection zone (GPZ) of the RSRMPA.

6.36 The Working Group agreed that a second focused tagging program be conducted in 2019/20 and 2020/21 in the Ross Sea region and recommended:

(i) the skate tag-release program be conducted for a minimum of a two-year period, during which an evaluation is conducted as to the benefit of continuing as an ongoing measure

(ii) the tagging rate be all live skates up to 15 per line

(iii) the area of the program be limited to the exploratory fishery in Subareas 88.1 and SSRUs 882A–B

(iv) the e-longline logbook be updated to include a column with dropdown menus to record skate condition, the guide to the injury assessment (described in WG-FSA-18/38, Figure 6, Figure 6 of this report) be added to the e-longline skate tagging instructions, and the suitability assessment guide in the skate tagging protocols be updated for Subarea 88.1 and SSRUs 882A–B to include the injury assessment

(v) chemical marking be on a voluntary basis with interested Members working with New Zealand to co-ordinate the methodology (see details in WG-FSA-18/38 Rev. 1)

(vi) sampling protocols for age structures to be collected will be developed intersessionally in time for the 2019/20 season

(vii) CMs 41-01 and 41-09 be updated this year to include the tagging requirements for this program for the 2019/20 and 2020/21 seasons. Specifically, a new paragraph be added to CM 41-01, Annex 41-01/C after paragraph (v):

'During the 2019/20 and 2020/21 seasons, each longline vessel operating in Subareas 88.1 and SSRUs 882A–B shall tag and release by-caught skates according to the CCAMLR Tagging Protocol, as specified in the conservation measure for that fishery. All tagged skates must be double-tagged and released alive.'

(a) And paragraph (ix) be updated to read:

'Recaptured tagged skates should be identified to the lowest possible taxonomic level and biologically sampled (pelvic length and disc width, weight, sex, gonad stage, and caudal thorns for samples in Subareas 881 and SSRUs 882A–B). Two electronic time-stamped photographs should be taken, one of the whole skate with tag attached and one close-up of the tag detailing the number and colour of the tag.'

(b) And CM 41-09 paragraph 6, a paragraph stating:

'All live skates, irrespective of condition and up to a maximum of 15 per line, shall be tagged following CM 41-01, Annex 41-01/C. Skate, and the species, disc width and injury category should be recorded along with tag numbers.'

(c) Inserted before the following paragraph:

'Unless otherwise specified by scientific observers, all other skates and rays caught alive and with a high probability of survival should be released alive, by vessels, by cutting snoods, and when practical, removing the hooks, and the number should be recorded and reported to the Secretariat.'

(viii) The Secretariat make S-series t-bar tags available for this program and make them available to be ordered.

6.37 WG-FSA-18/73 presented work on the genetics of the skates *A. georgiana* within Subarea 48.3. Previous studies indicated that there may be three *Amblyraja* species in this region, including two morphs of *A. georgiana* (WG-FSA-02/54) and *A. taaf*. This paper examined the genetic relationships between the two species and two morphs and concluded that while there are clear morphological differences between *A. georgiana* and *A. georgiana* sp. anon, at genetic level, location is more indicative of species than morphology. The paper highlighted that a low level of mixing of the *Amblyraja* populations between Subareas 48.3 and 48.4 may occur.

6.38 The Working Group noted that based on these results, to facilitate the work of scientific observers in Subareas 48.3 and 48.4 (see also WG-FSA-18/27), the species identification for *Amblyraja* could be limited to the generic *Amblyraja* spp. code (SRX), as this species seems to have a number of morphotypes.

6.39 WG-FSA-18/27 provided an update on stock status of *A. georgiana* in Subarea 48.3. This is a by-catch species in the longline *D. eleginoides* fishery. The update used a Chapman estimated biomass to explore trends in biomass of this species. The biomass estimates ranged from 73 to 1 664 tonnes with fishery exploitation rates ranging from 0.6 to 3.12% with a mean of approximately 1%. Based on movement of tag recaptures it is assumed that this area is a single stock. The overall trend of both biomass estimates and exploitation rate is stable across the time series, indicating there is a low impact on this species from the *D. eleginoides* fishery in this area.

6.40 The paper also highlighted that there is large variation in species identification of skates, which was linked to observer experience in this region. Using morphometrics (wingspan to length ratio) allows post-hoc classification of unidentified skates into the two dominant species groups *Amblyraja* spp. and *Bathyraja meridionalis*, and to flag any unusual species identifications. This method can also be used to check observers' identification skills comparing experienced observers with newer observers. The paper further outlined how this method allowed for the reclassification of tag releases and recaptures to validate data used for the Chapman estimates.

6.41 The Working Group noted the relatively large and constant amount of tag recaptures over time in this long-term tagging program. The working group recalled discussion about a designated by-catch workshop and highlighted this may be a good option for exploring the combination of these biomass estimates with skate removals to ensure limits are consistent with Article II.

6.42 The Working Group noted that based on the information around morphology presented in these two papers, region-specific by-catch guides would assist in species identifications better than Convention Area wide by-catch guides.

6.43 WG-FSA-18/10 provided an update on fish by-catch within the krill fishery. The paper highlighted the increase of fish by-catch reported in the C1 data provided by vessels in relation to species identified by observers, noting this season is still incomplete. The paper highlighted that between the improved by-catch reporting and the confidence in SISO species identifications (WG-EMM-18/30), there are now sufficient data available to explore the factors associated with observed by-catch distributions.

6.44 The Working Group noted that there will be a requirement for 100% observer coverage in the krill fishery after 2020, this could result in more data in future. It also noted that some Members had implemented 100% coverage since 2014.

6.45 The Working Group recalled the discussion on WG-FSA-18/14 (paragraphs 6.1 to 6.7) and recommended a similar analysis be undertaken within the krill fishery exploring the effects of Member and gear type on by-catch reporting.

6.46 The Working Group requested that the Scientific Committee note that it is currently not possible to provide an impact assessment for the krill fishery on finfish populations until previous concerns relating to reporting on continuous fishing system trawl vessels are addressed (SC-CAMLR-XXXVII, Annex 7, paragraph 6.2).

Risk assessment methods for finfish by-catch

6.47 The Working Group recalled that in the history of CCAMLR, a range of methods have been used to assess the risk of impact to non-target species within the wider ecosystem. The Working Group discussed (i) how to prioritise the species which should be assessed, and (ii) what is expected to be in these assessments.

6.48 The Working Group noted that Article II requires advice on related species and that some conservation measures are in place for some non-target species. The Working Group also noted that a number of these conservation measures relating to by-catch species may be based on outdated information, or adopted as precautionary measures until information became available, and encouraged Members to provide updates where new data exists.

6.49 Noting CCAMLR's approach to by-catch of (i) avoidance, (ii) mitigation, and (iii) the setting of sustainable by-catch limits if mortality is not preventable, the Working Group requested the Scientific Committee clarify whether region-specific by-catch limits should be considered, and whether the catch limits based on a percentage of by-catch versus target species currently in place satisfy the requirements under Article II.

6.50 The Working Group noted there are a range of methods used in fisheries around the world available for assessing the risk of impact to a species from a fishery where limited data is available such as the SAFE method (Zhou and Griffiths, 2008) and suggested these could be explored as options for the less common and/or data-poor by-catch species. It also considered that trends in by-catch over time could be included in the Fishery Report (paragraphs 2.28 to 2.33).

6.51 The Working Group further noted that effects on a by-catch species are not just by removals but also through changes to the wider ecosystems driven by the removal of target species which can lead to effects such as predation release and consequential changes to species composition.

6.52 The Working Group noted that the Scientific Committee had requested a focus topic on by-catch for WG-FSA-18, however, as by-catch is a significant ongoing issue for CCAMLR it requested the Scientific Committee consider allocating time to the further development of risk assessments for non-target species in the Convention Area.

Incidental mortality of seabirds and marine mammals

6.53 The Secretariat provided an update on incidental mortality of seabirds and marine mammals in CCAMLR fisheries during 2017/18 (WG-FSA-18/13 Rev. 1). The paper summarised incidental mortality associated with fishing activities collected in scientific observer and vessel data during 2017/18 as received by the Secretariat up to 8 October 2018.

6.54 This paper presented incidental mortality numbers for longline fisheries in which seabird mortalities have been reported. The extrapolated total of 87 birds killed is the lowest on record. This reduction has been most noticeable in the French exclusive economic zone (EEZ) fisheries (Division 58.5.1 and Subarea 58.6) where mortalities have shown a 95% reduction over the same period. One marine mammal mortality was observed during longline fishing in Division 58.5.2; a southern elephant seal (*Mirounga leonina*) was recovered entangled in the main line.

6.55 The 11 krill vessels operating in Subareas 48.1, 48.2 and 48.3 reported one seabird mortality and 19 marine mammal mortalities. For some of these cruises the observer data have yet to be received as the observers have not yet returned to their home port.

6.56 The 19 Antarctic fur seals (*Arctocephalus gazella*) caught in 2018 represent a sudden increase as only one mortality has been recorded since 2013. However, as 18 of the 19 mortalities were reported from one vessel, this indicates that this is likely to be a vessel-specific, rather than a fishery-wide issue. As the Secretariat is yet to receive the observer data for the cruises where the mortalities occurred the Working Group requested further details on this incident when they are available.

6.57 The Working Group noted that the relevant conservation measures (CMs 51-01 to 51-03) contain the requirement for a marine mammal exclusion and that the specification for the device is part of the requirement in CM 21-03, Annex 21-03/A. The Working Group noted that an analysis of these designs could provide a better understanding of the operation of mitigation devices and procedures in relation to reported mortalities. The Working Group also noted that there are currently no by-catch limits specified for the krill fishery.

6.58 The Working Group noted that there was considerable interannual variation in reported seabird mortalities by area and that some of this variation was likely a result of interpolation. Large mortality events at a single vessel scale also contributed to this variation.

6.59 The Working Group thanked the Secretariat for the paper and recommended that in future the information in WG-FSA-18/13 Rev. 1, Table 2, include an additional category for observed mortality in addition to the extrapolated mortality and the observed mortality rate, as in some areas observers reported all seabird mortalities from each line.

6.60 The Working Group recalled WG-EMM-18/33 which discussed potential interactions and competition between the krill fishery and krill-dependent predators during fishing operations. The Working Group noted that while reporting of incidental mortality of seals was required, there was no requirement for other marine mammal interactions with gear or fishing vessels to be reported. It was therefore not possible to understand at the scale of the entire Convention Area how marine mammal mortalities relate to the potential overlap between vessels and marine mammal activities.

6.61 WG-FSA-18/57 reported on fishing effort and seabird interactions during the season extension trials in the longline fishery for *D. eleginoides* in Division 58.5.2. The Commission endorsed three trial season extensions for this statistical division (CCAMLR-XXXIV, paragraph 5.68). Australia undertook to report annually on the results of all the trials. This paper presented information on fishing effort and seabird interactions with fishing gear collected during the periods of 1–14 November 2017, 15–30 November 2017, 1–14 April 2018 and 15−30 April 2018. The Working Group noted that the conditions set in WG-FSA-15/48 for the conclusion of the trial season extensions have now been met in all three trials and that a full analysis of all season extension trials, with complete data up until the end of the current fishing season, will be presented to WG-FSA-19.

6.62 The Working Group noted a proposal by Norway to trial the use of a third wire on krill trawl vessels that was approved by the Scientific Committee (SC-CAMLR-XXXV, paragraphs 4.10 and 4.11). The Scientific Committee recommended that a one-season trial be carried out with the proposed design on any krill trawl vessel using a net monitoring cable, and that results of these trials be reported to the Scientific Committee to further evaluate the safety of the use of this cable. The Working Group noted that the time for this exemption had now expired and that no report had been received on the trial.

Invertebrate by-catch and VMEs

6.63 WG-FSA-18/23 provided a report on recent catches of sea pens (Pennatulacea) in Division 58.4.4b from research activities in 2018. The Working Group noted the request by WG-SAM to further review information on the locations and amount of catch of 44.49 kg of this taxon described in WG-SAM-18/31 (Annex 6, paragraph 6.43).

6.64 The Working Group noted that further analysis of the weight of the four morphotypes of sea pens from longline sets in Division 58.4.4b, when standardised to 1 000 hooks, did not meet the threshold of VME indicator units as specified in CM 22-07. It was further noted that the spatial distribution of sea pen densities was heterogeneous, with a peak concentration in the eastern part of research block 5844b_2, and a low density over the rest of Division 58.4.4b on Lena Bank.

6.65 Noting that sea pens are relatively small and therefore a light VME indicator taxa in terms of weight, the Working Group agreed that it would be worthwhile reviewing appropriate thresholds for these light taxa and other VME indicator taxa to determine whether the thresholds as set out in CM 22-07 remain appropriate. The Working Group further noted that it would be useful to review the sea pen taxa from previous research cruises in the region, as the large number of sea pens may represent a gear-specific effect between trotlines and autolines.

6.66 The Working Group noted that previously the application of CM 22-07 in research fishing in closed areas, conducted under CM 24-01 was unclear. However, it noted that conservation measure exemptions in accordance with CM 24-01 shall now explicitly be specified in CM 24-05.

6.67 WG-FSA-18/51 provided a preliminary report on invertebrate by-catch in research blocks in Divisions 58.4.1, 58.4.2, 54.4.3a and 58.4.4b for the 2013/14 and 2017/18 seasons. The Working Group noted that more diverse VME communities were shown in research blocks 5841_2–5, whilst research block 5844b_1 and Division 58.4.3a had higher catches, with lower diversity. It was again noted that potential gear effect on VME indicator taxa capture with trotlines only yielding <1% of the total VME indicator taxa catch, although further work is needed to confirm this. The authors suggested that an index of taxonomic diversity and specimen counts could be developed and considered as an indicator of a VME.

6.68 The Working Group welcomed the analysis of VME data in this region, and noted that there may be some difficulty reconciling observer data on line segments with C2 catch and effort data, and that in some cases position errors in line segment data from C2 forms have also been shown to be an issue. The Working Group suggested these could be starting points for refining analyses and developing advice on this topic. The Working Group also noted that using an index of diversity for analysing VME data could be considered further, while bearing in mind that data are often collected at a phylum level, which would underrepresent the true diversity.

6.69 The Working Group recalled WG-EMM-12/51, which proposed a differentiating diversity threshold of VME indicator taxa to trigger VME move-on rules. WG-EMM had recommended that more work on this topic be undertaken to advance scientific advice toward future refinement of CM 22-06 and CM 22-07.

6.70 The Working Group agreed that a greater understanding of the gear efficiency and how repeated sampling can be used over time to detect benthic features, size of habitats and patch distributions for VME communities would be useful, noting that a small number of sets in an area is unlikely to give a reliable estimate of VME community structure and spatial variability. Analysis of all available data sources in aggregate including any available video monitoring data would allow more accurate maps of where communities exist to be developed.

6.71 The Working Group noted that conservation measures relating to VMEs (particularly CM 22-07) have not been reviewed for several years and asked the Scientific Committee to develop a plan to evaluate these measures.

Marine debris

6.72 Following the request from WG-FSA-17 (SC-CAMLR-XXXVI, Annex 7, paragraph 8.4), the Secretariat presented an analysis of gear loss by fishing vessels in the Convention Area as contribution to the marine debris monitoring program (WG-FSA-18/17). Gear loss was analysed using data on hooks lost as reported by fishing vessels in the haul-by-haul C2 data form. The Secretariat highlighted the differences in rates of reported gear loss and proportions of line lost between statistical areas and over time, noting that the results may reflect differences in the interpretation and implementation of gear loss reporting requirements. The Secretariat recommended a modification to the C1 form to include reporting of gear loss, and clarification of the definition of 'hooks lost attached to sections' and 'other hooks lost' in the C2 form to reduce reporting discrepancies.

6.73 The Working Group thanked the Secretariat for its work and recommended that the requirements for reporting gear loss be clarified, including the removal of 'other hooks lost' from the C2 form, and that the Scientific Committee consider modifying the C1 data form to incorporate reporting of gear loss by trawl vessels.

6.74 The Working Group recommended that future work on fishing gear loss consider the following:

(i) the correlation between gear type and rates of gear loss

(ii) consideration of the retrieval of lost gear in estimates of cumulative gear loss

(iii) further analysis of the relationship between the numbers of hooks reported lost and the extrapolated length of line lost to investigate trends between variables

(iv) the effect of the presence of sea-ice as a potential indicator of high risk gear loss areas.

6.75 The Secretariat presented an update on the CCAMLR marine debris monitoring program (WG-FSA-18/18), including a summary of data holdings. The Working Group acknowledged that this is one of the longest time series within the CCAMLR dataset and encouraged more Members to participate in monitoring and data collection.

6.76 The Working Group considered debris levels over time and noted the clear decline in observed marine debris since the implementation of the program in 1989, suggesting the efficacy of conservation measures in place.

6.77 The Working Group recommended that potential opportunities for engagement with other organisations, such as the Committee for Environmental Protection (CEP) or the Council of Managers of National Antarctic Programs (COMNAP), be further considered in order to increase the scope of the marine debris program in the Antarctic.

Future work

Organisation of intersessional activities

7.1 The Working Group recommended that an e-group focused on the collection, formatting and use of by-catch data be created during the intersessional period, and its activities reported to WG-FSA-19.

7.2 The Working Group recommended that an e-group focusing on CPUE standardisation methods be created during the intersessional period in order to summarise the different approaches used by the different Members and to produce a list of recommended approaches according to the characteristics of the available data, fishing gear and aim of the research, and its activities reported to WG-SAM-19 and WG-FSA-19.

7.3 The Working Group agreed that the proposed survey in the Ross Sea MPA SRZ (WG-FSA-18/33 Rev. 1) required additional consideration prior to implementation. It requested that the Scientific Committee consider mechanisms that would advance the development of a statistically robust sampling design that would address the objectives of the proposal within the SRZ.

7.4 The Working Group noted that PSATs can provide useful information (e.g. WG-FSA-18/22), but are expensive and still have a high failure rate. The Working Group recommended a focused workshop on PSAT specifications and best practices be held to improve their functionality, reliability of data and success rate.

Notifications of other scientific research

7.5 The Working Group noted the notification submitted by New Zealand (SC CIRC 18/01), indicating the intent to contribute research towards the Research and Monitoring Plan for the RSRMPA, including ecosystem and fish surveys (WG-EMM-18/02) as well as oceanic buoys deployed as part of international research collaborations.

7.6 The Working Group noted the notification submitted by Germany (SC CIRC 18/43), indicating the intent to deploy vertical longlines in Subareas 48.6 and/or 48.5 to sample *D. mawsoni* in order to test population hypotheses, better understand the species' ecological role in the Weddell Sea and to demonstrate the ability of scientific research vessels such as the RV *Polarstern* to conduct such sampling.

7.7 The Working Group noted the notification submitted by Australia (SC CIRC 18/58), indicating the intent to conduct research in Division 58.4.1 and Subarea 88.1 focusing on krill and its predators. Dr Ziegler also notified the Working Group that Australia plans to conduct its annual random stratified trawl survey in Division 58.5.2 in 2019.

7.8 The Working Group noted the notification submitted by the UK (SC CIRC 18/63), indicating the intent to conduct research on icefish (Subarea 48.3) and krill in the South Sandwich Islands, including the use of deep-water cameras for benthic work combined with genetic information to inform connectivity across these islands.

Other business

Weddell Sea MPA (WSMPA) Proposal

8.1 WG-FSA-18/08 Rev. 1 presented revisions made from the first submission of the Weddell Sea MPA (WSMPA) proposal to the Commission in 2016 (CCAMLR-XXXV/18). An additional area at the east coast of the Antarctic Peninsula had been included and the depth delineation of the adult *D. mawsoni* habitat had been revised to 550–2 100 m in the light of the habitat analyses and modelling presented at WG-SAM-17 (WG-SAM-17/30). Additionally, the harmonisation of the management plan and the research and monitoring plan with the RSRMPA (CM 91-05) had been carried out to the extent possible. Both the management plan and the research and monitoring plan for the proposed WSMPA also now reflect the outcomes from the WS-DmPH-18 (see WG-SAM-18/33 Rev. 1).

8.2 The Working Group noted that the work presented had addressed the advice from WG-SAM-18 (Annex 6, paragraphs 8.1 to 8.6) and WS-SM-18 (Annex 7, paragraphs 3.61 to 3.65), on the identification and establishment of potential unfished scientific reference areas (SRA) outside the existing fisheries research blocks in Subarea 48.6, particularly the suitability of each parameter in terms of high, medium and low for 5° longitude segments in Subarea 48.6.

8.3 The Working Group noted that the inclusion of SRA within the WSMPA proposal would be a valuable addition to enable research into whether longline fishing for *D. mawsoni* had wider ecosystem and trophic impacts. The Working Group further noted the two locations in the adult toothfish habitat of Subarea 48.6 suggested in WG-FSA-18/08 Rev. 1 had been identified as most suitable for establishment of SRA, inter alia based on their similarity to areas within the current fishery: one in the sector between 20°–15°W (i.e. between Subarea 48.5 and the fisheries research block 486_5) and a second one in the sector between 10°–15°E on Astrid Ridge, north of the fisheries research block 486_4.

8.4 The Working Group noted the offer from Germany for accommodating 20 scientists from CCAMLR Members on each of two research cruises to be undertaken in the first 10 years after the adoption of the WSMPA.

Catch and effort mapping

8.5 WG-FSA-18/43 presented a method to produce high-resolution maps of effort and catches in longline fisheries. The Working Group noted the method provided significant advances over methods that only used longline midpoints and recalled WG-FSA-12/55 and WG-FSA-14/P06 which also presented methods of spatially mapping catch and effort data. The Working Group thanked the authors for their offer to share the code with interested Members.

Weird leech

8.6 WG-FSA-18/P01 presented features on a new species of weird deep-sea leech found parasitising Whitson's grenadier (*Macrourus whitsoni*) in the Ross Sea. The paper described morphological features and phylogenetic relationships with similar taxa. The Working Group was thrilled with the new discovery and expressed its appreciation to the authors of the study.

Otolith library

8.7 Following the request from Members (SC-CAMLR-XXXVI, paragraph 4.98) the Secretariat demonstrated an online otolith library to the Working Group. The Working Group thanked the Secretariat for the development and noted the utility of the resource for training purposes.

8.8 The Working Group agreed that the otolith library should be a public access site and recommended the addition of the following features:

(i) extra metadata fields to accommodate fish serial numbers and methods used to age otoliths

(ii) standardised image resolutions and readability index criteria

(iii) training and validation sets of images for instructing otolith readers.

8.9 The Working Group recommended that the Secretariat develop a database that contains ageing data, metadata, reference sets and readings thereof, to store data collected by multiple Members conducting age readings. The Working Group noted that a potential database structure was developed at the *Dissostichus* Ageing Workshop (SC-CAMLR-XXX, Annex 7, paragraphs 10.1 to 10.19 and in WG-FSA-12/43). The Working Group requested the Secretariat to correspond with those Members engaged in otolith ageing to determine how to integrate this data into the existing CCAMLR database.

Whale depredation research

8.10 The Working Group welcomed a presentation by Dr P. Tixier (Australia) on his current research on orca and sperm whale depredation across Patagonian toothfish fisheries in the CCAMLR Convention Area and adjacent waters. This research aims at assessing the implication of depredation on fish stock management and developing new mitigation measures. Dr Tixier invited other members to contribute to this project by sharing data (whale sightings, photos, etc.), and noted that he intends to present more research outcomes to future meetings of WG-FSA.

Advice to the 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) IUU fishing activity –

  (a) fishing prior to the start of the fishing season negatively impacting assessments (paragraph 2.3)

  (b) estimation of IUU removals across the Convention Area (paragraph 4.96)

  (c) data collection protocols to report effort, catch and biological data for recovered IUU fishing gear (paragraph 4.97).

(ii) Catch and effort data collection –

  (a) indications of intention to fish (paragraph 2.6)

  (b) clarity required on how incomplete hauls at the end of a reporting period should be reported in catch and effort forms (paragraph 2.18).

(iii) De-identification of vessels in VMS data –

  (a) review the requirement of CM 10-04, Annex 10-04/B to allow testing of the approach for the early season closure mechanism (paragraph 2.23).

(iv) Catch limit management –

  (a) procedure for forecasting closure of exploratory fisheries, especially in Subareas 88.1 and 88.2 (paragraphs 2.21 and 2.26).

(v) Assessments –

  (a) catch limit for *C. gunnari* in Subarea 48.3 (paragraph 3.8)

  (b) catch limit for *C. gunnari* in Division 58.5.2 (paragraph 3.15)

  (c) catch limit for *D. eleginoides* in Subarea 48.3 (paragraph 3.22)

  (d) catch limit for *D. mawsoni* in Subarea 48.4 (paragraph 3.27)

  (e) catch limits for *D. mawsoni* in Subarea 88.1, including shelf survey (paragraphs 4.144, 4.145 and 4.150).

(vi) Ross Sea region –

  (a) winter survey proposal (paragraphs 4.143 and 4.144, Table 7)

  (b) shelf survey continuation (paragraphs 4.147 to 4.151, Table 7

  (c) research in SRZ of the RSRMPA (paragraph 4.161 and Table 7).

(vii) Subarea 88.2 –

  (a) requirement for research plans in notifications for the exploratory fishery in Subarea 88.2 (paragraph 4.174)

(b) catch limits for *D. mawsoni* in individual research blocks (paragraphs 4.176 and 4.178).

(viii) Research fishing including data-poor fisheries for *Dissostichus* spp. –

(a) proposed catch limits for research blocks based the trend analysis using the last 5 years of data (paragraphs 4.5 and 4.8)

(b) review the requirement in CM 21-02 for a data collection plan and a fishery operation plan in notifications that require a research plan (paragraph 4.21)

(c) standardisation of notification of research timeframes (paragraph 4.23)

(d) review the objectives and provisions of CM 24-01 given differences in interpretation (paragraph 4.26)

(e) review the need to review research plans in both WG-SAM and WG-FSA (paragraph 4.25)

(f) review the objectives, priorities and definitions of data-poor exploratory fisheries (paragraph 4.19)

(g) research fishing in Subarea 48.1 (paragraphs 4.43 to 4.54, Table 5)

(h) research fishing in Subareas 48.2 and 48.4 (paragraphs 4.61 and 4.68)

(i) research fishing in Subarea 48.6 (paragraphs 4.5, 4.74, 4.85 and 4.92, Table 5)

(j) research fishing in Divisions 58.4.1 and 58.4.2 (paragraph 4.119, Table 6)

(k) research fishing in Division 58.4.3a (paragraphs 4.127 and 4.128, Table 6)

(l) research fishing in Division 58.4.4b (paragraphs 4.136 and 4.137, Table 6)

(m) research fishing in Subarea 88.3 (paragraphs 4.189 to 4.199, Table 7).

(ix) Other fisheries research –

(a) consideration of crab research fishing in Subarea 88.2 (paragraphs 4.209 and 4.217)

(b) design of acoustic surveys to assess the distribution of fish (paragraph 4.221)

(c) krill larvae identified in zooplankton data collected during research fishing samples (paragraph 4.237).

(x) Non-target catch and interactions in CCAMLR fisheries –

(a) by-catch reporting instructions (paragraph 6.4)

(b) development of a by-catch work plan (paragraph 6.14)

(c) mechanisms to improve data collection on sharks (paragraph 6.31)

(d) proposed changes to CMs 41-01 and 41-09 (paragraph 6.36)

(e) the inability to assess the impacts of the krill fishery on finfish populations (paragraph 6.46)

(f) consideration of region-specific by-catch limits (paragraph 6.49)

(g) allocating time to the further development of risk assessments for non-target species (paragraph 6.52)

(h) review of VMEs and the implementation CMs 22-06 and 22-07 (paragraph 6.71)

(i) modifications to C1 form to report gear loss (paragraph 6.73).

Close of the meeting

10.1 At the close of the meeting Dr Welsford thanked all participants for their patience and hard work that had allowed the Working Group to make significant progress in addressing the priorities of the Scientific Committee. He also thanked the rapporteurs and the Secretariat for their efficiency and support throughout the meeting.

10.2 On behalf of the Working Group, Mr Somhlaba thanked Dr Welsford for his even-handed guidance of the Working Group and his ability to keep the meeting focussed and to keep everyone entertained.

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Table 1: WG-FSA priorities for consideration by the Data Management Group.

Topic	Priority
Section A – Mandatory data collection under CCAMLR and CCAMLR conservation measures **Data type examples: Catch and effort data (C1, C2, C5 etc.), in-season reporting (5-/10-day reporting, monthly reporting, daily reporting), Scheme of International Scientific Observation (SISO) observer data, activity notifications**	
1. Assuring the quality of the **formally required** data that is submitted by Members and vessels to the CCAMLR Data Centre (C1, C2, etc. and observer data forms)	
(i) Development and management of required data submission form versions	High – but need to link to timeframe (see 1iv)
(ii) Development of standard data instructions and manuals for data submission and collection, including version management of these instructions and manuals; development of standard metadata information	High
(iii) Development and documentation of data validation and data correction algorithms to be used to assure quality prior to data submission to the CCAMLR Data Centre	Medium
(iv) Development of timeline and priorities for incoming data workflow, integration into Data Warehouse timeframe and in discussion with Members	High
(v) Development of standard data APIs for data collection/submission that work alongside Excel spreadsheets to allow Members to generate data submissions directly from generalised or in-house software	Low
2. Timelines for revisions of **required data and data formats**	
(i) Timelines for the review of data collected (including trade-offs with existing data collection, versioning, technology aides/automation, timing) by CCAMLR for all required data	Medium
(ii) Development of standard timelines for the post-submission revision and correction of errors of data submitted to the CCAMLR Data Centre; focus on development of default processes to streamline this point	Medium
Section B – Additional data not mandatory through conservation measures **Data type examples: Research plan data, CEMP data, age–length data, otoliths, krill acoustic data**	
3. Assuring the availability and quality of data submitted by Members that are not required to be submitted to the Secretariat (e.g. age or otolith data, age–length data)	
(i) Development and management of non-required datasets held by the CCAMLR Data Centre (e.g. research plan additional data collection, age data, otoliths readings)	High
(ii) Description of data collection forms, instructions and manuals used to collect these data, including version management, of data held by the CCAMLR Data Centre; development of a single repository/website for data collection version control that allows to cross-reference to collected data retrospectively	Medium
Note – an example is the *Data Collection Manual* from 1999, now mostly translated into Column A of C1/C2 forms	
(iii) Development and documentation of data validation and data correction algorithms used by the CCAMLR Data Centre; primarily led/driven by Members for data not required through CCAMLR conservation measures	Low

(continued)

Table 1 (continued)

Topic	Priority
Section C – Processes for all data types post submission	
4. Post-submission data validation, algorithms and subsequent data correction	
(i) Documentation of data loading/verification rules and processes, including versioning of these data, used to assure quality by the CCAMLR Data Centre when loading submissions	Medium
(ii) Documentation and improvement of tag-matching methods and algorithms used by the CCAMLR Data Centre, including version control; task is critical to toothfish management	High
(iii) Post-submission error correction processes, including consideration of potential corrections by Members who analyse data held by the CCAMLR Data Centre	Low
5. Data access and extracts	
(i) Standard database documentation, extract formats, tables included, secure access methods for required and non-required data that is released by the CCAMLR Data Centre	High
(ii) Development of timelines for improvement and revisions to data extract documentation and formats of data released by the CCAMLR Data Centre	High
(iii) Standard documentation of data requests to the Data Centre:	Medium
(a) data requests in relation to the work of CCAMLR and its working groups, including information on use	
(b) data requests to the Data Centre not in direct relation to the work of CCAMLR and its working groups, including information on use	
6. Data visualisation	
(i) Development of tools to explore data, integration of online geographic information system (GIS), links to larger projects such as any marine protected area research and monitoring plans (MPA RMPs) for data and summaries of data held by the CCAMLR Data Centre	Low
7. Data communication	
(i) Consistent development and documentation of standard and automated reporting for internal and external reporting of data held by the CCAMLR Data Centre:	Medium Medium
(a) internal reporting, e.g. repeated requests from the Working Groups to the Secretariat during meetings should be automated where sensible which is a priority for WG-FSA	Medium
(b) further development of external reporting (Fishery Reports) is not a high priority to WG-FSA. However, a priority is to ensure that Fishery Reports are self-contained. Data communication could be improved in the process of automating report output.	
(c) reporting for the *Statistical Bulletin* is mostly automated already and thus a low priority, but development or improvement of documentation of the reporting is a priority.	

Table 2: Illustrative example of estimates of productivity parameters for time periods 2000–2018 in five-yearly blocks.

Parameter		2000–2004	2005–2009	2010–2014	2014–2018
Mean size at age (cm)	Age = 5	75.0	76.0	73.2	77.1
	Age = 6	80.1	80.2	79.7	81.3
	Age = 7	…	…	…	…
	Etc…				
Mean weight at length	Length = 80 cm				
	Length = 90 cm				
	Length = 100 cm				
	Length = 110 cm				
	Etc…				
Mean recruitment	Model estimated YCS	n/a	0.99	0.95	1.05
Recruitment variability	Model estimated (sigma R)	0.64	0.65	0.55	0.62
50% maturity (age)		8.5	7.6	7.3	6.4
50% maturity (length)					
90th percentile age		17.3	16.7	16.8	17.2
Sex ratio		55:45			

Table 3: Recommendations from the Stock Assessment Review extracted verbatim from the report (Annex 5, where further description of these points can be found), and target group, priorities and timelines suggested by WG-FSA. RP – review panel, SC – Scientific Committee, SA – stock assessments, VB – von Bertalanffy.

Review panel comments	Target	Evaluation	Priority	Timeline
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 the CCAMLR, and that a public summary document with these details be developed and updated at a fixed period (e.g. five years).	WG-SAM WG-FSA	Summary	High	2019/20
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.	SC WG-SAM WG-FSA	Area dependent data review	High / Medium	Ongoing
Surveys				
3. Where possible, such surveys should be continued and optimised to ensure recruitment variability can be detected.	SC WG-FSA	Assessment	High	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-SAM WG-FSA	Sensitivity	High	2019
5. Subareas 88.1/88.2 – Consideration should be given to designing the 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.?	SC WG-FSA	Review	Medium	Ongoing
6. Division 58.5.2a 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.	WG-SAM WG-FSA	Sensitivity	High	2019
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.	Members	Uncertainty	Medium	Ongoing
8. It would be interesting to investigate how smoothing the ALK matrix (by applying a kernel or use some sort of spline function) would affect the SA.	WG-SAM	Sensitivity	Medium	Ongoing
Growth				
9. The RP suggests that all SA's implement methods to account for these potential biases in fitting Von Bertalanffy growth curves.	WG-SAM	Sensitivity	Medium	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.	WG-SAM WG-FSA	Sensitivity	Medium	Ongoing

(continued)

Table 3 (continued)

Review panel comments	Target	Evaluation	Priority	Timeline
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.	WG-SAM WG-FSA	Sensitivity	Medium	2019
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.	WG-SAM WG-FSA	Sensitivity	Medium	2019
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.	WG-SAM WG-FSA	Sensitivity	Medium	2019
14. Potential changes in growth rates and fishery selectivity will influence tag-recapture rates, particularly due to the domed-shaped selectivity of these fisheries. The RP also recommends that more flexible growth curves be investigated.	WG-SAM WG-FSA	Sensitivity	Medium	2019
15. The RP recommends that the use of age-length keys 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.	WG-SAM WG-FSA	Sensitivity	Medium	2019/20
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.	WG-SAM WG-FSA	Sensitivity	Medium	Ongoing
Tag loss				
17. The RP suggests that it is timely to update this analysis for the Subarea 48.3+Subarea 48.4 and Subarea 88.1, SSRUs 882A and 882B 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.	WG-SAM WG-FSA	Sensitivity	High	2019
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.	WG-SAM WG-FSA	Experimental	Medium	Ongoing
Tag detection				
19. The review panel encourages future research on the estimation of tag detection rates, and factors that may cause this to vary.	WG-SAM WG-FSA	Sensitivity	Medium	Ongoing
20. The RP recommends that implementation of good tagging protocols (release and recapture) be encouraged for all vessels involved in these fisheries.	WG-FSA	Review	High	Ongoing
Time at liberty truncation				
21. Tagging data was limited to recapture years-at-liberty less than 4 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, SSRU 882A and 882B assessments. The RP recommends further investigation of this issue.	WG-SAM WG-FSA	Sensitivity	Medium	Ongoing

(continued)

Table 3 (continued)

Review panel comments	Target	Evaluation	Priority	Timeline
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, SSRU 882A and 882B and temporal changes in selectivity should be considered.	WG-FSA	Sensitivity	Medium	2019/20
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.	WG-SAM	Research & sensitivity	Medium	2019/20
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.	WG-SAM WG-FSA	Sensitivity	Medium	2019
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.	WG-FSA	Sensitivity	Medium	Ongoing
26. A standard set of diagnostic plots across the assessments covering important and sensitive parameters is encouraged to be included in each stock assessment.	WG-FSA	Review	Medium	2019
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.	WG-FSA	Review	Medium	This WG

Table 4: Research block biomass estimates and recommended catch limits for Subareas 48.6 and 58.4.

Subarea/ division	Research block	Species	Trend decision	Adequate recaptures	B (tonnes)	Catch limit 2017/18	0.04*B	0.8*CL	1.2*CL	Recommended catch limit 2018/19 (tonnes)
48.6	486_2	*D. mawsoni*	I.S.U	Y	4372	169	175	135	203	175
48.6	486_3	*D. mawsoni*	D	Y	2521	40	101	32	48	32
48.6	486_4	*D. mawsoni*	I.S.U	Y	8387	120	335	96	144	144
48.6	486_5	*D. mawsoni*	I.S.U	N	8569	228	343	182	274	274
58.4.1	5841_1	*D. mawsoni*	I.S.U	N	6520	96	261	77	115	115
58.4.1	5841_2	*D. mawsoni*	I.S.U	N	4497	97	180	78	116	116
58.4.1	5841_3	*D. mawsoni*	I.S.U	N	3683	186	147	149	223	149
58.4.1	5841_4	*D. mawsoni*	I.S.U	N	591	16	24	13	19	19
58.4.1	5841_5	*D. mawsoni*	I.S.U	N	4004	42	160	34	50	50
58.4.1	5841_6	*D. mawsoni*	I.S.U	N	4069	108	163	86	130	130
58.4.2	5842_1	*D. mawsoni*	I.S.U	N	4585	42	183	34	50	50
58.4.4b	5844b_1	*D. eleginoides*	I.S.U	N	470	20	19	16	24	19
58.4.4b	5844b_2	*D. eleginoides*	D	N	298	28	12	22	34	22
58.4.3a	5843a_1	*D. eleginoides*	D	N	1263	38	51	30	46	30

Table 5: Summary of the assessment of the new and underway Area 48 research proposals against the criteria set out in SC-CAMLR-XXXVI, Annex 7, paragraph 4.7. Summary of the rationale behind the scores are in the notes below, and details in paragraphs 4.39 to 4.92. n/a indicates not applicable.

Subarea:	48.1	48.2	48.2 and 48.4	48.6
Proposal and country/criteria:	WG-FSA-18/20 Rev. 1 Ukraine	WG-FSA-18/49 Ukraine	WG-FSA-18/52 UK	WG-FSA-18/34 Japan, South Africa and Spain
Conservation measure under which proposal submitted				
(i) (a) Is the proposed research likely to generate an index of local stock abundance?	2	Y	n/a	Y
(b) Is the proposed research likely to generate estimates of biological parameters relating to productivity?	Y	3	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	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?	4	5	Y	Y
(iii) Are the likely impacts from the proposed research to dependent and related species consistent with Article II?	1	6	Y	7
(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	1	Y	1
(v) Do the proposed research platforms intended for this work have demonstrated experience and performance in toothfish tagging programs?	Y[8]	Y[8]	Y[8]	Y[8]
(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)?[10]	2	Y	Y	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)?[10]	9	9	Y	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?	n/a[12]	10	Y	11

(continued)

Table 5 (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 (Figure 5).
3. Requires an increase in the number of otoliths collected and aged.
4. Catch limit only applies to 1st year of proposal.
5. CPUE in southern research area is declining.
6. Requires increased sampling of by-catch species.
7. Requires more data analysis.
8. Based on vessel tagging detection and survival rates in WG-FSA-17/36.
9. Priority should be given to the completion of research programs already in place over new research proposals (SC-CAMLR-XXXVI, paragraph 3.64).
10. Based on milestones not being achieved on the assessment of biological parameters, analyses of by-catch species, seabirds and marine mammals.
11. Based on milestones not being achieved on productivity parameters.
12. Not applicable as this is a new proposal by this Member for this area.

Table 6: Summary of the assessment of the new and underway Area 58 research proposals against the criteria set out in SC-CAMLR-XXXVI, Annex 7, paragraph 4.7. Summary of the rationale behind the scores are in the notes below and details in paragraphs 4.107 to 4.138.

Subarea:	58.4.3a	58.4.4b	58.4.1 and 58.4.2
Proposal and country/criteria:	WG-FSA-18/61 France and Japan	WG-FSA-18/44 France and Japan	WG-FSA-18/59 Australia, France, Japan, Republic of Korea, Spain
Conservation measure under which proposal submitted			
(i) (a) Is the proposed research likely to generate an index of local stock abundance?	2	2	Y
(b) Is the proposed research likely to generate estimates of biological parameters relating to productivity?	Y	Y	Y
(c) Is the proposed research likely to test a hypothesis of relationship of fish in the research area to the overall stock?	1	1	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?	Y	Y	Y
(iii) Are the likely impacts from the proposed research to dependent and related species consistent with Article II?	6	5	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?	1	1	Y
(v) Do the proposed research platforms intended for this work have demonstrated experience and performance in toothfish tagging programs?	3	3	4
(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)?[10]	2	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)?[10]	2	2	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?	2	2	Y

(continued)

Table 6: (continued)

Notes:

1. There is not enough information in the proposal.
2. There is a lack of data due to low research fishing effort in these area in recent seasons.
3. The proposed vessels have multiple years of experience but have unknown calculated effective survival rates.
4. 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.
5. Spatio–temporal patterns of data were presented, however, further analysis of biological samples is pending.
6. A large proportion of by-catch species are present in catch data.

Table 7: Summary of the assessment of the new and underway Area 88 research proposals against the criteria set out in SC-CAMLR-XXXVI, Annex 7, paragraph 4.7. Summary of the rationale behind the scores are in the notes below and details in paragraphs 4.141 to 4.199. n/a indicates not applicable.

Subarea:	88.1		88.1 and 88.2	88.2	88.3	
Proposal and country/criteria:	WG-FSA-18/33 Rev. 1 Russia	WG-FSA-18/41 New Zealand	WG-FSA-18/40 New Zealand	WG-FSA-32 Rev. 1 Russia	WG-FSA-18/16 Rev. 1 Ukraine	WG-FSA-18/42 Republic of Korea and New Zealand
Conservation measure under which proposal submitted						
(i) (a) Is the proposed research likely to generate an index of local stock abundance?	Y	Y	n/a	10	Y	Y
(b) Is the proposed research likely to generate estimates of biological parameters relating to productivity?	Y	Y	Y	Y	Y	4
(c) Is the proposed research likely to test a hypothesis of relationship of fish in the research area to the overall stock?	Y	Y	Y	11	5	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?	Y	Y	Y	12	1	Y
(iii) Are the likely impacts from the proposed research to dependent and related species consistent with Article II?	Y	Y	Y	13	1	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?	14	Y	Y	15	6	6
(v) Do the proposed research platforms intended for this work have demonstrated experience and performance in toothfish tagging programs?	16	Y[3]	Y[3]	17	Y[3]	7
(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	18	Y	8
(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)?[10]	Y	Y	Y	Y	2	Y

(continued)

Table 7 (continued)

Subarea:	88.1		88.1 and 88.2	88.2	88.3	
Proposal and country/criteria:	WG-FSA-18/33 Rev. 1 Russia	WG-FSA-18/41 New Zealand	WG-FSA-18/40 New Zealand	WG-FSA-32 Rev. 1 Russia	WG-FSA-18/16 Rev. 1 Ukraine	WG-FSA-18/42 Republic of Korea and New Zealand
(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?	19	Y	Y	n/a	n/a	9

Notes:

1. There is not enough information in the proposal.
2. Priority should be given to the completion of research programs already in place over new research proposals (SC-CAMLR-XXXVI, paragraph 3.64).
3. Based on vessel tagging detection and survival rates in WG-FSA-17/36.
4. Aging data still to be provided.
5. No hypothesis presented to consider stock connectivity between Subareas 88.3 and 48.1.
6. The Working Group requested more integration between Ukraine and the existing research in Subarea 88.3.
7. Tagging statistics are not available for the vessel proposed by the Republic of Korea, but it is part of the experimental design.
8. Catch distribution agreed between Members.
9. Milestones have been delayed due to the New Zealand vessel not fishing in 2017/18 due to ice conditions.
10. There is no information available on the distribution of the target species within CCAMLR data
11. Alternative hypotheses exist for estimating crab populations in the Southern Ocean
12. No information exists for this area, and survey is effort limited.
13. By-catch estimation will be difficult if lice depredation occurs.
14. The Working Group recommended a review after one year of the research program.
15. Additional details for the proportion of the catch that are mature males is desirable. This information could be derived from first year of survey or other publications on related species.
16. 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).
17. Of the two vessels proposed for this research only one has calculated tag detection and survival statistics (WG-FSA-17/36).
18. The research program is new therefore operational practices are unknown
19. Analyses are pending for this region.

Table 8: Catch Limits from the trend analysis for Subarea 88.2. * – individual 200 tonne limits with an overall limit of 400 tonnes in research blocks 882_1–882_4.

Subarea/ division	Research block	Species	Trend decision	Adequate recaps	B (tonnes)	Catch limit 2017/18	0.04*B	0.8*CL	1.2*CL	Proposed catch limit 2018/19 (tonnes)
882	SSRUH	*D. mawsoni*	ISU	Y(all)	11759	200	470	160	240	240
			ISU	Y(effective)	4419	200	177	160	240	177
882	882_1	*D. mawsoni*	ISU	N	11288	200*	451	160	240	240
882	882_2	*D. mawsoni*	ISU	Y(all)	15523	200*	620	160	240	240
			ISU	Y(effective)	8370	200*	330	160	240	240
882	882_3	*D. mawsoni*	ISU	N	3342	200*	134	160	240	160
882	882_4	*D. mawsoni*	D	N	6666	200*	266	160	240	160

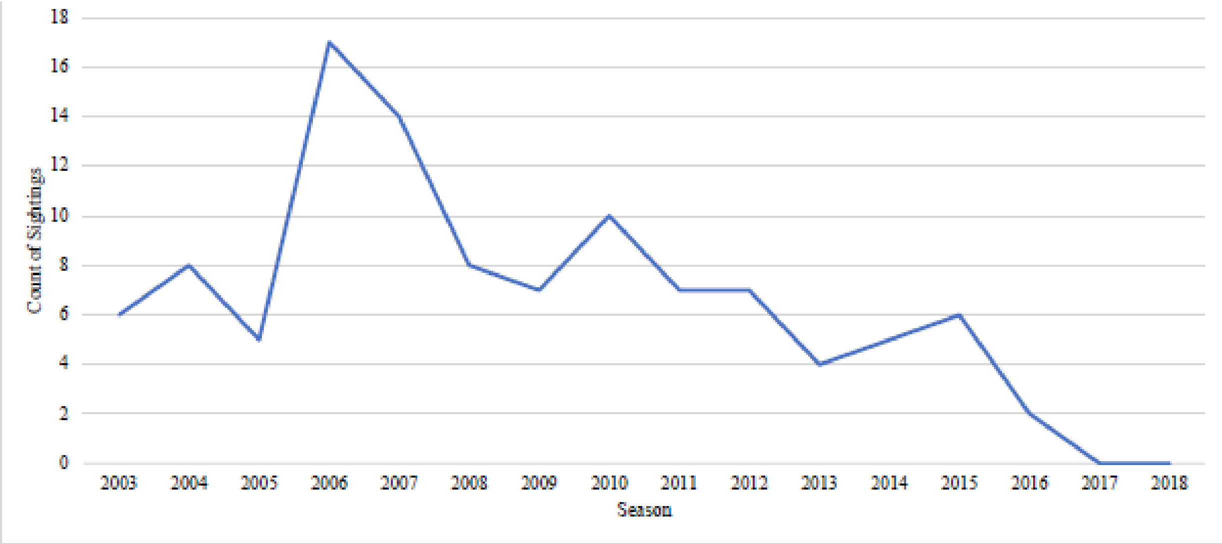
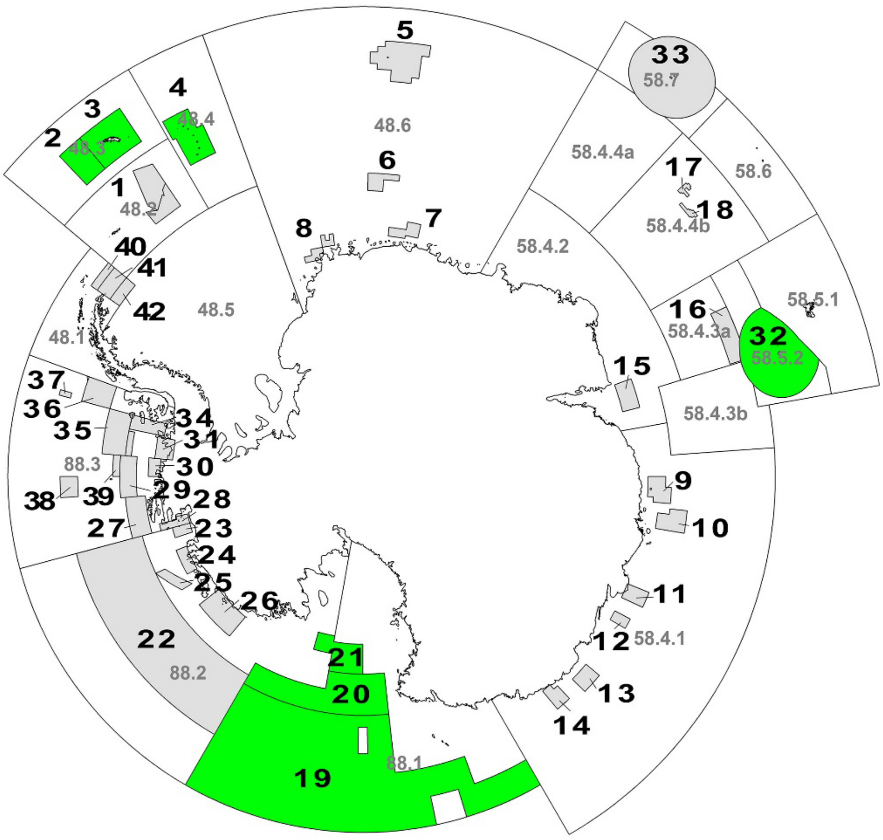


Figure 1: Reported sightings of IUU or unidentified vessels within the Convention Area. The figure does not include reports of unidentified fishing gear sighted or retrieved in the Convention Area which may be indicative of IUU activity and is not corrected for changes in surveillance effort.



ID	Area code
1	48.2
2	48.3 B
3	48.3 C
4	48.4
5	48.6_2
6	48.6_3
7	48.6_4
8	48.6_5
9	58.4.1_1
10	58.4.1_2
11	58.4.1_3
12	58.4.1_4
13	58.4.1_5
14	58.4.1_6
15	58.4.2_1
16	58.4.3a_1
17	58.4.4b_1
18	58.4.4b_2
19	RSR North 70
20	RSR South 70
21	RSR SRZ
22	88.2 H
23	88.2_1
24	88.2_2
25	88.2_3
26	88.2_4
27	88.3_1
28	88.3_2
29	88.3_3
30	88.3_4
31	88.3_5
32	HIMI
33	PEI
34-39(P)	88.3
40(P)	48.1
41(P)	48.1
42(P)	48.1

Figure 2: Map of the Convention Area showing areas with toothfish catch limits in place or areas with proposed research fishing. Areas shown in green have catch limits set using integrated assessments. Areas 34 to 42 are areas that have been proposed for the first time in 2018 for research fishing.

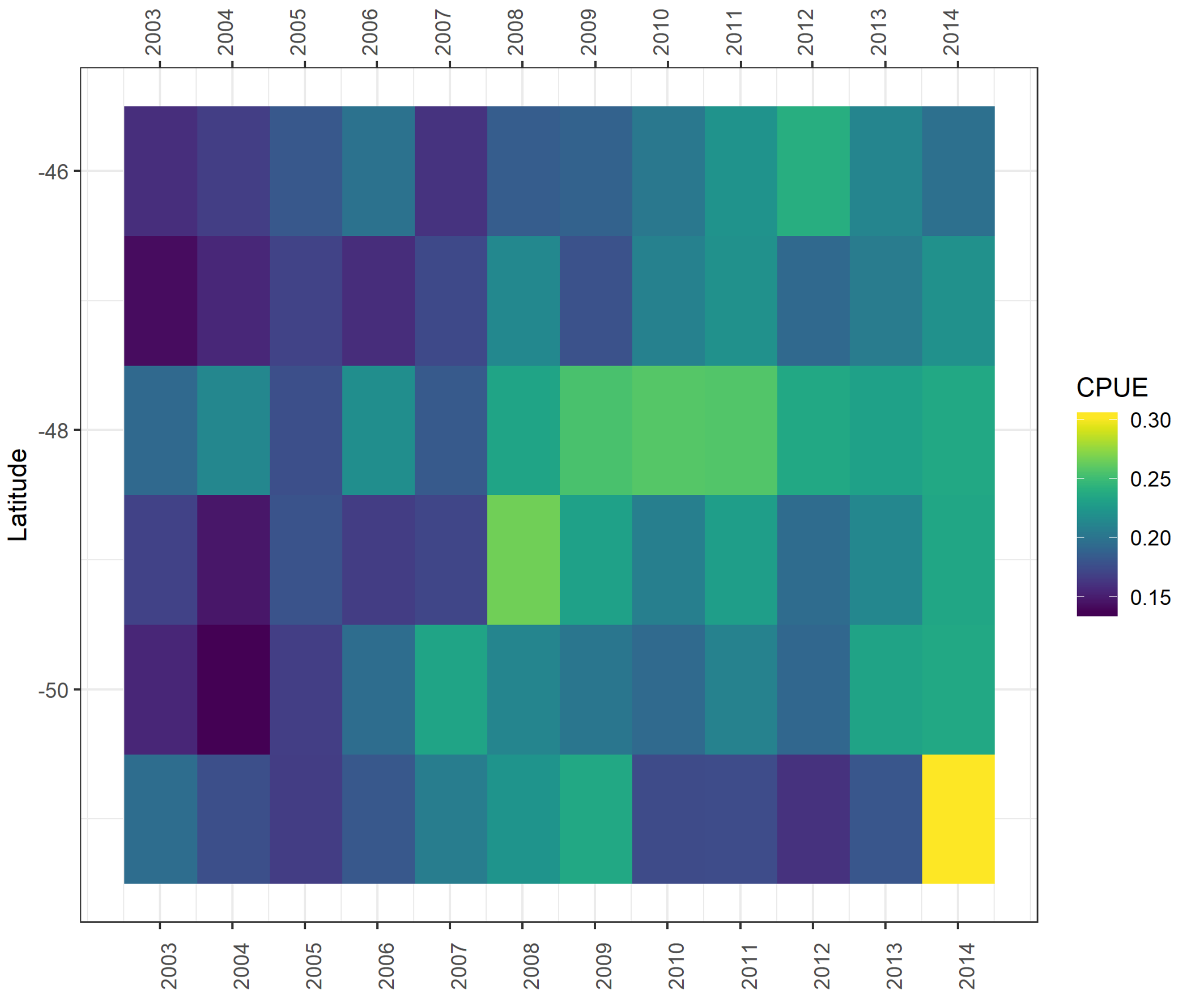


Figure 3: An example of mean CPUE by latitude over time for the years 2003–2015 for Division 58.5.1.

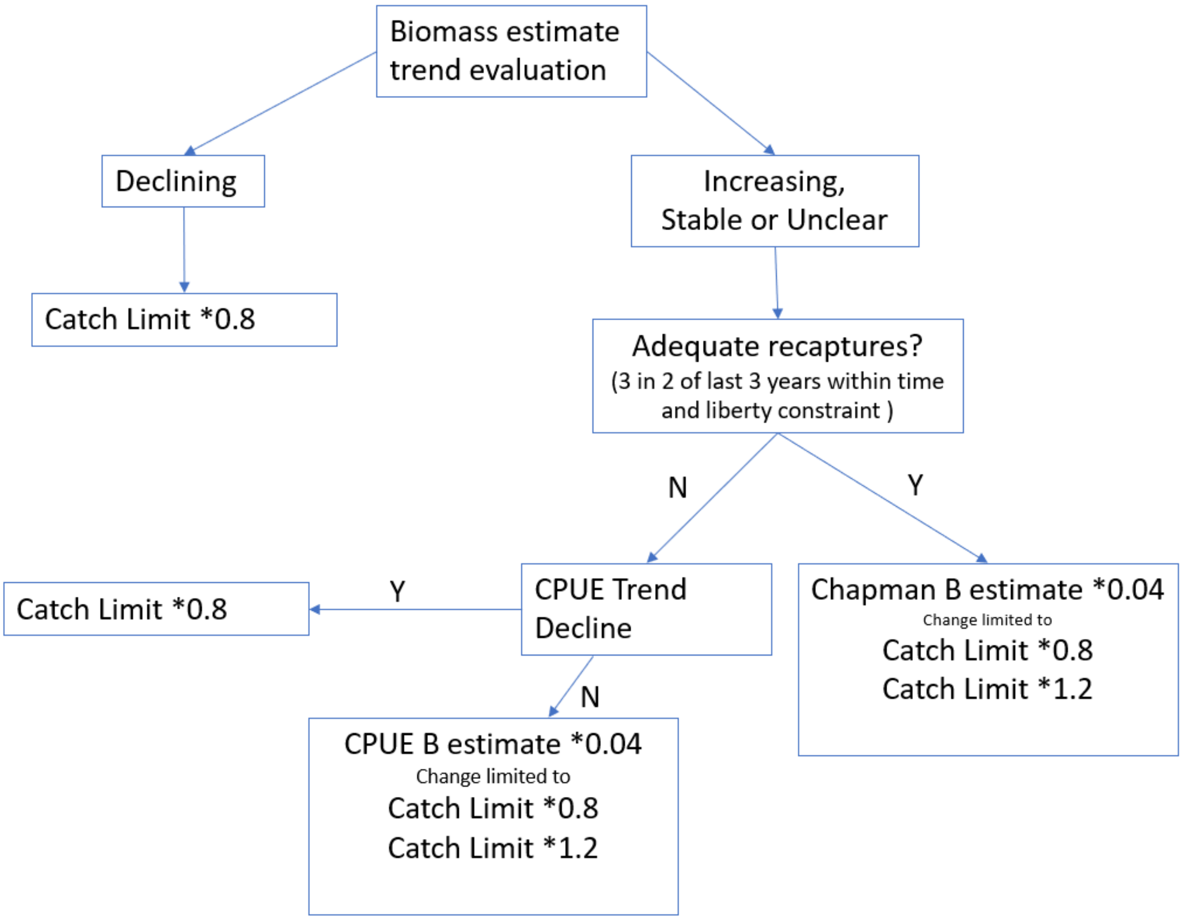


Figure 4: Linear trend analysis decision rules for determining catch limits for research blocks using biomass estimates from CPUE by seabed area and/or Chapman based estimates from tag release – recapture data. All changes to catch limits are bound by a maximum increase or decrease of 20% in relation to the previous decision (see SC-CAMLR-XXXVI, Annex 7, paragraph 4.33 for decision rules on linear trend analysis outcomes).

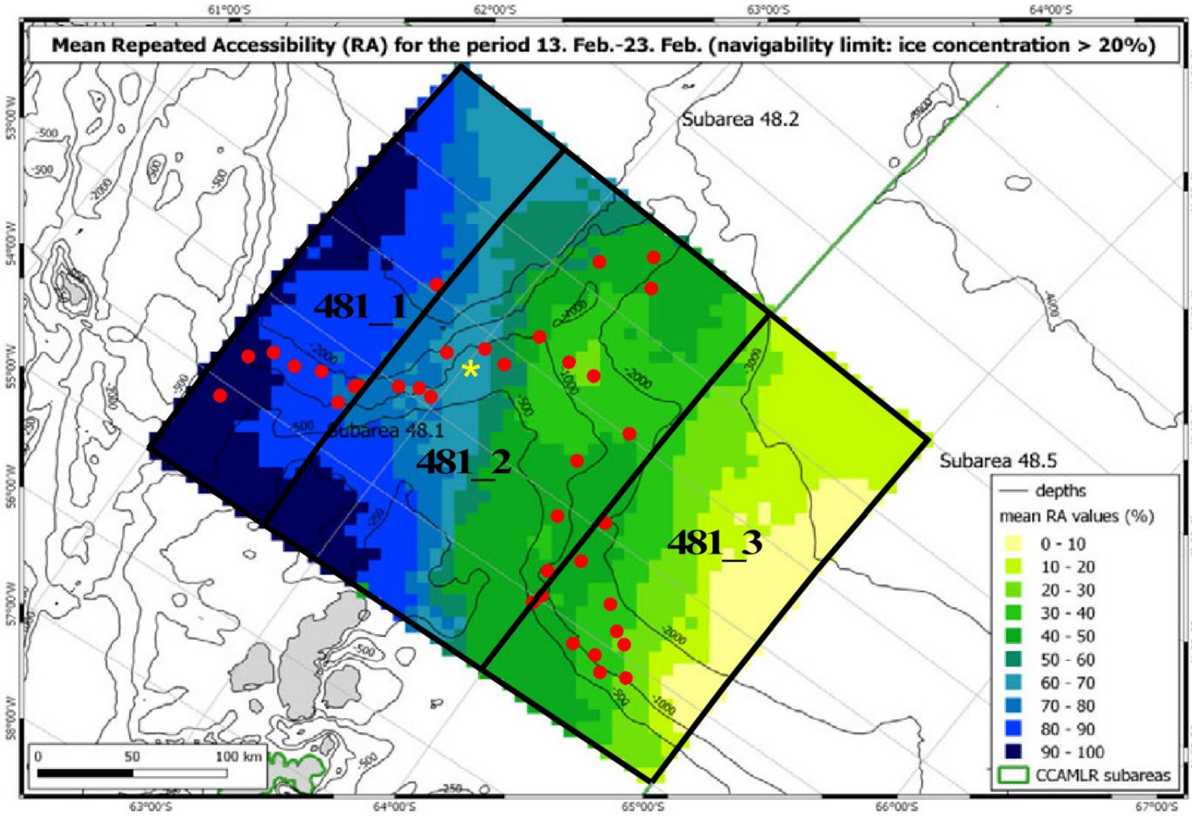
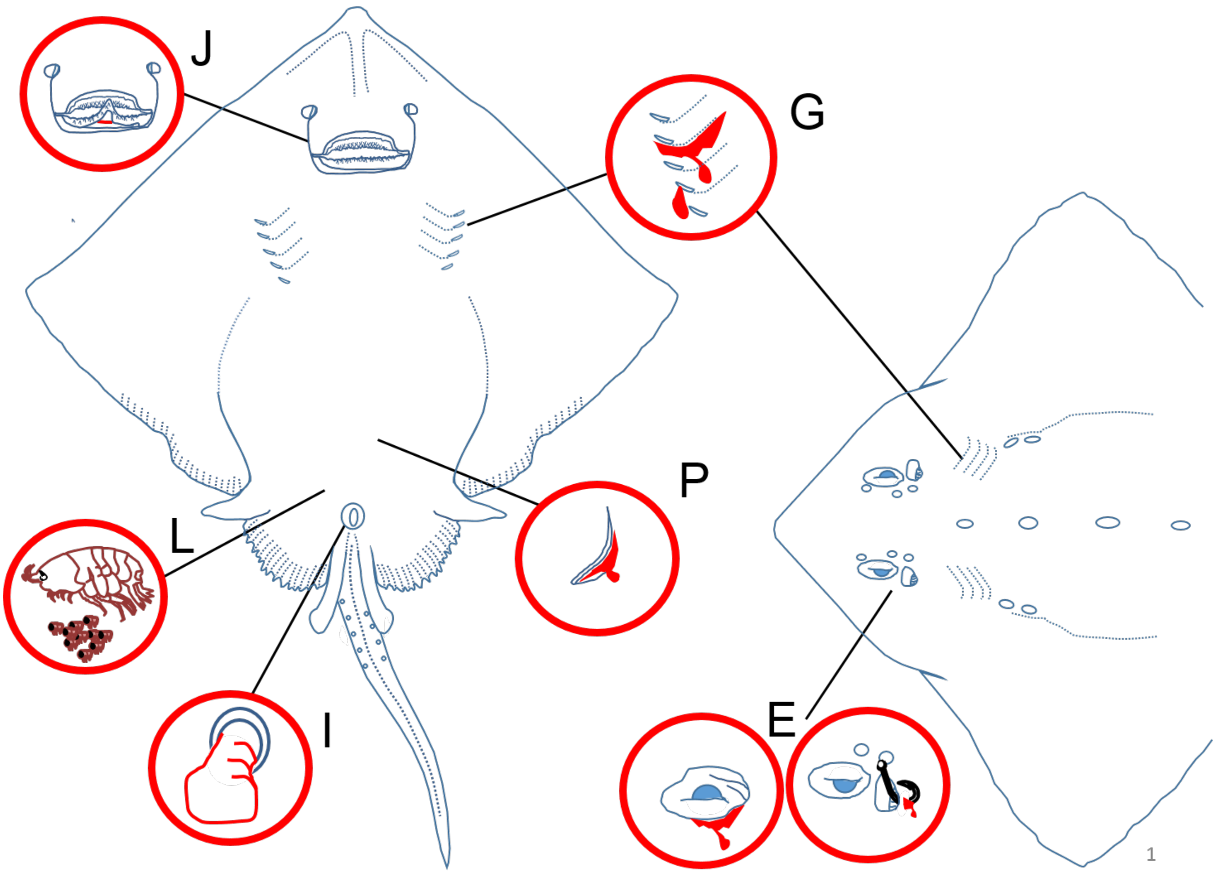


Figure 5: Map showing the mean repeated accessibility (RA) for the period 18–23 February for fishing vessels with a fishing limit of 20% sea-ice concentration (as estimated in WG-FSA-18/01) in the research blocks proposed by Ukraine for a new 3-year *Dissostichus* spp. research program. The locations of the proposed longline stations are shown as red points (based on Table 1 in WG-FSA-18/20 Rev. 1) and the registered VME is shown as a yellow star. Repeated accessibility was calculated as the probability that a particular area is fishable by fishing vessels at a given time and again at least once within the subsequent two years, i.e. that accessibility was given at least twice within the 3-year time span.



Category	Description
0	No visible injuries
J	Broken jaw or significant tearing of tissue around jaw.
G	Bleeding from the gills on either dorsal or ventral surface
L	Significant damage from sea lice around the peritoneal cavity
I	Intestinal prolapse exceeding 3 cm, including if bleeding
P	Injury penetrating the peritoneal cavity
E	Injury to the eye or spiracle

Figure 6: Diagram showing categories of skate injuries to be recorded at tagging and release of skates and a description of each category. A skate with no injuries would receive a category of '0'. The alphabetical code(s) could be recorded in a 'Injury' field in the tagging sheet of the e-longline book.

Appendix A

List of Participants

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(Hobart, Australia, 8 to 19 October 2018)

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French Translator	Floride Pavlovic
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Russian Translator	Blair Denholm
Russian Translator	Vasily Smirnov
Spanish Translator/Team Coordinator	Jesús Martínez
Spanish Translator	Margarita Fernández
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Systems Analyst	Ian Meredith
Data Steward	Dr Elanor Miller

Appendix B

Agenda

Working Group on Fish Stock Assessment
(Hobart, Australia, 8 to 19 October 2018)

1. Opening of the meeting

    1.1 Organisation of the meeting
    1.2 Subgroup organisation and coordination

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* Subarea 48.3
        3.1.2 *C. gunnari* Division 58.5.1
        3.1.3 *C. gunnari* Division 58.5.2

    3.2 *Dissostichus* spp.
        3.2.1 *Dissostichus* spp. in Subarea 48.4

4. Research to inform current or future assessments in 'data-poor' fisheries (e.g. new fisheries, activities in closed areas, areas with zero catch limits and in Subareas 48.6 and 58.4) notified under Conservation Measures 21-01, 21-02 and 24-01

    4.1 Generic issues
        4.1.1 Trend analysis and setting catch limits
        4.1.2 Tagging performance
        4.1.3 Transitioning from area biomass estimates to integrated stock assessments
        4.1.4 Process for reviewing research proposals

    4.2 Management area research reviews and management advice
        4.2.1 *Dissostichus* spp. Area 48
        4.2.2 *Dissostichus* spp. Area 58
        4.2.3 *D. mawsoni* Area 88
        4.2.4 Other fisheries research

5. Scheme of International Scientific Observation

6. Non-target catch and ecosystem impacts of fishing

    6.1 Fish by-catch
        6.1.1 Status and trends in finfish by-catch
        6.1.2 Risk assessment methods for finfish by-catch

    6.2 Incidental mortality of seabirds and marine mammals
    6.3 Invertebrate by-catch and vulnerable marine ecosystems (VMEs)
    6.4 Marine debris

7. Future work

    7.1 Organisation of intersessional activities
    7.2 Notifications of other scientific research

8. Other business

9. Advice to 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, 8 to 19 October 2018)

WG-FSA-18/01	Analyses of ice conditions in the research area proposed by Ukraine for a multi-year *Dissostichus* research program in Statistical Subarea 48.1 H. Pehlke, S. Hain, K. Teschke and T. Brey
WG-FSA-18/02	On multi-year variability of the Patagonian toothfish (*Dissostichus eleginoides*) size composition in longline catches in the South Georgia maritime zone N.N. Kukharev and A.F. Petrov
WG-FSA-18/03	Finding of a tag on toothfish from the stomach of *Dissostichus mawsoni* L. Pshenichnov and P. Zabroda
WG-FSA-18/04	Brief report on the results of oceanological work of Ukrainian vessels in the CCAMLR area in the season 2017/18 V. Paramonov and L. Pshenichnov
WG-FSA-18/05	Hydroacoustic data obtained around Elephant Island and South Orkney Islands during austral summer 2018 N.A. Alegría and P.M. Arana
WG-FSA-18/06	Preliminary insights of Antarctic toothfish sub-adults life-history traits from the southern Weddell Sea (Subarea 48.5) M. La Mesa, F. Donato and E. Riginella
WG-FSA-18/07	Managing the Ross Sea toothfish fisheries – A response to the consultation responses (COMM CIRC 18/39) Secretariat
WG-FSA-18/08 Rev. 1	Informing the Working Group on Fish Stock Assessment about the revisions of the WSMPA proposal about the revisions of the WSMPA proposal S. Hain, K. Teschke, H. Pehlke and T. Brey on behalf of the German Weddell Sea MPA project team
WG-FSA-18/09	Implementation of by-catch move-on rules in exploratory fisheries Secretariat

WG-FSA-18/10	Fish by-catch in the krill fishery: 2018 update Secretariat
WG-FSA-18/11 Rev. 1	Implementation of the CCAMLR Scheme of International Scientific Observation during 2017/18 Secretariat
WG-FSA-18/12	Estimates of local biomass with uncertainty for Antarctic (*Dissostichus mawsoni*) and Patagonian (*D. eleginoides*) toothfish in research blocks in Subareas 48.6 and 58.4 Secretariat
WG-FSA-18/13 Rev. 1	Summary of incidental mortality associated with fishing activities collected in scientific observer and vessel data during the 2018 season Secretariat
WG-FSA-18/14	Meta-analysis of catch reporting in CCAMLR exploratory fisheries Secretariat
WG-FSA-18/15	Measurement of capacity in CCAMLR exploratory fisheries in Subareas 88.1 and 88.2: Secretariat update 2018 Secretariat
WG-FSA-18/16 Rev. 1	Research proposal for *Dissostichus* spp. in Subarea 88.3 by Ukraine in 2019 Delegation of Ukraine
WG-FSA-18/17	Analysis of gear loss by fishing vessels in the CCAMLR Convention Area as contribution to the marine debris program Secretariat
WG-FSA-18/18	Report on the CCAMLR Marine Debris monitoring program: 2018 update Secretariat
WG-FSA-18/19	Mesozooplankton distribution and community structure in the Pacific and Atlantic sectors of the Southern Ocean during austral summer 2017/18: a pilot study conducted from Ukrainian longliners E.A. Pakhomov, L.K. Pshenichnov, A. Krot, V. Paramonov, I. Slypko and P. Zabroda
WG-FSA-18/20 Rev. 1	Research proposal for *Dissostichus* spp. in Subarea 48.1 by Ukraine in 2019 Delegation of Ukraine

WG-FSA-18/21	Trophic niche of the Antarctic toothfish caught in SSRU 88.3 as inferred from fatty acids and stable isotopes C.-K. Kang, S.-G. Choi, H.Y. Kang, Y.-J. Lee, S. Chung and D.H. An
WG-FSA-18/22	Depth and temperature preferences of Antarctica toothfish (*Dissostichus mawsoni*) from a pilot popup satellite archival tag study in the Mawson Sea C.H. Lam, S.-G. Choi, E. Kim, S. Chung, J. Lee and D.H. An
WG-FSA-18/23	Report on recent French catches of sea pens (Pennatulacea) in Lena Bank (CCAMLR sector 58.4.4b) A. Martin, J. Blettery and M. Eléaume
WG-FSA-18/24	Diet composition and feeding strategy of Antarctic toothfish, *Dissostichus mawsoni* in the research blocks 58 and 88 for the exploratory longline fishery in 2014–2018 of Korea G.W. Baeck, S.-G. Choi, S. Chung and D.H. An
WG-FSA-18/25	Sharks by-catch observed on bottom longlines fishery off the Kerguelen Islands in 2006–2016, with a focus on *Etmopterus viator* C. Chazeau, S.P. Iglésias, N. Gasco, A. Martin and G. Duhamel
WG-FSA-18/26	Preliminary tag-recapture based population assessment of Antarctic toothfish in Subarea 48.4 T. Earl and A. Riley
WG-FSA-18/27	Stock status and population assessment of the Antarctic starry skate (*Amblyraja georgiana*) in Subarea 48.3 M. Söffker, N.D. Walker, M. Belchier and J. Ellis
WG-FSA-18/28	Report on fish by-catch on exploratory fishing in Divisions 58.4.1 and 58.4.2 C. Péron, P. Yates, D. Maschette, C. Chazeau, P. Ziegler, D. Welsford, N. Gasco and G. Duhamel
WG-FSA-18/29	New C2 form project N. Gasco, C. Chazeau, A. Martin, P. Pruvost, C. Péron and G. Duhamel
WG-FSA-18/30	Improving observer's identification skills for better data quality through a phone application N. Gasco, A. Martin, C. Chazeau, C. Péron, P. Pruvost and G. Duhamel

WG-FSA-18/31	Outline for year 3 of the 3-year longline survey to determine toothfish population connectivity between Subareas 48.2 and 48.4 G. Robson, P. Hollyman and C. Darby
WG-FSA-18/32 Rev. 1	Research program on study of life cycle, species composition, biology and resource potential of craboids (Anomura, Decapoda) in the Pacific Ocean Antarctic Area in 2018–2021 by the Russian Federation Delegation of the Russian Federation
WG-FSA-18/33 Rev. 1	Research program to examine the life cycle and resource potential of *Dissostichus* species in the Special Research Zone within the Ross Sea region marine protected area (RSRMPA) in 2018–2027 Delegation of the Russian Federation
WG-FSA-18/34	Proposed continuation of a multi-Member longline survey on Antarctic toothfish (*Dissostichus mawsoni*) in Statistical Subarea 48.6 in 2018/19 by Japan, South Africa and Spain Delegations of Japan, South Africa and Spain
WG-FSA-18/35	Preliminary results from the second year of a three-year survey into the connectivity of toothfish species in Subareas 48.2 and 48.4 – update to WG-SAM-18/30 G. Robson, M. Söffker, E. MacLeod and P. Hollyman
WG-FSA-18/36	Summary of the toothfish fishery and tagging program in the Amundsen Sea region (SSRUs 882C–H) to 2017/18 S. Mormede and S. Parker
WG-FSA-18/37	Progress towards an assessment of Antarctic toothfish (*Dissostichus mawsoni*) in Subarea 88.2 SSRUs 882C–H for the years 2002/03 to 2017/18 using a two-area model S. Mormede and S. Parker
WG-FSA-18/38 Rev. 1	Proposal for a skate tagging program in the Ross Sea region to estimate the local biomass trend for starry skates (*Amblyraja georgiana*) S. Parker and M. Francis
WG-FSA-18/39	Research results from the SPRFMO exploratory fishing program for Antarctic toothfish 2016 and 2017 J.M. Fenaughty, M. Cryer and A. Dunn
WG-FSA-18/40	Proposal for a winter longline survey of Antarctic toothfish in the northern region of Subareas 88.1 and 88.2 Delegation of New Zealand

WG-FSA-18/41	Proposal to continue the time series of research surveys to monitor abundance of Antarctic toothfish in the southern Ross Sea, 2018–2022 S.M. Hanchet, K. Large, S.J. Parker, S. Mormede and A. Dunn
WG-FSA-18/42	Revised joint research proposal for *Dissostichus* spp. in Subarea 88.3 by Korea and New Zealand Delegations of the Republic of Korea and New Zealand
WG-FSA-18/43	A new method to produce high resolution maps of effort and catches in longline fisheries N. Gasco, C. Péron, C. Chazeau, A. Martin, P. Pruvost and G. Duhamel
WG-FSA-18/44	Revised continuation proposal of a multi-Member longline survey on Patagonian toothfish (*Dissostichus eleginoides*) in Division 58.4.4b in 2018/19 by Japan and France Delegations of Japan and France
WG-FSA-18/45	Spatial distribution and population structure of juvenile Antarctic toothfish (*Dissostichus mawsoni*) in the South Shetland Islands (Subarea 48.1) M. La Mesa, E. Riginella and C.D. Jones
WG-FSA-18/46	Summary of the toothfish fishery and tagging program in the Ross Sea region (Subarea 88.1 and SSRUs 882A–B) through 2017/18 S. Mormede and S. Parker
WG-FSA-18/47	A comparative morphometric analysis of sagittal otoliths of three icefishes (Channichthyidae) in Antarctic waters G. Plaza, C. Rodríguez-Valentino and P.M. Arana
WG-FSA-18/48 Rev. 1	Description of the tagging process and the development of a cradle for optimum landing and measuring of large fish followed by the Spanish F/V *Tronio* R. Sarralde, C. Heinecken and P. Lafite
WG-FSA-18/49 Rev. 1	Progress report on the research for *Dissostichus* spp. in Subarea 48.2 by the Ukraine in 2015–2018 and notification of research in 2019 Delegation of Ukraine
WG-FSA-18/50	Annual report of research fishing operations at Division 58.4.3a in the 2017/18 fishing season Delegations of France and Japan

WG-FSA-18/51	Preliminary report on invertebrate by-catch in research blocks 58.4.1, 58.4.2, 54.4.3a and 58.4.4b M. Eléaume, C. Chazeau, A. Martin and J. Blettery
WG-FSA-18/52	Subarea 48.2 research and research proposals for 2019 – overview G. Robson, L. Pshenichnov, D. Marichev and C. Darby
WG-FSA-18/53 Rev. 1	Information about tagged Patagonian toothfish (*Dissostichus eleginoides*) tagged in the CCAMLR Convention Area and recovered in the SIOFA management area by two Spanish vessels in 2017/18 R. Sarralde and S. Barreiro
WG-FSA-18/54 Rev. 1	Update of ongoing work on age and growth of Antarctic toothfish (*Dissostichus mawsoni*) from Division 58.4.1 by Australia and Spain L.J. López-Abellán, M.T.G. Santamaría, R. Sarralde, S. Barreiro, B. Farmer and T. Barnes
WG-FSA-18/55	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 2018 G. Nowara, T. Lamb and P. Ziegler
WG-FSA-18/56	A preliminary assessment for mackerel icefish (*Champsocephalus gunnari*) in Division 58.5.2, based on results from the 2018 random stratified trawl survey D. Maschette and D. Welsford
WG-FSA-18/57	Report on fishing effort and seabird interactions during the season extension trials in the longline fishery for *Dissostichus eleginoides* in Statistical Division 58.5.2 T. Lamb
WG-FSA-18/58 Rev. 1	Report on *Dissostichus mawsoni* exploratory fishery research in East Antarctica (Divisions 58.4.1 and 58.4.2) between the 2011/12 and 2017/18 fishing seasons P. Yates and P. Ziegler
WG-FSA-18/59	Proposal for 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-18/60	Analyses of illegal, unreported and unregulated (IUU) fishing activities in Divisions 58.4.1 during the 2013/14 season and 58.4.3b during the 2014/15 season Delegation of Australia and CCAMLR Secretariat
WG-FSA-18/61	Revised continuation proposal of multi-Member research on Patagonian toothfish (*Dissostichus eleginoides*) exploratory fishery in 2018/19 in Division 58.4.3a by France and Japan Delegations of France and Japan
WG-FSA-18/62	Baited Remote Underwater Video (BRUV) system to monitor Antarctic toothfish distribution and abundance: pilot study results and future design D. Di Blasi, S. Canese, E. Carlig, L. Ghigliotti, S.J. Parker and M. Vacchi
WG-FSA-18/63 Rev. 1	Indicative trends in by-catch of sharks in the CAMLR Convention Area C.D. Jones
WG-FSA-18/64	Progress update on Antarctic toothfish inter-connectivity project D. Maschette, A. Polanowsk, B. Deagle, D.C. Welsford and P. Ziegler
WG-FSA-18/65	Reproductive ecology of Antarctic toothfish, *Dissostichus mawsoni* (Norman, 1937) (Actinopterygii: Nototheniidae), in the Antarctic waters (SSRUs 58 and 88) J.-W. Kim, S.-G. Choi, S. Chung and D.H. An
WG-FSA-18/66	Towards further development of stock assessment of stock abundance for Subarea 48.6 taking into account the developments since 2012 – a discussion paper Delegations of Japan and South Africa
WG-FSA-18/67	Annual report of research fishing operations at Division 58.4.4b in the 2017/18 fishing season Delegations of Japan and France
WG-FSA-18/68	Spatial pattern of major by-catch fishes at Division 58.4.4b during 2012/13–2016/17 Delegations of Japan and France
WG-FSA-18/69	Spatial pattern of major by-catch fishes at Division 58.4.3a during 2012/13–2016/17 Delegations of Japan and France

WG-FSA-18/70	Spatial pattern of major by-catch fishes at Subarea 48.6 during 2012/13–2016/17 Delegations of Japan and South Africa
WG-FSA-18/71	Annual report of research fishing operations at Subarea 48.6 in the 2017/18 fishing season Delegations of Japan and South Africa
WG-FSA-18/72	Preliminary results of stock estimation for *D. mawsoni* using CASAL in the research block 486_2 T. Okuda
WG-FSA-18/73	Genetic analysis of skates (*Amblyraja* spp.) caught as by-catch around South Georgia and the South Sandwich Islands W.P. Goodall-Copestake, S. Perez-Espona, P. Hollyman and M. Belchier
WG-FSA-18/74	Ageing two myctophid fishes using otolith from king and macaroni penguins in the Marion Island and its implication to feeding preference of penguins on those myctophids M. Duan, G.P. Zhu, A. Makhado and L. Wei
WG-FSA-18/75	Otolith chemistry reveals local population structure of Antarctic toothfish (*Dissostichus mawsoni*) within the CCAMLR Subarea 48.6 L. Wei, G.P. Zhu, S. Somhlaba, X.Y. Yu and M. Duan
WG-FSA-18/76	Fatty acids composition of spiny icefish *Chaenodraco wilsoni* in the Bransfield Strait and its implication to local food availability Q.Y. Yang, G.P. Zhu and K. Reid

Other documents

WG-FSA-18/P01	New Antarctic deep-sea weird leech (Hirudinida: Piscicolidae): morphological features and phylogenetic relationships A. Utevsky and S. Utevsky *Syst. Parasitol.*, (2018). Springer, Netherlands, doi: https://doi.org/10.1007/s11230-018-9816-y. This article was registered in the Official Register of Zoological Nomenclature (ZooBank) as 0FFF1867-BF3B-4D2B-83EFBE894F838912
CCAMLR-XXXVII/12	IUU fishing activity and trends in 2017/18 and IUU Vessel Lists Secretariat
SC-CAMLR-XXXVI/20	The Ross Sea region Marine Protected Area Research and Monitoring Plan A. Dunn, M. Vacchi and G. Watters (Co-conveners)

SC-CAMLR-XXXVII/01	Report of the Co-conveners of the CCAMLR Workshop for the Development of a *Dissostichus mawsoni* Population Hypothesis for Area 48 (19 to 21 February 2018, Berlin, Germany) Workshop Co-conveners (C. Darby (UK) and C. Jones (USA))
SC-CAMLR-XXXVII/02 Rev. 1	Summary Report of the CCAMLR Independent Stock Assessment Review for Toothfish (Norwich, United Kingdom, 18 to 22 June 2018)
SC-CAMLR-XXXVII/BG/01 Rev. 2	Catches of target species in the Convention Area Secretariat
SC-CAMLR-XXXVII/BG/21	Marine debris and entanglements at Bird Island and King Edward Point, South Georgia, Signy Island, South Orkneys and Goudier Island, Antarctic Peninsula 2017/18 C. Waluda
SC-CAMLR-XXXVII/BG/23	Efficiency of the multi-year research programs for the *Dissostichus* species exploratory fishery: comments on the multi-Member research in the East Antarctic (Division 58.4.1) Delegation of the Russian Federation
WG-SAM-18/33 Rev. 1	Annex to WS-DmPH-18 report: Towards the development of a stock hypothesis for Antarctic toothfish (*Dissostichus mawsoni*) in Area 48 M. Söffker, A. Riley, M. Belchier, K. Teschke, H. Pehlke, S. Somhlaba, J. Graham, T. Namba, C.D. van der Lingen, T. Okuda, C. Darby, O.T. Albert, O.A. Bergstad, P. Brtnik, J. Caccavo, A. Capurro, C. Dorey, L. Ghigliotti, S. Hain, C. Jones, S. Kasatkina, M. La Mesa, D. Marichev, E. Molloy, C. Papetti, L. Pshenichnov, K. Reid, M.M. Santos and D. Welsford

Appendix D

Using catch data in fishery monitoring and closure forecasting in the Ross Sea toothfish fisheries

1. This procedure has been developed specifically for the Ross Sea, it would be equally applicable to any area for which the catch limit was small and the number of vessels notified to fish was large.

2. For the first three days of fishing operations in the Ross Sea region, which will open on 1 December, calculations will be made on historical catch data for the vessels that have notified their intent to fish. The historical catch rate (kg/day) for any vessel notified to fish in an area of Conservation Measure (CM) 41-09 (northern, southern) will be calculated as the sum of the catch taken in the relevant area over the last five years divided by the number of days fished, defined as a day on which hooks were set, in the relevant area over the last five years. The catch rate applicable to vessels which have not fished in the relevant area in any of the last five years will be the sum of the total catch by all vessels divided by the number of days fished by all vessels over the last five years.

3. The Secretariat will request that all vessels that are present send a message to the Secretariat by 0001 UTC on 30 November to indicate if they intend to fish in the area north of 70°S on 1–3 December; noting that a null response will be interpreted as intention to fish.

4. On 30 November the Secretariat will calculate a projected daily total catch for each vessel that is present in the relevant area and that has declared its intention to fish, using the historical daily catch calculation described in paragraph 2. Based on this projection, the Secretariat will apply the following procedure:

(i) if an area in a fishery is projected to exceed its catch limit after only one day of setting hooks, the Secretariat will advise Members accordingly and that area of the fishery will not be opened; or

(ii) if an area in a fishery is projected to exceed its catch limit after two days of setting hooks, a notification that that area of the fishery would close at 2359 on 2 December (i.e. with no gear set after 2359 on 1 December) will be made on 30 November; or

(iii) if an area in a fishery is projected to exceed its catch limit after three days of setting hooks, the Secretariat will not indicate a closure for that area of the fishery until data from 1 December is available. The historical catch data for those vessels that are actively fishing will then be used in the projection

(iv) a revised projection indicating that an area in the fishery will exceed its catch limit after five days of setting hooks would result in a notification of closure from 2359 on 4 December

(v) if the revised projection indicates that an area in the fishery will not exceed its catch limit after five days of setting hooks, the Secretariat will, on day 4, transition to a projection based on catch and effort data from the current season.

5. The Secretariat will inform Members and vessels of the outcomes of this procedure on 30 November, and as required thereafter.

6. Because the catch in the northern area of the Ross Sea is relatively low, significant over- or under-runs of the limit may be expected. Both over- or under-runs can be accommodated within the overall catch limit with the following change to CM 41-09:

The total catch of *Dissostichus mawsoni* in the 2018/19 season in Statistical Subarea 88.1 and SSRUs 882A–B shall not exceed a precautionary catch limit of 3 157 tonnes applied as follows:

All areas outside the Ross Sea region marine protected area –

2 645 tonnes, of which no more than 591 tonnes be taken north of 70°S.

If, however, more than 591 tonnes have been taken north of 70°S by the time that the Secretariat has issued a closure notice for the fishery north of 70°S, then the amount that may be taken south of 70°S is reduced by the amount taken over 591 tonnes north of 70°S.

Special Research Zone of the Ross Sea region marine protected area –

467 tonnes.

Vessel tagging procedures survey

All vessels should follow the CCAMLR tagging protocol for tagging toothfish (www.ccamlr.org/node/85702).

This survey has been designed for an observer to be able to complete independently from the vessel, however, it may be useful to liaise with the fishing master for accuracy in some instances (e.g. the volume of the holding tank). You are requested to select the most appropriate fields for the questions listed or provide descriptive details where instructed. If possible, provide an example representative video or photos of the tagging process which includes fish landing, fish handling, tagging, data recording and fish release.

Equipment and operation	
Tagging station location	On deck – Open air
	On deck – Under cover
	In factory
	Other – Please describe
	How frequently are tagging guns cleaned or maintained? Every haul, periodically, once per trip
	Vertical distance from water surface to hauling bay (m)
	Vertical distance from fish release position to water surface (m)
	Distance from tagging station to release location (m)
Holding tank	Y/N
Holding tank information (if used)	Volume (l)
	Shape (square, rectangle, circle etc.)
	Does the tank have flowing water (Y/N)
Landing and handling fish	
Large fish landing and lifting equipment	Net
	Stretcher or cradle
	Other – Please describe
	Approximate minimum length of fish when lifting gear is used (cm)
Transporting fish	When transporting the fish between the hauling bay and the tagging station, are any of the following obstacles present: • Bulkheads • Machinery • Factory equipment (e.g. conveyor belts) • Steps or multiple levels Any other obstruction?
	Is lifting equipment used to carry fish between hauling bay and tagging station? (Y/N)
How are tagging data recorded at the tagging station?	Direct to computer/Paper data sheet/waterproof board or notepad/Photograph/Other
Releasing fish	Describe any aids used for release of fish (e.g. cradle, slide)

Personnel and training	
Tagging responsibilities	Crew
	Observer(s)
	Combination
	Number of crew trained for tagging procedures
	If any tagging training occurs on the vessels is it practical, theoretical or a combination?
	Languages by crew trained for tagging
	Title of person responsible for overall tagging training (e.g. fishing master, bosun, factory manager, observer, company representative/other)
	When a tagged fish is landed and the observer is not present, how is the observer notified?
Assessment of fish suitability for tagging	CCAMLR tagging protocol and fish suitability assessment criteria available for viewing near tagging station: (Y/N)

Terms of Reference for the CCAMLR Data Services Advisory Group (DSAG)

Terms of Reference for the CCAMLR Data Services Advisory Group (DSAG)

1. The Data Services Advisory Group (DSAG) will be a conduit between CCAMLR data users, data providers and the Secretariat, in accordance with the rules for access and use of CCAMLR data to provide feedback and advice on:

(i) communication of information on data and metadata management and development

(ii) development of data quality standards and rules

(iii) development of data infrastructure, including data submission processes

(iv) provision of data extracts to Members

(v) development of data analysis tools.

2. The DSAG will review the Secretariat Information System and Data Services workplan annually and provide feedback on the prioritisation and scope of data projects planned for the following year.

3. The Convener(s) of the DSAG will be selected by the Scientific Committee and be responsible for the coordination of the work of the group. The DSAG will conduct its work using the most effective means, which can include the CCAMLR e-group facility, teleconferences, or online meetings. It may also meet periodically in association with a Scientific Committee and/or relevant working group meetings. Summaries of DSAG discussions will be communicated via an e-group as well as reported to relevant working groups and annually to the Scientific Committee.

4. Participation in the DSAG is open to all Members with participants nominated by their respective Scientific Committee Representative. The DSAG may call on invited experts to develop specific aspects of its work following the procedures for inviting experts to meetings of the Scientific Committee and its working groups.

Using catch data in fishery monitoring and closure forecasting in the Ross Sea toothfish fisheries

Using catch data in fishery monitoring and closure forecasting in the Ross Sea toothfish fisheries

1. This procedure has been developed specifically for the Ross Sea. It would be equally applicable to any area for which the catch limit was small and the number of vessels notified to fish was large.

2. For the first three days of fishing operations in the Ross Sea region, which will open on 1 December, calculations will be made on historical catch data for the vessels that have notified their intent to fish. The historical catch rate (kg/day) for any vessel notified to fish in an area of Conservation Measure (CM) 41-09 (northern, southern) will be calculated as the sum of the catch taken in the relevant area over the last five years divided by the number of days fished, defined as a day on which hooks were set, in the relevant area over the last five years. The catch rate applicable to vessels which have not fished in the relevant area in any of the last five years will be the sum of the total catch by all vessels divided by the number of days fished by all vessels over the last five years.

3. The Secretariat will request that all vessels that are present send a message to the Secretariat by 0001 UTC on 30 November to indicate if they intend to fish in the area north of 70°S on 1–3 December; noting that a null response will be interpreted as intention to fish.

4. On 30 November the Secretariat will calculate a projected daily total catch for each vessel that is present in the relevant area and that has declared its intention to fish, using the historical daily catch calculation described in paragraph 2. Based on this projection, the Secretariat will apply the following procedure:

(i) if an area in a fishery is projected to exceed its catch limit after only one day of setting hooks, the Secretariat will advise Members accordingly and that area of the fishery will not be opened; or

(ii) if an area in a fishery is projected to exceed its catch limit after two days of setting hooks, a notification that that area of the fishery would close at 2359 on 2 December (i.e. with no gear set after 2359 on 1 December) will be made on 30 November; or

(iii) if an area in a fishery is projected to exceed its catch limit after three days of setting hooks, the Secretariat will not indicate a closure for that area of the fishery until data from 1 December is available. The historical catch data for those vessels that are actively fishing will then be used in the projection

(iv) a revised projection indicating that an area in the fishery will exceed its catch limit after five days of setting hooks would result in a notification of closure from 2359 on 4 December

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5. The Secretariat will inform Members and vessels of the outcomes of this procedure on 30 November and as required thereafter.

6. Because the catch in the northern area of the Ross Sea is relatively low, significant over- or under-runs of the limit may be expected. Both over- or under-runs can be accommodated within the overall catch limit with the following change to CM 41-09:

> The total catch of *Dissostichus mawsoni* in the 2018/19 season in Statistical Subarea 88.1 and SSRUs 882A–B shall not exceed a precautionary catch limit of 3 157 tonnes applied as follows:
>
> All areas outside the Ross Sea region marine protected area –
>
> 2 041 tonnes, of which no more than 587 tonnes be taken north of 70°S.
>
> If, however, more than 587 tonnes have been taken north of 70°S by the time that the Secretariat has issued a closure notice for the fishery north of 70°S, then the amount that may be taken south of 70°S is reduced by the amount taken over 587 tonnes north of 70°S.
>
> Special Research Zone of the Ross Sea region marine protected area –
>
> 464 tonnes.

Annex 12

Research plan for Division 58.4.4b

Research plan for Division 58.4.4b

Management advice given by WG-FSA-18

1. WG-FSA noted that this is a closed area and requested that the Scientific Committee consider the viability of this research plan and the sustainability of this stock given: (i) that proposed research designs have not been implemented, (ii) low and declining catch rates, (iii) low numbers of historical tag recaptures, (iv) low expected numbers of future recaptures due to low catches, and (v) limited milestone achievement (Annex 9, paragraph 4.137).

Objectives of the research plan (WG-FSA-18/44)

Objective 1 – An assessment of the stock status of Patagonian toothfish (*D. eleginoides*)
Objective 2 – Improving the knowledge about growth of *D. eleginoides*
Objective 3 – Improving the knowledge about population structure of *D. eleginoides*
Objective 4 – Investigating ecological traits of *D. eleginoides*
Objective 5 – Revealing the spatio–temporal pattern of by-catch species distribution
Objective 6 – Improving the knowledge about Antarctic marine ecosystems
Objective 7 – Investigating effects of depredation.

2. Japan and France recognised further clarifications were needed to understand how to recover the delay in achieving the milestones. The proponents announced that they will strengthen their research capacity in 2019 and that a new Japanese vessel will start operation in April 2020 expecting to increase survey capacity.

3. Following the discussions at WG-FSA, the proponents made the following suggestions to improve achievements of the research plan objectives, which are outlined in the research proposal (WG-FSA-18/44):

(i) amendments to the research design:

(a) achieve the catch limit, as far as possible, to be able to meet research objectives

(b) respect the grid design (Figure 1) in place since 2012/13 (WG-FSA-12/58), with two additional recommendations:

- focus effort in research block 5844b_1 where the catch-per-unit-effort (CPUE) is higher and more stable (Figure 2)

- avoid the area where high density of pennatulacea was identified. Figure 3 shows spatial distribution of sea pens and fine-scale rectangles that would need to be avoided

(c) continue the tagging program as set out in the research plan (WG-FSA-18/44)

(d) agree to transfer allowable catch between vessels if one vessel cannot operate

(ii) Japan and France will commit to implementing further recommendations made by WG-FSA:

   (a) use of a holding tank on board to retain tagged toothfish in presence of predators

   (b) consider e-monitoring onboard to estimate reporting rate

(iii) updates to analyses to be conducted for WG-SAM-19 and/or WG-FSA-19 regarding objectives:

   (a) the proponents are committed to recover the delay in achieving the agreed milestones, and as follows.

Biomass estimation using CASAL

4. The analyses presented below will contribute to objectives 1 and 2.

5. These analyses will be included in a preliminary CASAL stock assessment model, building on the model presented at WG-FSA in 2015:

(i) Document WG-FSA-15/23

   (a) update biological parameters (objectives 1.1 and 4):

      - growth curve (2 000 otoliths read, see Table 2 for details)
      - age–length key
      - maturity ogive (15 000 fish examined)

   (b) update estimation of illegal, unreported and unregulated (IUU) catches (objective 1.2):

      - using the analyses presented by Australia in Division 58.4.1 (WG-FSA-18/60)

   (c) estimate depredation from marine mammals (objectives 1.3 and 7):

      - using methods developed in Subarea 58.6

   (d) evaluate effective tagging-survival and tag-detection rate among vessels (objective 1.4).

By-catch analyses

6. The analyses presented below will contribute to objectives 5 and 6:

(i) retrospective fish by-catch analyses as in WG-FSA-18/28 (in Division 58.4.1)
(ii) retrospective vulnerable marine ecosystems (VME) analyses.

7. The milestones table as provided in WG-FSA-18/44 has been amended to consider recommendations by WG-FSA-18.

Table 1: The revised timelines of milestones to conduct research fishing and to report progresses corresponding to objectives 1 to 7 in Division 58.4.4b. A progress report will be provided to WG-FSA every year, which will provide a summary of data collected in the ongoing fishing season. A final report of series of research fishing will be submitted to WG-FSA in 2021. Role sharing is represented by an initial letter of Member: F – France, J – Japan. Years 2020 and 2021 appear in grey italic because they will depend on recommendations by WG-FSA-19.

	2017	2018	2019	*2020*	*2021*
Survey fishing	F+J	F+J	F+J	*F+J*	*F+J*
Objective 1. Stock assessment					
1.1 Update biological parameters:					
Growth curve Age–length key Maturity ogive			J+F	*J+F*	*J+F*
1.2 Update estimation of IUU catches			J+F		*J+F*
1.3 Estimate depredation from marine mammals			F+J		*F+J*
1.4 Evaluate effective tagging-survival and tag-detection rates among vessels			F+J		*F+J*
1.5 Update CASAL model			J+F	*J+F*	*J+F*
Objective 2. Growth knowledge					*F+J*
2.1 Ageing toothfish	J	J	J+F	*J+F*	*J+F*
Objective 3. Population structure					
3.1 Reviewing stock hypothesis				*F+J*	*F+J*
Objective 4. Ecological traits			J	*J*	*J*
Objective 5. By-catch pattern					
5.1 Fish by-catch	J+F	J	F+J	*F+J*	*F+J*
5.2 Macro-invertebrates by-catch		F	F	*F*	*F*
Objective 6. Antarctic Marine ecosystem		F	J+F	*J+F*	*J+F*
Objective 7. Depredation			F+J	*F+J*	*F+J*

Table 2: Number of otoliths aged by Japan.

Year	Number of otolith readings
2008	652
2010	134
2011	287
2012	265
2013	279
2014	310
2016	207
2017	206 (under aging in this year)

Table 3: Summary table of *D. eleginoides* biological data in Division 58.4.4b. Values are the number of fish observed for each biological parameter and sample collection (WG-FSA-18/67). Data are for all vessels and cruises pooled. Season is abbreviated to the end year.

Research block	Season	Length	Weight	Sex	Maturity	Gonad	Otolith
5844b_1	2008	1337	807	804	804	805	806
5844b_1	2010	1149	700	1149	813	813	600
5844b_1	2011	1745	860	1745	1745	1745	858
5844b_1	2012	1589	861	1586	916	916	823
5844b_1	2013	1790	877	1790	1790	1790	848
5844b_1	2014	1296	1295	1162	1166	1166	915
5844b_1	2015	1944	1944	1943	1944	1944	1166
5844b_1	2016	2118	2118	2096	2114	2114	1096
5844b_1	2017	1879	1887	1891	1891	1891	1168
5844b_2	2008	1022	504	504	504	504	503
5844b_2	2010	742	528	742	526	536	485
5844b_2	2013	1083	819	1083	1083	1083	809
5844b_2	2014	1062	1062	836	837	837	790
5844b_2	2015	1261	1261	1260	1261	1261	1115
5844b_2	2016	1003	1039	1029	1031	1031	959
5844b_2	2017	1292	1292	1290	1290	1290	903
5844b_2	2018	265	264	265	265	265	150
Outside	2008	1889	1053	1052	1052	1052	1050
Outside	2010	2876	1408	2868	1756	1756	1145
Outside	2011	2628	1053	2620	2620	2620	1052
Outside	2012	1949	909	1948	1941	1941	843

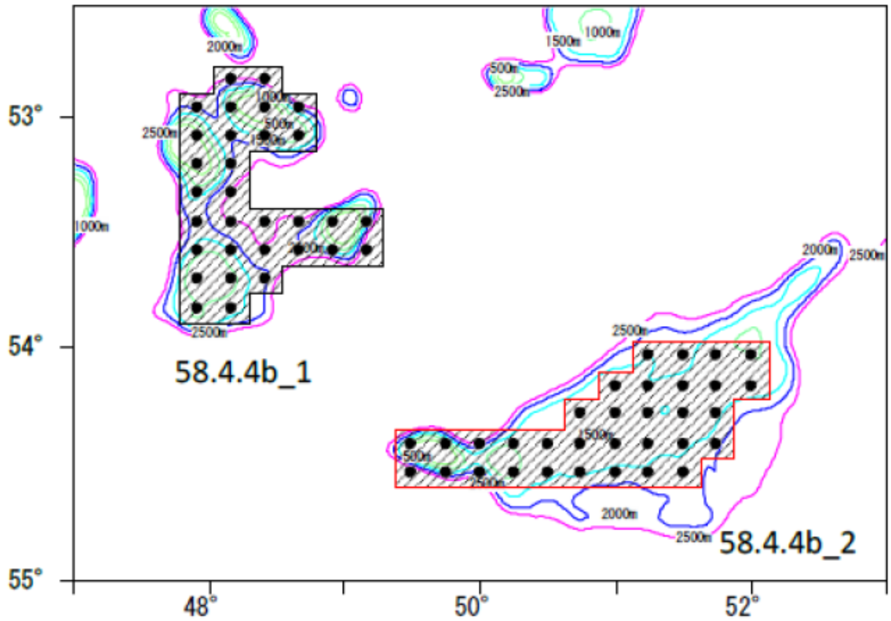

Figure 1: Proposition for allocated locations (64 lattices) for longline surveys in research blocks 5844b_1 (31 lattices) and 5844b_2 (33 lattices) in 2018/19. The longline gear will be set within 7.5 n miles square (grey oblique lined portions) in order to capture toothfish effectively and achieve high tagging performance. Because the fishing areas within the research blocks are small, and the first 64 hauls have to be set under grid survey design, no depth stratification is proposed in the current research plan (WG-FSA-18/44).

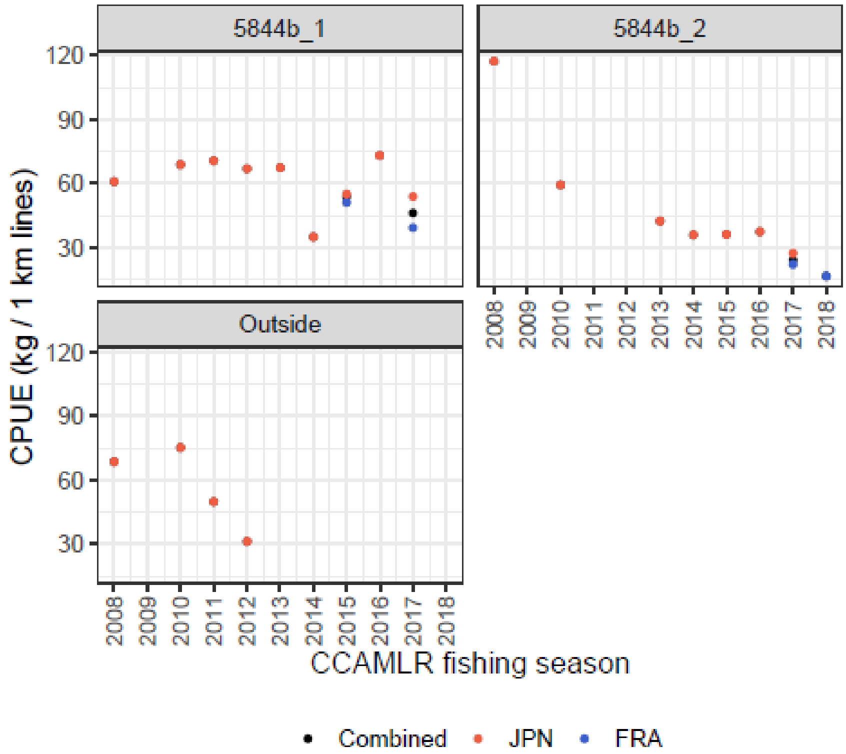

Figure 2: CPUE in Division 58.4.4b for Japanese and French vessels over the last decade (WG-FSA-18/67).

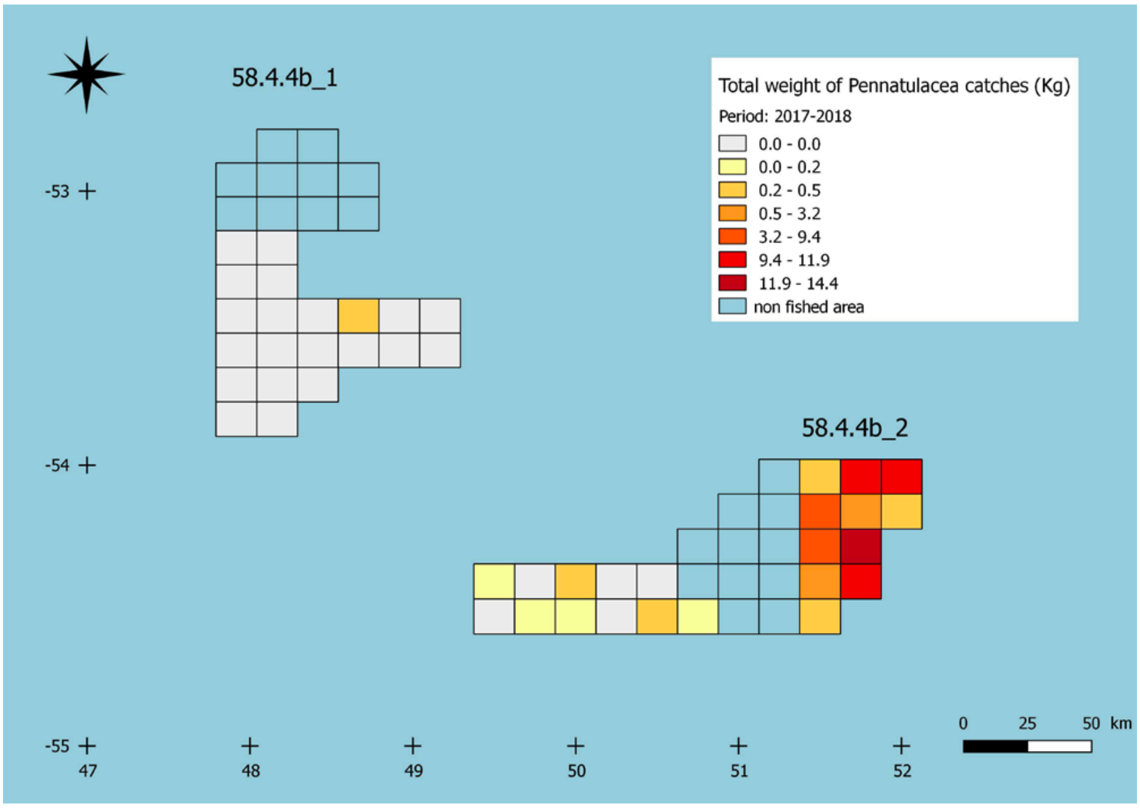

Figure 3: Spatial distribution of sea pen (Pennatulacea) catches in Division 58.4.4b between 12/06/2017 and 08/03/2018; catches given in total weight (kg) per fine-scale rectangle. It indicates that the high density of sea pens is limited to the eastern part of research block 5844b_2 which will be avoided by fishing vessels (WG-FSA-18/23).

Format for Submitting Finfish Research Proposals in Accordance with Paragraph 3 of Conservation Measure 24-01 and Paragraph 6(iii) of Conservation Measure 21-02

Format for Submitting Finfish Research Proposals in Accordance with Paragraph 3 of Conservation Measure 24-01 and Paragraph 6(iii) of Conservation Measure 21-02

Category	Information
1. Main objective	(a) Objectives for the research and why it is a priority for CCAMLR. (b) Detailed description of how the proposed research will meet the objectives, including start date, annual research milestones (where applicable), and end date of research. (c) Rationale for research, including relevant existing information on the target species from this region, linkage between research objectives and the stock hypothesis, and information from other fisheries in the region or similar fisheries elsewhere.
2. Fishery operations	(a) Fishing Member (b) Vessel to be used: • Vessel name • Vessel owner • Vessel type (research or commercial vessel) • Port of registration and registration number • Radio call sign • Overall length and tonnage • Equipment used for determining position • Fishing capacity • Fishing processing and storage capacity. (c) Target species (d) Fishing or acoustic gear to be used: • Trawl type, mesh shape and size • Longline type • Other sampling gear • Type of acoustic gear and frequency. (e) Fishing regions (divisions, subareas and SSRUs) and geographical boundaries (f) Estimated dates of entering and leaving the CAMLR Convention Area.
3. Survey design, data collection and analysis	(a) Research survey/fishing design (description and rationale): • Spatial arrangements or maps of stations/hauls (e.g. randomised or gridded) • Stratification according to e.g. depth or fish density • Calibration/standardisation of sampling gear • Proposed number and duration of stations/hauls • Tagging rates and other performance metrics such as tag overlap statistics for tagging programs at the scale of research blocks (where applicable). • Other requirements. (b) Data collection: Types and sample size or quantities of catch, effort and related biological (including taxonomic resolution), ecological and environmental data (e.g. sample size by location/haul) with minimum observer sampling requirements as detailed in the *Observer Sampling Requirements* (Conservation Measure 41-01, Annex 41-01/A). (c) Method for data analysis to achieve the objective in 1(a). (d) How and when will the research outcomes meet the objectives of the research (e.g. lead to a robust estimate of stock status and precautionary catch limits). Include evidence that the proposed methods are highly likely to be successful.
4. Proposed catch limits	(a) Proposed catch limits and justification. (Note that the catch limits should be at a level not substantially above that necessary to obtain the information specified in the Research Plans and required to meet the objectives of the proposed research.)

(continued)

	(b) Evaluation of the impact of the proposed catch on stock status, including: • rationale that proposed catch limits are consistent with Article II of the Convention • evaluation of timescales involved in determining the responses of harvested, dependent and related populations to fishing activities • information on estimated removals, including IUU fishing activities, where available. (c) Details of dependent and related species and the likelihood of their being affected by the proposed fishery.
5. Research capability	(a) Name(s) and address(es) of the chief scientist(s), research institute or authority responsible for planning and coordinating the research. (b) Number of scientists and crew to be on board the vessel. (c) Is there opportunity for inviting scientists from other Members? If so, indicate a number of such scientists. (d) Commitment that the proposed fishing vessel(s) and nominated research provider(s) have the resources and capability to fulfil all obligations of the proposed Research Plan.
6. Reporting for evaluation and review	(a) List of dates by which specific actions will be completed and reported to CCAMLR. If the research is a stand-alone survey, Members shall commit to providing a progress report to the appropriate working group for review and comment and a final report within 12 months of completion of the research to the Scientific Committee. (b) If research is multi-annual, Members shall commit to providing annual research reviews to be submitted to the appropriate working group, including a review of progress towards meeting research objectives and associated proposed time lines in initial proposal; a summary table comprising the applicable milestones of the research from the beginning of the plan, planned and actual achievement dates, papers submitted, and noting any changes in the milestone timeline; a review of previous Working Group and Scientific Committee commentary; and proposals for adjustments to the research proposal if required.
7. Conservation measure exemptions	(a) Intended exemptions from applicable conservation measures in whole or in part (other than those specified in Conservation Measure 24-01) and justification. Any intended exemptions shall be necessary for the Research Plan and objectives of the proposed research.

Annex 14

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

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
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
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)
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
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 Convention
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)