SC-CAMLR-XXXV

SCIENTIFIC COMMITTEE FOR THE CONSERVATION OF ANTARCTIC MARINE LIVING RESOURCES

REPORT OF THE THIRTY-FIFTH MEETING OF THE SCIENTIFIC COMMITTEE

HOBART, AUSTRALIA
17–21 OCTOBER 2016

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Chair of the Scientific Committee
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Abstract

This document presents the adopted report of the Thirty-fifth Meeting of the Scientific Committee for the Conservation of Antarctic Marine Living Resources held in Hobart, Australia, from 17 to 21 October 2016. 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.

1031-2889

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Report of the Thirty-fifth Meeting
of the Scientific Committee
(Hobart, Australia, 17 to 21 October 2016)

Opening of the meeting

1.1 The Scientific Committee for the Conservation of Antarctic Marine Living Resources met from 17 to 21 October 2016 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, Chile, People's Republic of China (China), European Union (EU), France, Germany, India, Italy, Japan, Republic of Korea, Namibia, 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, the Netherlands, Islamic Republic of Pakistan, Republic of Panama, Peru and Vanuatu were invited to attend the meeting as Observers, but did not attend.

1.4 The Chair also welcomed to the meeting Observers from intergovernmental organisations ACAP, CCSBT, CEP, FAO, IUCN, SCAR, SCOR, SEAFO and UNEP and non-governmental organisations ARK, ASOC, COLTO and Oceanites Inc. The Chair encouraged all Observers to participate in the meeting to the extent possible.

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 The Scientific Committee's report was prepared using the CCAMLR meetings server, which allowed rapporteurs and other meeting participants to develop and edit report text, and supported the workflow associated with the translation and production of the meeting report.

1.7 The report of the Scientific Committee was prepared by J. Clark (EU), A. Constable (Australia), C. Darby (UK), A. Dunn and J. Fenaughty (New Zealand), I. Forster (Secretariat), O.R. Godø (Norway), S. Grant (UK), E. Grilly (Secretariat), S. Hanchet (New Zealand), C. Jones (USA), A. Lowther (Norway), S. Parker (New Zealand), P. Penhale (USA), D. Ramm and K. Reid (Secretariat), C. Reiss (USA), L. Robinson (Secretariat), M. Söffker (UK), R. Sinegre (France), P. Trathan (UK), G. Watters (USA), P. Yates and P. Ziegler (Australia).

1.8 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.

Adoption of the agenda

1.9 The Scientific Committee discussed the Provisional Agenda which had been circulated prior to the meeting (2 September 2016). The Scientific Committee agreed to add a subitem on 'Advice to the Commission' under Item 3.3 on fish and invertebrate by-catch, and the revised agenda was adopted (Annex 3).

Chair's report

1.10 Dr Belchier reflected on the Scientific Committee's work in the 2015/16 intersessional period. The following meetings had taken place:

(i) the Subgroup on Acoustic Survey and Analysis Methods (SG-ASAM) met in La Jolla, USA, from 21 to 25 March 2016 (Annex 4) and was convened by Dr C. Reiss (USA) (the Co-convener Dr X. Zhao (China) was unable to attend the meeting); 11 participants from 6 Members participated

(ii) the Working Group on Statistics, Assessments and Modelling (WG-SAM) met in Genoa, Italy, from 27 June to 1 July 2016 (Annex 5) and was convened by Dr S. Parker (New Zealand); 38 participants from 15 Members participated

(iii) the Working Group on Ecosystem Monitoring and Management (WG-EMM) met in Bologna, Italy, from 4 to 15 July 2016 (Annex 6) and was convened by Dr S. Kawaguchi (Australia); 68 participants from 19 Members and 1 Acceding State participated

(iv) the Working Group on Fish Stock Assessment (WG-FSA) met in Hobart, Australia, from 3 to 12 October 2016 (Annex 7) and was convened by Dr D. Welsford (Australia); 44 participants from 14 Members participated

(v) the Scientific Committee Symposium was held in Hobart, Australia, on 13 and 14 October 2016 and was convened by Dr M. Belchier (UK); 17 Members and 5 Observers participated

(vi) a Joint CEP–Scientific Committee Workshop on Climate Change and Monitoring was held in Punta Arenas, Chile, on 19 and 20 May 2016 and was co-convened by Drs S. Grant (UK) and P. Penhale (USA); 42 participants participated.

1.11 Dr Belchier, on behalf of the Scientific Committee, thanked the conveners of SG-ASAM, WG-SAM, WG-EMM, WG-FSA and the joint workshop, and Chile, Italy and the USA for hosting these meetings in 2016. He also thanked participants for developing the Scientific Committee's work in 2015/16 and Members for supporting these activities.

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

Statistics, assessments and modelling

2.1 The Scientific Committee reviewed advice from WG-SAM (Annex 5) concerning three main areas of work:

(i) methods for assessing krill and toothfish fisheries and, in particular, the calculation of local biomass estimates for setting catch limits in exploratory toothfish fisheries in Subareas 48.6 and 58.4

(ii) review of the research plan for toothfish in Subarea 48.6

(iii) evaluation of research plans from Members notifying to fish in exploratory fisheries in Subarea 58.4, and research proposals for Subareas 48.2, 48.4 and 88.3

(iv) review of catch data analysis methods.

2.2 The Scientific Committee noted that many issues discussed by WG-SAM had been taken up by WG-FSA and are further considered under subsequent agenda items and in the report of WG-FSA (Annex 7).

2.3 The Scientific Committee noted advice from WG-SAM regarding krill-related research. It reviewed:

(i) developments towards an integrated assessment of krill in Subarea 48.1 (Annex 5, paragraphs 2.1 to 2.6)

(ii) design of a dedicated cetacean-sighting vessel-based krill survey in East Antarctica (Annex 5, paragraphs 2.7 to 2.10)

(iii) effective sample sizes to evaluate the efficiency of length samples collected by at-sea observers in the krill fishery, including data quality assurance (Annex 5, paragraphs 2.11 to 2.20).

2.4 The Scientific Committee endorsed the advice from WG-SAM regarding the process for calculating local biomass estimates that can be used to set catch limits for toothfish in Subareas 48.6 and 58.4 (Annex 5, paragraphs 2.21 to 2.34). This calculation, to be implemented by the Secretariat, includes:

(i) an estimation of local biomass for Patagonian (*Dissostichus eleginoides*) and Antarctic (*D. mawsoni*) toothfish separately, using the catch-per-unit-effort (CPUE) by seabed area analogy and Chapman mark-recapture estimate methods (Annex 5, paragraphs 2.28 and 2.29)

(ii) an agreed choice of reference areas for each research block (Annex 5, paragraph 2.30)

(iii) a limitation of released tagged fish to the last three years which are considered to be available for recapture in Chapman mark-recapture estimates in research blocks where movement has yet to be assessed (Annex 5, paragraph 2.34).

2.5 The Scientific Committee noted that developing measures of the uncertainty in the estimates of local biomass in exploratory fisheries, and how such measures are used in the decision of selecting the most appropriate biomass estimate to be used, should be a priority area of work in the intersessional period for WG-SAM.

2.6 The Scientific Committee recommended that local biomass estimates in exploratory fisheries should not be considered as a biomass estimate upon which to set long-term catch limits for a sustainable fishery, but they are designed to facilitate research and it was, therefore, important to define the period of that research (Annex 5, paragraph 2.46).

2.7 For the exploratory fishery in Subarea 48.6, the Scientific Committee recommended that in order to expedite the process of testing the stock hypothesis and increasing the likelihood of obtaining sufficient tags necessary for the development of an integrated stock assessment:

(i) research fishing should be targeted towards *D. mawsoni* since a greater amount of data derived from research fishing is available compared to *D. eleginoides*. Catches from research block 486_1 have been comprised solely of *D. eleginoides* and this block should be removed from research proposals

(ii) research blocks 486_2, _3 and _4 should be considered priority areas for research fishing since they are consistently free of sea-ice at the time of the research fishing and represent a diverse range of likely toothfish habitat

(iii) pop-up satellite archival tags (PSATs) should be used in the priority research blocks to provide data on fish movement within and outside these areas

(iv) further analyses should be reported to WG-SAM-17 on –

(a) sea-ice dynamics over the whole of the continental shelf region of Subarea 48.6 to identify other regions of suitable toothfish habitat that may be more reliably ice free in a given year and would enable the detection of tags with an assumed tag availability period of three years

(b) available tag data to better characterise fish movement within and between research blocks and to assist with validation and development of the stock hypothesis.

2.8 WG-SAM reviewed results and a proposal to continue research in the north of small-scale research units (SSRUs) 882A–B (Annex 5, paragraphs 4.5 to 4.29). The Scientific Committee noted that WG-SAM and WG-FSA have not achieved consensus on appropriate methods for analysis of catch rate data. Further, WG-SAM requested that the Secretariat provide an analysis of vessel monitoring system (VMS) data to verify reported catch locations with VMS locations.

2.9 The Scientific Committee noted that WG-SAM had identified several risks associated with the business-as-usual approach, such as review of research plans and proposals (Annex 5, paragraphs 6.1 to 6.3). Furthermore, the lack of a coordinated approach in some areas, and lack of measureable milestones, made the reviews time consuming. While there had been additional progress in the development of coordinated proposals, WG-SAM suggested a rotating review of progress towards assessments by statistical area may be more productive, similar to the review in Subarea 48.6 this year (Annex 5, paragraphs 6.4 to 6.7).

2.10 The Scientific Committee noted that both WG-SAM and WG-FSA have been tasked to review research proposals since 2012. It recommended that WG-FSA review the design of the proposal only if WG-SAM had requested any changes to the proposal and requested that WG-FSA provide advice on catch limits for all proposals.

Acoustic survey and analysis methods

2.11 The Scientific Committee reviewed progress by the SG-ASAM to use fishing-vessel-based acoustic data to produce specific products from those validated acoustic data. The Scientific Committee also reviewed progress by SG-ASAM to document the methods and details of estimating krill biomass using standard protocols as requested by the Scientific Committee (SC-CAMLR-XXXIV, paragraph 2.21).

2.12 The Scientific Committee noted that over the last five years there has been considerable progress in engaging the fishery to collect acoustic data during fishing operations and along nominated transects and in completing and expanding the number of biomass surveys conducted in subareas.

2.13 The Scientific Committee agreed that incentivising the collection of acoustic data from across the krill fishing fleet may be a possible way to ensure data are available to further feedback management (FBM) strategies that will rely on fishing vessels. The Scientific Committee requested the Commission consider which incentives may be used to facilitate this process.

2.14 The Scientific Committee noted the progress made to better understand the uncertainty in acoustic biomass estimates. It discussed the high variability in estimates of nautical area scattering coefficient (NASC) generated from the same acoustic data using different noise removal algorithms. The Scientific Committee requested that SG-ASAM develop standardised processing algorithms for the removal of noise and consider how such algorithms could be incorporated into the eventual automation of the data processing, and for storage of those data at the Secretariat in near-real time.

2.15 The Scientific Committee indicated that SG-ASAM consider data management issues in the same manner as WG-SAM and WG-FSA that are also actively looking to increase the amounts and type of data that will be useful for management.

2.16 The Scientific Committee noted the importance of collecting acoustic data along nominated transects, but also noted that other transects in undersampled areas, or extending existing transects in areas where navigation conditions are appropriate, is also important. Additionally, Members noted that collecting acoustic data during fishing operations could provide useful data on the intra-seasonal distribution of krill biomass, as well as the impact of fishing on krill within fished areas.

2.17 Further, the Scientific Committee asked the Secretariat to liaise with Members to ensure that fishing vessels are reminded of the request to collect acoustic data along the nominated transects, if possible.

2.18 The Scientific Committee noted that some questions are beyond the purview of SG-ASAM as it reflects the need for WG-EMM and WG-SAM and other working groups to decide on the use of fishing vessel data. Such questions included how clean must the acoustic data be to be useful, how can acoustic data collected during fishing be used to look at flux, or retention, or intra-seasonal patterns of habitat use. However, the Scientific Committee noted that some of these questions may need the input from outside experts, including physical oceanographers.

2.19 SG-ASAM requires data from the fishery to continue the development of FBM and to better understand the data that can be provided by fishing vessels during fishing operations. The Scientific Committee asked SG-ASAM to reflect on the priorities in Table 1.

2.20 The Scientific Committee noted that some tasks requested of SG-ASAM are more suitably discussed in working groups that are developing FBM strategies. While the Scientific Committee requested a number of important issues be examined by SG-ASAM in 2017, it agreed that arrangements could be made in the future for SG-ASAM and WG-EMM to meet in order to consider net sampling strategies for the estimation of population length-frequency distribution and biomass estimation using survey-based and statistical approaches.

Harvested species

Krill resources

Krill fishing activity

3.1 The Scientific Committee reviewed krill fishing activity for 2014/15 and 2015/16 (SC-CAMLR-XXXV/BG/01) and noted that historically fishing in Subarea 48.1 had taken place primarily in the summer, but that for the past few seasons, fishing in this area had been occurring throughout the austral summer and winter. The Scientific Committee also noted that the fishery was regularly operating in areas in the southern part of Subarea 48.1 where no regular krill surveys are conducted. It noted that:

(i) in 2014/15 (1 December 2014 to 30 November 2015), 12 vessels fished in Subareas 48.1, 48.2 and 48.3 and the total catch of krill reported was 225 646 tonnes of which 154 176 tonnes (68%) was taken from Subarea 48.1; Subarea 48.1 was closed on 28 May 2015

(ii) in 2015/16 (to 14 September 2016), 11 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 258 365 tonnes of which 154 461 tonnes was taken from Subarea 48.1; Subarea 48.1 was closed on 28 May 2016.

3.2 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 (Annex 6, paragraph 2.6).

3.3 The Scientific Committee noted that data and information from the krill fishery and/or scientific surveys and sampling will provide data that can help to elucidate the issues raised in paragraph 3.2.

3.4 The Scientific Committee agreed that the data on krill catches by month and small-scale management unit (SSMU) (WG-EMM-16/07, Table A2.1) should be included in the *Statistical Bulletin*.

Krill fishery notifications

3.5 The Scientific Committee reviewed the notifications for krill fisheries in 2016/17 which had been received by the submission deadline (1 June 2016). Six Members had notified a total of 18 vessels for krill fisheries in Subareas 48.1 (17 vessels), 48.2 (16 vessels), 48.3 (15 vessels) and 48.4 (10 vessels) and Divisions 58.4.1 (3 vessels) and 58.4.2 (3 vessels), and there were no notifications submitted for exploratory fisheries for krill in 2016/17. The Secretariat advised that Poland had withdrawn the notifications for its vessels *Alina* and *Saga*, and that two vessels had as yet not paid their notification fee.

3.6 The Scientific Committee noted that the daily processing capacity for notified vessels ranged from 120 to 700 tonnes green weight per day.

3.7 The Scientific Committee noted that the new online system for submitting fishery notifications had greatly facilitated its work in reviewing the krill fishery notifications.

3.8 The Scientific Committee endorsed advice from WG-EMM (Annex 6, paragraph 2.14) that the information provided in the notifications for krill fisheries in 2016/17 was consistent with the requirements of Conservation Measure (CM) 21-03.

Escape mortality

3.9 The Scientific Committee noted discussions during WG-EMM (Annex 6, paragraphs 2.15 to 2.17) regarding krill escape mortality, including details of work being undertaken by Norwegian scientists. It agreed that quantifying escape mortality was an essential element of estimating the total removals by the fishery and that it would be useful for the Secretariat to compile results on escape mortality once the Norwegian work was complete.

Reporting interval for the continuous fishing system

3.10 The Scientific Committee noted discussions at WG-EMM (Annex 6, paragraphs 2.18 to 2.22) concerning the reporting interval for the continuous fishing system. It noted that the catch reported in a two-hour period is not the amount that is actually caught during that period, but the amount of krill passing from the holding tanks to the factory. The Scientific Committee agreed that the current two-hour reporting procedures be continued in order to provide continuity and comparative analyses. However, it also agreed that a new method be developed which should be trialled alongside the existing two-hour reporting procedure to align the actual catch with that reported in a two-hour period and the results be presented to WG-EMM for evaluation.

CPUE and fishery performance

3.11 The Scientific Committee noted discussions (Annex 6, paragraphs 2.26 to 2.30) concerning CPUE and encouraged further investigation of the influence of krill fishing strategy on CPUE dynamics.

Fishing season

3.12 The Scientific Committee noted WG-EMM discussions (Annex 6, paragraphs 2.31 to 2.34) related to whether the CCAMLR season for the krill fishery should start at a time of year based on ecological events, e.g. predator breeding cycles, rather than on a date that is convenient for management.

3.13 It noted that the start date of the fishery and the period when fishing takes place each year must be balanced with the overall requirements for land-based predators during both the summer breeding period and other times of year, including the requirements for predators which overwinter in the areas in which the fishery operates. It also noted that such requirements may vary between subareas and this may require different management approaches (Annex 6, paragraph 2.33).

3.14 The Scientific Committee recommended that WG-EMM explore the utility of developing a general summer and winter schedule for each subarea, with summer covering the period October to March and winter the period April to September. This would then better facilitate consideration of the possible benefits of aligning operation of the fishery with spatial and temporal aspects of local ecosystem operation.

3.15 The Scientific Committee recognised that the Olympic nature of the krill fishery meant interpretation of seasonal fishing activity required careful consideration when evaluating seasonal patterns and interactions and consideration of fishing season start date.

3.16 The Scientific Committee noted that establishment of an experimental fishing regime whereby fishing would be concentrated in local areas in conjunction with an appropriate predator monitoring program would facilitate evaluation of predator–fishery interactions.

Ecosystem effects of krill fishing

3.17 The Scientific Committee noted WG-EMM discussions (Annex 6, paragraphs 2.56 to 2.62) on krill flux across Area 48. It noted the importance of seasonal and interannual variability in water circulation in space and time and its implications for krill flux across the region and between SSMUs. The Scientific Committee noted that an estimate of the variability of flux would be useful, and the importance of developing fine-scale four-dimensional numerical circulation models that could better represent the temporal variability and total flux of krill.

3.18 The Scientific Committee noted that when developing methods to quantify flux, there would be a need to engage with scientists from outside the CCAMLR community, as well as with experts from both WG-EMM and SG-ASAM, including to identify appropriate data to further enhance understanding of flux and krill movement. It agreed that better understanding of flux was an important medium-term (2 to 5 years) objective and that it would be valuable to facilitate a workshop or symposium on the subject (Table 1).

3.19 The Scientific Committee welcomed information from the Antarctic Wildlife Research Fund (AWR) about the recent funding of two research proposals that will enhance understanding of flux.

3.20 The Scientific Committee noted that better understanding of ecosystem connectivity was important for managing finfish fisheries as well as for managing krill fisheries. It noted that enhanced understanding of connectivity could be facilitated by the use of fishing vessels with appropriate acoustic instruments, whilst other information collected from research vessels would also be vital. The Scientific Committee, therefore, requested that Members interested in flux collaborate to help provide enhanced understanding and improved management information.

Ecosystem monitoring and observation

3.21 The Scientific Committee noted WG-EMM discussions on ecosystem monitoring and observation (Annex 6, paragraphs 2.63 and 2.82 to 2.94).

3.22 The Scientific Committee welcomed information from Argentina regarding results from a recent survey to the north of the South Orkney Islands, detailing sampling of early krill larvae (WG-EMM-16/51). It encouraged analysis of results and future reporting to WG-EMM.

3.23 The Scientific Committee endorsed recommendations (Annex 6, paragraph 2.90) that the Scheme of International Scientific Observation (SISO) data reporting forms be modified to collect data on salps by requesting observers to record whether salps were present or absent in the 25 kg samples collected for the analysis of fish by-catch.

3.24 The Scientific Committee noted WG-EMM discussions on developing priority variables (ecosystem Essential Ocean Variables – eEOVs) for observing dynamics and change in Southern Ocean ecosystems. It agreed that interaction with the Southern Ocean Observing System (SOOS) would be needed, particularly regarding the development of eEOVs (Annex 6, paragraph 2.94).

Ecosystem interactions

3.25 The Scientific Committee noted WG-EMM discussions on ecosystem interactions (Annex 6, paragraphs 2.95 to 2.125).

3.26 The Scientific Committee noted discussions (Annex 6, paragraphs 2.95 to 2.100) on the retrospective analysis of antarctic tracking data (RAATD), sponsored by the Scientific Committee on Antarctic Research (SCAR) Expert Group on Birds and Marine Mammals (SCAR-EGBAMM). The workshop reviewed interim progress on habitat utilisation model development and identifying areas of ecological significance (AES).

3.27 The Scientific Committee agreed that if RAATD analyses were to be used for management advice, then the data, model and analyses should be reviewed by WG-SAM and WG-EMM.

3.28 The Scientific Committee agreed the importance of considering krill consumption by baleen whales in the development of an effective FBM regime (Annex 6, paragraph 2.118). It noted the increasing numbers of humpback and fin whales in Bransfield Strait as one area where consideration of cetaceans in FBM may be important. It noted that with a staged approach to FBM, effects on cetaceans could be incorporated in the future but that temporal lags due to cetacean life-history characteristics would need to be considered. It noted that cetaceans may be good candidates for monitoring the ecosystem as a whole.

3.29 The Scientific Committee agreed that it would be valuable to receive regular updates from the International Whaling Commission (IWC) on the status of whale populations (Annex 6, paragraph 2.119) and noted the reciprocal interest from the IWC with regards to CCAMLR data. It noted that the proposed Joint CCAMLR–IWC Workshop could provide a basis for data sharing related to the krill-based ecosystem (Annex 6, paragraphs 6.3 to 6.7), and to discuss areas of mutual interest.

CEMP and WG-EMM-STAPP

3.30 The Scientific Committee noted that nine Members working at 15 sites in Areas 48, 58 and 88 contributed data for 12 CCAMLR Ecosystem Monitoring Program (CEMP) parameters on six species of krill-dependent predators for the 2015/16 breeding season. Additional data have since been submitted by Ukraine and entered into the CEMP database. Further data from the USA and France are also expected in the near future.

3.31 The Scientific Committee was advised that WG-EMM noted the analysis in WG-EMM-16/45 presented plausible evidence for negative impacts of fishing on krill-dependent predator performance in Subarea 48.1 and showed that previous assumptions about a lack of such impact may not be supported (Annex 6, paragraph 2.144).

3.32 Some Members agreed with the findings of WG-EMM.

3.33 Other Members did not agree that existing data on predator performance indicate plausible impacts from krill fishing.

3.34 The Scientific Committee welcomed the development of the camera network in Subarea 48.1 for monitoring predators (Annex 6, paragraphs 2.147 to 2.149). It noted the successful collaboration of multiple Members in establishing the network to support CEMP and FBM efforts. The Scientific Committee also noted that the CEMP camera project expects data from all cameras to be available following the 2016/17 field season. It noted that the collaborative development of image analysis software, funded by the CEMP Fund, would further enhance the value of the project to FBM.

3.35 The Scientific Committee requested that scientists participating in the development of the CEMP camera network prepare and submit a paper to WG-EMM describing the development of the network and the number and location of all cameras.

Predator consumption

3.36 The Scientific Committee recalled that the goal of the Subgroup on Status and Trend Assessment of Predator Populations (WG-EMM-STAPP) has been to estimate the consumption of Antarctic krill (*Euphausia superba*) by the major air-breathing predators, including pack-ice seals, fur seals, penguins and flying seabirds. It recognised that this is a complex task, with three separate components of work: the first to assess large-scale population abundance through surveys; the second to understand the foraging distribution of those populations through tracking, and the third to develop bio-energetics models.

3.37 The Scientific Committee noted that recent advances include:

(i) Work on assessing predator abundance. Some important developments in the last five years include the first surveys of penguin populations in previously unsurveyed regions, developing new methods for large-scale population assessment and estimating non-breeding penguin populations.

(ii) Work to understand foraging distribution through tracking is being addressed through current tracking and habitat modelling work supported by the CEMP Fund (SC-CAMLR-XXXIV, Annex 6, paragraphs 6.8 and 6.9) and national programs, and by the SCAR RAATD group. Following discussions with the Secretariat, a postdoc, Dr V. Warrick-Evans, has now been employed by BAS to fulfil the work supported under the CEMP Fund.

(iii) The development of bio-energetics models has been achieved for pack-ice seals and penguins. Although the penguin bio-energetics model was developed for Adélie penguins (*Pygoscelis adeliae*), it has been successively parameterised for macaroni penguins (*Eudyptes chrysolophus*), and will shortly be used as a general model for both penguins and flying seabirds.

3.38 The Scientific Committee noted the intention of WG-EMM-STAPP was now to deliver broad-scale prey consumption estimates for pack-ice seals and penguins around Antarctica by bringing together existing abundance data with bio-energetics models. This has already been achieved for some species in some regions. Partitioning consumption into smaller spatial units using habitat models should be feasible over a slightly longer time frame, and this will continue through the SCAR RAATD and CEMP Fund habitat modelling work.

3.39 The Scientific Committee welcomed the substantial progress made by WG-EMM-STAPP, given the magnitude of effort required for data collation and analysis (Annex 6, paragraph 2.158). It noted the general lack of data on flying seabirds in the considerations of WG-EMM-STAPP despite renewed attempts to estimate flying seabird abundance (Annex 6, paragraph 2.156).

3.40 The Scientific Committee welcomed information from the Republic of Korea, which has conducted GPS tracking to measure the foraging range, activity and diving depth of chinstrap and gentoo penguins (*P. papua*) on King George Island since 2013/14. It also welcomed reports that Korean scientists will deploy GPS-depth loggers on 10 Adélie penguins at Cape Hallett in the Ross Sea as part of a preliminary study in 2016/17; this will link with studies to investigate the spatial distribution of krill in the vicinity of Adélie breeding sites along the Northern Victoria Land coast using the Korean research vessel *Araon* in January and February 2018.

Acoustic surveys

3.41 The Scientific Committee noted WG-EMM discussions (Annex 6, paragraphs 2.172 to 2.177) on the use of the random forest statistical method to classify icefish and krill echoes from 38 and 120 kHz acoustic data. It noted that the results were part of a PhD project which it was hoped would help inform fishing operations in the future.

3.42 The Scientific Committee endorsed recommendations (Annex 6, paragraph 2.191) that the geographic distribution of net samples within a survey area, what type of net samples (targeted or oblique) and how many net samples are required to provide a relevant krill length-frequency distribution to parameterise the krill density estimates from acoustic surveys, should be discussed by SG-ASAM.

3.43 The Scientific Committee also recommended that comparison of EK60 and ES70 data from a single vessel over a common transect (WG-EMM-16/61) be considered by SG-ASAM at its next meeting (Annex 6, paragraph 2.194).

Net haul data

3.44 The Scientific Committee noted SC-CAMLR-XXXV/BG/24 Rev. 1 which described a freely available dataset of krill and salp density, compiled from c. 15 000 scientific net hauls. The data are available via a website (which can be accessed via www.bas.ac.uk/project/krillbase/ or via the doi: http://doi.org/brg8). The database includes standardised krill density so it is possible to include different sampling methods in the same analysis.

Feedback management

Feedback management – stage 1

Subarea-scale exploitation rates

3.45 The Scientific Committee reviewed the estimated potential, annual subarea-scale krill exploitation rates considered by WG-EMM (Annex 6, paragraphs 2.202 to 2.205) and noted that if the fishery continues to achieve the catch limits established in CM 51-07 and the trigger limit in CM 51-01 continues to be fixed, the precautionary exploitation rate of 9.3% agreed by CCAMLR might be exceeded in one out of every five years within Subarea 48.1, but less frequently in Subarea 48.2.

3.46 A revised proposal by the Delegation of Ukraine (CCAMLR-XXXV/30) to increase the trigger limit in Subarea 48.1, and enact trade-off strategies to offset increased catch allocations by implementing protective measures for land-based predators such as coastal buffer zones, was considered to fall under the remit of the Commission (paragraphs 3.72 to 3.74).

Concentration of fishing effort

3.47 The Scientific Committee noted the increased levels of catch as well as the associated numbers of hauls in Subarea 48.1 since 2013 (Annex 6, paragraph 2.215). Furthermore, the Scientific Committee noted the non-random exploitation of fishing grounds, with the fishing fleet repeatedly visiting fishing hotspots within the centre of the Bransfield Strait and the northern section of the Gerlache Strait (Annex 6, paragraph 2.217). It recognised that there is currently a lack of empirical data describing krill abundance and distribution in fishing hotspots. The Scientific Committee noted that collection of acoustic data by fishing vessels to estimate temporal changes in biomass and the integration of a move-on rule may reduce the effects of local concentration of fishing effort.

Feedback management stages 1–2 – Subarea 48.1

3.48 The Scientific Committee noted discussions during WG-EMM pertaining to the development of FBM in Subarea 48.1 (Annex 6, paragraphs 2.253 to 2.262). It thanked the USA and its collaborators for the substantial amounts of analysis conducted to further development of FBM in this subarea.

Feedback management stages 1–2 – Subarea 48.2

3.49 The Scientific Committee noted the work conducted by the proponents for FBM in Subarea 48.2 (Annex 6, paragraphs 2.263 to 2.266) and thanked those that had developed the analyses.

3.50 The Scientific Committee considered how resources could be committed to the experimental framework in Subarea 48.2 to develop baseline data in the subarea (Annex 6, paragraph 2.267). It noted that Subarea 48.1 is currently the preferred target subarea for the krill fishery which also coincides with the location of where most monitoring data exists. The Scientific Committee, therefore, advised the Commission that additional monitoring capability will be needed if krill fishing management is to advance in Subarea 48.2.

General recommendations on feedback management

3.51 The Scientific Committee considered the request by WG-EMM to provide guidance regarding prioritisation of FBM during WG-EMM-17 (Annex 6, paragraphs 2.280 and 2.285). It agreed that FBM should be a priority next year, recognising that development of FBM requires input from other groups within SC-CAMLR, such as SG-ASAM.

3.52 The Scientific Committee considered whether co-locating SG-ASAM and WG-EMM in 2017 might facilitate the development of FBM. It also endorsed the need for greater collaboration between industry, SG-ASAM and WG-EMM to deliver FBM. The Scientific Committee agreed that clearly articulated questions, with realistic expectations and timelines, were needed. It therefore requested that WG-EMM develop a detailed work plan and time schedule to further the development of FBM.

3.53 The Scientific Committee noted advice from WG-EMM that the collection of appropriate acoustic information from fishing vessels was critical for both proposed FBM approaches and highlighted that there was a need for SG-ASAM to continue its work program for delivering the necessary acoustic procedures, data and information required.

3.54 The Scientific Committee recognised that, while data from calibrated echosounders is preferable, acoustic information from non-calibrated echosounders can be valuable under certain circumstances (SC-CAMLR-XXXIII, Annex 4, paragraph 3.1).

Conservation Measure 51-07

3.55 The Scientific Committee recalled its obligation to review and advise on CM 51-07, which is due to lapse at the end of the 2015/16 fishing season. It noted discussions at WG-EMM (Annex 6, paragraphs 2.225, 2.241 and 2.247 to 2.252) and WG-FSA (Annex 7, paragraphs 8.1 to 8.24) as well as considering CCAMLR-XXXV/30, SC-CAMLR-XXXV/11, BG/14, BG/36 and BG/37 which relate to this subject. The Scientific Committee also considered SC-CAMLR-XXXV/BG/17 and BG/18 which contained information relevant to its discussions on CM 51-07.

3.56 The Scientific Committee identified that the work to review CM 51-07 and provide advice on the spatial distribution of the krill trigger level should be undertaken within the context of developing FBM for the krill fishery. It noted that work on CM 51-07 is stage 1 of FBM. The relationship of CM 51-07 to FBM is illustrated in Figure 1, which shows how considerations by WG-EMM of approaches to FBM fit together to help progress the development of FBM through the different stages identified by WG-EMM in 2013.

3.57 The Scientific Committee recalled the discussions from WG-EMM in 2011 and in 2013, which consolidated the staged approach to the development of the krill fishery. In those discussions, it was envisaged that the fishery would be able to expand beyond the trigger level once measures were in place to manage the potential spatial effects of fishing on krill predators. Figure 2 (SC-CAMLR-XXX, Annex 4, Figure 4) illustrates the point that, as knowledge improves and data become available, as well as having procedures in place to spatially manage the fishery, then the level of uncertainty would be reduced and the fishery could expand, while maintaining the same level of precaution. In 2013, this was consolidated into the staged approach, where stage 1 was the approach currently encapsulated in CM 51-07. Stage 2 would be where the fishery could expand beyond the trigger level using new mechanisms to determine the new catch level. Stages 3 and 4 would be the implementation of further developments in FBM that would enable effective spatial management of the fishery at higher catch levels.

3.58 Figure 1 illustrates current considerations by WG-EMM and the Scientific Committee in relation to the staged approach, recalling that the staged approach was adopted in 2013 (SC-CAMLR-XXXII, paragraph 3.15):

(i) stage 1 – continuation of the current trigger level and its spatial distribution among subareas

(ii) stage 2 – an increase from the trigger level to a higher interim catch limit and/or changes in the spatial distribution of catches that are adjusted based on decision rules that take account of results from the existing CEMP and other observation series

(iii) stage 3 – a further increase to a higher interim catch limit and/or changes in the spatial distribution of catches that take account of results from an 'enhanced' CEMP and other observation series

(iv) stage 4 – a fully developed FBM strategy that is based on forecasts from ecosystem models, may involve structured fishing and/or reference areas, and includes catches up to the precautionary catch limit based on decision rules taking account of enhanced CEMP and other observation series.

3.59 The Scientific Committee noted the significant progress in many aspects of this work. The development of a risk assessment framework (WG-FSA-16/47 Rev. 1 and 16/48 Rev. 1 and SC-CAMLR-XXXV/BG/37) improves the implementation of stage 1 and could assist in progressing FBM from stage 1 to stage 2. The current CM 51-07 was established using information from scientific work in the 2000s and applied to the trigger level of 620 000 tonnes. It was recognised that the trigger level was established as a level that was considered not to affect predators regionally, but that local effects on predators may occur if the full trigger level was taken. The Scientific Committee noted the work on options for stage 2 at WG-EMM (Annex 6, paragraphs 2.253 to 2.285) but that, if an option for stage 2 is not progressed, then it may be desirable to undertake a scientific review of the trigger level and, if possible, assess a new regional limit, based on available scientific data, and use the risk assessment framework to establish a new set of local area catch limits. It was noted that this would help progress the management arrangements towards stage 2 of the management of the krill fishery.

3.60 The Scientific Committee noted that the development of the FBM procedure will progress from spreading the risk of regional catch limits, as in the risk assessment framework, to managing local areas and the effects of fishing directly through monitoring activities specific to the requirements for detecting effects.

3.61 The Scientific Committee noted the discussion in the report of WG-EMM:

(i) the background and purpose of the trigger level and the agreement on the previous advice provided by WG-EMM (Annex 6, paragraphs 2.247 to 2.249)

(ii) the establishment of the e-group to progress the risk assessment approach in time for review by WG-FSA and the Scientific Committee this year (Annex 6, paragraph 2.241).

3.62 The Scientific Committee endorsed the following advice of WG-EMM subject to the discussion below:

(i) continuing the current spatial allocation of the trigger level would offer an opportunity for continued evaluation of the potential impacts to krill-dependent predators of catching nearly 155 000 tonnes per year in the subarea (Annex 6, paragraph 2.225)

(ii) in the future, risk analyses such as those envisioned for the review of CM 51-07 should be conducted on a regular basis, and the assumptions underlying such risk assessments should be continually reviewed, and that these be added to the standing work program of WG-EMM (Annex 6, paragraph 2.241)

(iii) a future revision of CM 51-07 should consider how catch limits could be spatially and temporally apportioned within subareas to avoid negative impacts on predator populations at smaller spatial scales, particularly in Subarea 48.1; buffer zones could be considered as alternative or additional management options (Annex 6, paragraph 2.252).

3.63 The Scientific Committee noted that all fishing will have impacts and that the advice in paragraph 3.62(iii) needs to relate to the avoidance of significant negative impacts rather than any impacts.

3.64 The Scientific Committee endorsed the following advice of WG-FSA subject to the discussion below:

(i) the risk assessment framework as presented in WG-FSA-16/47 Rev. 1 and 16/48 Rev. 1 for use as a tool for providing advice on the spatial distribution of the trigger level (Annex 7, paragraph 8.21)

(ii) the risks associated with historical fishing patterns as well as those that may be associated with plausible subdivisions of the trigger level (Annex 7, paragraph 8.22, Tables 4 to 7, Figures 3 to 7)

(iii) the risk assessment model be further developed and that a standard way to include or reject data be part of that development (Annex 7, paragraph 8.23)

(iv) a number of factors will be important to consider in revising CM 51-07, in particular for distributing the trigger level, including factors influencing the krill fishery, such as the spatial distribution of krill, conditions affecting the krill fishery and the amount of the catch limit being taken.

3.65 The Scientific Committee congratulated those scientists that had contributed to the development of the risk assessment framework (WG-FSA-16/47 Rev. 1, 16/48 Rev. 1 and SC-CAMLR-XXXV/BG/37) for distributing the krill trigger level. It endorsed the use of the risk framework as it provides a useful tool for providing advice with regard to CM 51-07.

3.66 The Scientific Committee noted that the risk assessment framework, as parameterised and described in SC-CAMLR-XXXV/BG/37, provides advice about the distribution of the catch trigger level between subareas, but also within subareas (Tables 2 and 3). It noted that the model is flexible and can provide risk assessments at the scale of available data.

3.67 The process for using the risk assessment framework to distribute the catch throughout a region results in a set of alphas, which are the proportions of the regional catch that would be taken in each local area. These alphas are then combined with the regional limit, the trigger level in this case, to give the local catch limits based on the outcomes of the risk assessment. The regional catch limit is the catch that is unlikely to affect predators in the region. The following steps are used to assess the risk of selected fishing patterns (a set of alphas) and the steps to modify the fishing pattern so that the risk can be equivalent to the baseline risk:

(i) quantify local area risks and the relative abundances of krill in each local area

(ii) establish the baseline for spreading risk, including:

(a) optimise fishing pattern to spread the risk
(b) assess the realised risk in each local area
(c) assess the baseline regional risk by summing the local realised risks

(iii) select the fishing pattern (initial alphas for consideration), including by:

(a) subarea
(b) SSMU, and/or
(c) finer scale, e.g. buffer zones or specially protected areas to reduce local realised risks, which could include temporary closed areas to protect vulnerable colonies following periods of stress

(iv) assess the risks of the nominated fishing pattern, including the changes from the baseline in:

(a) local realised risks
(b) regional risk

(v) steps to moderate the risk, including:

(a) monitoring to detect effects
(b) managing the effects directly
(c) scale alphas so the regional risk is equivalent to the baseline regional risk.

3.68 The Scientific Committee recalled the discussion of WG-EMM in 2011 on the spatial distribution of the krill trigger level for Area 48 (SC-CAMLR-XXX, Annex 4, paragraphs 2.66 to 2.97) and noted that progress had been made on collating advice on the concentration of the fishery, the distribution of krill and the requirements of predators (SC-CAMLR-XXX, Annex 4, paragraph 2.87). It also noted that the risk assessment framework provides a means of examining whether a subdivision of the trigger level is precautionary enough or over-precautionary (SC-CAMLR-XXX, Annex 4, paragraph 2.96).

3.69 The Scientific Committee noted that the risk assessment framework aims to minimise the risk to predator populations of being inadvertently or disproportionally affected by the krill fishery, according to the requirements of the preamble in CM 51-07 (SC-CAMLR-XXXV/BG/37). Assessment of overall regional risk can be done by comparing the specific regional risk for the proposed catch distribution to a baseline regional risk.

3.70 For a nominated spatial distribution of catches, risk is the assessed relative probability of local effects of fishing on krill or krill-dependent predators. This does not imply there is a current negative effect of fishing.

3.71 The Scientific Committee also noted that the baseline is used to determine an ideal distribution of the catch that will optimally spread the risks of effects of fishing on predators and krill. The calculation utilises the following (SC-CAMLR-XXXV/BG/37):

(i) the abundance of krill in the different locations
(ii) an estimate of overall risk in each area and, if needed, also by season.

The estimate of risk by area and season utilises the data for the risk factors in each area and combines these using the method in WG-FSA-16/47 Rev. 1, which results in a risk scaled between 0 and 1. The baseline scenario sets the fishing desirability of all areas to 1, i.e. that the fishery operates across all areas with catches taken to best spread the risk (SC-CAMLR-XXXV/BG/37).

3.72 The Scientific Committee recognised that the model for the risk framework was based upon the best available scientific evidence (Annex 7, paragraph 8.19), and agreed that the model should be reviewed periodically and data updated. It agreed that this should become a regular part of the work of WG-EMM. The Scientific Committee recognised that future revisions of the risk assessment framework would need to consider a variety of different biological and physical datasets.

3.73 The Scientific Committee noted that risk is affected by a number of environmental variables which are not included in the current risk framework. Notwithstanding, the Scientific Committee agreed that the present model is a synthesis of the data currently available.

3.74 The Scientific Committee further noted that future development of the risk assessment framework, if suitable data were incorporated, had the potential to provide advice over the short, medium and long term. It recognised that data collection for these different time periods should start as soon as possible. It recommended that WG-EMM consider how best to proceed with relevant data collation or collection and advised the Commission that this was a high priority for WG-EMM.

3.75 The Scientific Committee agreed that the summer and winter risks to krill and krill predators presented in Annex 7, Figure 3, are based on the best scientific evidence available (Figure 3). The baseline risks are given in Table 4 (Annex 7, Table 4).

3.76 The Scientific Committee recognised that the baseline scenario from the risk assessment (Table 2) provides an assessment of actual risk to the ecosystem. In contrast, alternative scenarios (Tables 2 and 3) provided an assessment of relative risk. The risks calculated for each fishing pattern in Tables 2 and 3 (Annex 7, Tables 5 and 6) are also actual risks of those patterns. The relative change in local realised risks and the regional risk of each scenario are presented in Table 5 (Annex 7, Table 7).

3.77 The risks calculated for each fishing pattern in Tables 2 and 3 are also actual risks of those patterns. The relative change in local realised risks and the regional risk of each scenario are presented in Table 5 (Annex 7, Table 7).

3.78 The Scientific Committee noted that comparisons with the risks associated with a baseline distribution of the trigger level would provide a means of assessing how much the risks of a scenario may deviate from an ideal distribution of catch that spreads the risks (see SC-CAMLR-XXXV/BG/37).

3.79 Table 2 (Annex 7, Table 5) shows risk associated with changes in historical fishing patterns. It summarises patterns observed in the past, and considers the risk of a possible pattern where the fishery is solely concentrated in Bransfield Strait. The Scientific Committee agreed that Table 2 demonstrates how, in recent years, the relative regional risk has increased with the fishery concentrating more in Bransfield Strait.

3.80 Table 3 (Annex 7, Table 6) shows several scenarios based on CM 51-07, with different allocations of the proportional regional catch to subareas. The table shows that certain scenarios have a higher regional risk because of catch being concentrated in areas where there are higher concentrations of krill predators and juvenile krill. The adjusted catches to maintain overall regional risk at the baseline level means that accumulation of risk from catches in the high-risk areas is offset by catches in lower-risk subareas that would then have little or no krill fishing. The table provides catch limits for each scenario for the area and subareas that would keep the overall regional risk in line with the baseline risk.

3.81 The Scientific Committee also considered how the local realised risks of each scenario have changed from the local realised risks of the baseline scenario, i.e. whether the local risks have increased or decreased in their contributions to the regional risk. The contribution of local areas (local realised risk) to the regional risk in the baseline scenario is given in Table 4 (Annex 7, Table 4).

3.82 The Scientific Committee agreed that the different scenarios were important, not just for providing advice to the Commission, but also for informing industry and external bodies such as eco-labelling corporations.

3.83 The Scientific Committee agreed that conveying details of the risk assessment framework to industry was important and the workshop organised by the Association of Responsible Krill harvesting companies (ARK) (scheduled for 22 October 2016) would be a valuable opportunity for engagement with krill fishing companies.

3.84 The Scientific Committee encouraged Members to participate in further development of the risk assessment method, including:

(i) the points raised by WG-EMM (Annex 6, paragraphs 2.228 to 2.244) and WG-FSA (Annex 7, paragraphs 8.1 to 8.24)

(ii) reviewing the assessment of local risks through:

(a) further identification of critical areas for predators at smaller scales than SSMUs, such as through the development of foraging habitat maps for predators or other analyses

(b) collection and analysis of data on krill abundance in critical areas for predators

(iii) compiling other data that may be useful in identifying risks arising from ecosystem variability and change

(iv) consideration of areas where there may be a high risk of fish larval by-catch.

3.85 Dr S. Kasatkina (Russia) noted that the available data on spatial patterns for krill, predators and the fishery reflect processes at different spatial and temporal scales. The acoustic surveys covered only short periods of fishing activity or may be provided outside of this period (e.g. in Subarea 48.3). Estimates of total biomass that can be located in SSMUs during fishing season under impact of krill flux should be compared with predator demand of krill. It was recalled that 23 CEMP parameters covering three CEMP sites and three CEMP species that forage in the Bransfield Strait were examined by the Scientific Committee in

2011 in relation to Subarea 48.1. The Scientific Committee concluded that CEMP monitoring parameters did not substantially overlap in time with the fishery and the CEMP data were unlikely to reflect the immediate impact the fishery might have had (SC-CAMLR-XXX, paragraph 3.18).

3.86 Dr Kasatkina noted that analysis of CEMP indices conducted during the intersessional period has not revealed any impact of krill fishery to predators. It has revealed spatial overlapping only. It is important to clarify how possible it is under the current level of fishing, to reveal the impact of catch on the status of krill resources and the status of monitored species or groups of krill-dependent predators.

3.87 Dr Kasatkina noted that methodical aspects of data collecting and processing from acoustic surveys and scientific observations are constantly in the focus of the Scientific Committee and its working groups (WG-EMM, WG-SAM, SG-ASAM) and accompanied by standardised protocols. At the same time, methodical aspects of CEMP data collecting and processing were not discussed by the working group in recent years. It is important to clarify how designs of CEMP data sampling meet with predator distributions and its population structure. However, analysis of structure and trends of CEMP indices should provide adequate information to reveal response time between fleet activity and predator response and delineate changes in CEMP indices caused by fleet activity and concurrent relationship between predators.

3.88 Dr Kasatkina recalled that the trigger level for the krill fishery in Area 48 (620 000 tonnes) corresponds to the value of the maximum historical catch achieved during the 1980s and reflects neither the status of the krill stock and predators in the past nor the current status of the krill stock and predators. She noted that there is no scientific-based argument for the trigger level, and it is necessary to clarify reference points for management of the krill fishery in Area 48. Risk assessment should be based on adequate information. It is necessary to clarify target points for predator population state and these points should be used as the base for krill fishery management.

3.89 In considering CCAMLR-XXXV/30, the Scientific Committee recalled that CM 51-07 was a useful interim mechanism to distribute the catch trigger level without the need to know the exact krill distribution and the precise impact on krill predators and that the Commission had already agreed that FBM was the most appropriate way forward for managing krill catch levels (CCAMLR-XXVIII, paragraph 4.21).

3.90 The Scientific Committee noted that subarea trigger allocations equivalent to those proposed in CCAMLR-XXXV/30 had been used as a plausible scenario in the risk assessment framework (WG-FSA-16/47 Rev. 1, 16/48 Rev. 1 and SC-CAMLR-XXXV/BG/37).

3.91 The Scientific Committee noted that the current catch allocation to Subarea 48.1 was valuable as it appeared to represent a level whereby signals from CEMP might become apparent, now that CEMP had been established for a number of decades. It also noted however, that impacts on predators were not universally apparent, largely because designed experimental fishing experiments had not yet been implemented.

3.92 The Scientific Committee noted SC-CAMLR-XXXV/11 and BG/14. It recognised that physical changes in the environment, including both directional climate change and natural climate variability, increased the complexity of managing the krill fishery in Area 48, particularly at small spatial and temporal scales. It also noted that physical and biological monitoring data are often not available until part way through a fishing season and are usually not analysed until later in the season. These factors further increase the complexity of fishery management.

3.93 The Scientific Committee noted that the fishing fleet generally adapted to the prevailing environmental conditions and to the associated distribution of krill. It noted that this impacted upon how the fishery operated in both existing areas and in new areas, creating additional challenges to management. The Scientific Committee agreed that management uncertainty associated with environmental variability necessitated that the krill fishery be managed with appropriate levels of precaution.

3.94 The Scientific Committee noted that during 2015/16, seasonal sea-ice extent during the early part of the krill fishing season was greater than the long-term median sea-ice extent. It noted that gentoo penguins showed reduced breeding performance at Biscoe Point and Port Lockroy and that gentoo mortality events of chicks occurred at Biscoe Point, Cuverville Island and Neko Harbour. Based on the information contained in SC-CAMLR-XXXV/BG/14, the Scientific Committee noted that the most plausible explanation for these events was the unusual environmental circumstance that impacted foraging conditions.

3.95 The Scientific Committee noted that available monitoring data from nearby locations could provide additional information to help explain the events observed. Remote cameras at Cierva Cove and moored acoustic Doppler current profilers (ADCPs) in the Gerlache Strait might provide further information. The Scientific Committee requested that Members with relevant data submit analyses to WG-EMM as soon as practical.

3.96 In the interim, while analyses are being undertaken, the Scientific Committee recommended that a temporary one-year closure around the colonies where the gentoo mortality events occurred would be a reasonable response to allow the colonies to recover. The Scientific Committee recognised that such temporary closures were consistent with feedback based on environmental conditions.

3.97 The Scientific Committee recalled previous discussions on the need to understand the confounding effects of harvesting and environmental variation (SC-CAMLR-XXII, paragraph 3.12) and that in the context of uncertainty, the Scientific Committee should seek advice from the Commission about the policy of how management should proceed when a significant change was detected, but that no single causal factor could be attributed.

3.98 The Scientific Committee agreed that plausible management procedures that would provide protection for gentoo penguins under conditions of environmental uncertainty included temporary area closures or coastal buffers. It recognised that such procedures would also protect other species and could provide important conservation benefits.

3.99 The Scientific Committee also recalled that one possible method that may assist in the separation of confounding effects of harvesting and environmental variation would be the establishment of an experimental fishing regime whereby fishing would be concentrated in local areas in conjunction with an appropriate predator monitoring program (SC-CAMLR-XXII, paragraph 3.12).

3.100 The Scientific Committee recognised that if seasonal coastal buffers were implemented, then the size of the buffer was a critical issue. It also recognised that coastal buffers would not only protect foraging opportunities for land-based predators, but also protect juvenile fish from being caught as by-catch by krill trawlers.

3.101 The Scientific Committee agreed that in the absence of any empirical data dictating the most effective size of buffer zones, the implementation of any such buffers should be time-limited and conditional upon additional work to quantify risk.

3.102 The Scientific Committee noted that spatial concentration of krill catches is now taking place, including in the summer months and in near-shore areas where krill-dependent species forage (SC-CAMLR-XXXV/BG/14). It recognised that concentration is occurring at spatial scales smaller than SSMUs and that concentration occurs repeatedly in some areas.

3.103 The Scientific Committee noted that SC-CAMLR-XXXV/BG/17, submitted by the Antarctic and Southern Ocean Coalition (ASOC), requests CCAMLR to consider various issues related to CM 51-07. These include reducing concentration of fishing, reduction in fishery–predator overlap and maintenance of krill stocks, so that depletion due to harvesting does not occur.

3.104 The Scientific Committee also considered SC-CAMLR-XXXV/BG/18, submitted by ASOC, which poses a number of questions to CCAMLR. These include how CCAMLR might engage more effectively with the fishing industry and how the development of FBM might link with the process of establishing marine protected areas (MPAs) in Domain 1.

Advice

3.105 Following a wide-ranging discussion concerning the risk assessment framework (WG-FSA-16/47 Rev. 1, 16/48 Rev. 1 and SC-CAMLR-XXXV/BG/37), the Scientific Committee endorsed the framework to assess and advise the Commission of the risks associated with spatial distributions of catches.

3.106 Based on the results of the risk assessment, the Scientific Committee agreed that the risks of localised effects of fishing were increasing and that CM 51-07 should continue for a minimum period of three years. It noted that Tables 2 and 3 could be used to help determine the distribution of catches that would reduce the risk of the current fishery causing localised effects as it expands towards the trigger level.

3.107 The Scientific Committee recognised that CM 51-07 and the risk assessment framework contribute towards the development of FBM. It also noted that the approach was an initial step towards setting local krill catch limits with a scientific basis. The Scientific Committee recognised that the involvement of industry, including through ARK, would be important to the success of FBM.

3.108 The Scientific Committee agreed that the risk assessment framework was based upon the best available scientific evidence, but that a program of work was needed to enhance the framework, including incorporation of new data as it becomes available. The Scientific Committee advised the Commission that the program of work was urgent, as analyses undertaken at WG-EMM and WG-FSA had shown that risks to the ecosystem associated with the krill fishery were increasing, particularly in Subarea 48.1 (Table 2). It further advised the Commission that data on effects of fishing on the predators were insufficient in many areas where the fishery now operated.

3.109 The Scientific Committee agreed that there is a need to be able to determine when fishing is likely to have impacts on the ecosystem. It recognised that the krill decision rule (allowing 75% escapement) was based on theoretical considerations and there was a need to move the decision rule towards a scientific basis with a precautionary approach in the interim.

3.110 The Scientific Committee further advised the Commission that risks associated with the concentration of catches, particularly in coastal areas and during the predator breeding season, might be offset by apportioning the catch at smaller spatial or temporal scales than the subarea scale (paragraph 3.77). Other mechanisms for reducing risks include the use of coastal buffer zones.

3.111 The Scientific Committee recommended that the risk assessments be updated each year, including new data as it becomes available from monitoring and/or re-analyses, in order to update the advice on the risks of an expanding fishery and to enable regular reviews and updates of CM 51-07 or other management measures related to krill.

3.112 The Scientific Committee noted that socioeconomic factors may be an important element in the management of marine living resources, and requested that the Commission provide advice as to whether such factors should also be considered by the Scientific Committee.

Fish resources

Icefish assessments

Champsocephalus gunnari in Subarea 48.3

3.113 Details of this fishery and the stock assessment of mackerel icefish (*Champsocephalus gunnari*) are contained in the Fishery Report (www.ccamlr.org/node/75667), and discussion by WG-FSA is in Annex 7, paragraphs 3.5 to 3.8.

3.114 The fishery for *C. gunnari* in Subarea 48.3 operated in accordance with CM 42-01 and associated measures. In 2015/16, the catch limit for *C. gunnari* was 3 461 tonnes. Fishing early in the season was conducted by one vessel using midwater trawls and the total reported catch was 2 tonnes as of 14 September 2016.

3.115 Dr E. Barrera-Oro (Argentina) noted that, to date, the catches in the current season had been only 2 tonnes, much below the 3 461 tonne catch limit. Low catches were also recorded in the majority of recent years. He commented that, as had been noted in previous CCAMLR meetings, the difference in the catches between pelagic trawl to which the fishery was restricted, and the bottom trawl used to conduct the demersal biomass survey, may account for some of the discrepancy between potential catch and realised catch. However, more than two decades ago, using the same pelagic gear, the commercial fishery obtained catches closer to the levels of the established catch limits. In 2015, Scientific Committee had noted that the inability of the fishery to achieve the catch limit was a result of the lack of effort exerted by the fishery. Dr Barrera-Oro asked if this was the result of a lack of interest by the fishery.

3.116 Dr Darby confirmed that low amounts of fishing effort were still being deployed in Subarea 48.3 and the combination, with the lack of pelagic icefish in the areas fished, has resulted in a very low uptake of quota by the fishery. Only one vessel had fished up to the time of the 2016 meeting, trawling for 72 hours, which compared to a total average vessel trawling time of 1 500 hours per season during the early 2000s when the uptake of the catch limits was higher.

3.117 Dr Barrera-Oro also noted that it was generally considered that icefish could not be distinguished from krill in the commercial vessel acoustic signals. However, the results from an acoustic analysis of data collected on a commercial fishing vessel in Subarea 48.3, described in WG-EMM-16/23, had outlined a potential method for discriminating icefish using random forest techniques and he asked whether this information would be provided to the industry.

3.118 Dr Darby noted that the paper presented to WG-EMM-16 resulted from a fishing industry sponsored PhD study. The intention was to try to help the industry improve their catchability for icefish, although the technique was statistically complex. He also highlighted the research conducted by Chile in 2016 in Subarea 48.1 (WG-SAM-16/19), which also indicated that current vessel technology may help in detecting the presence of icefish in the water column.

Management advice

3.119 The Scientific Committee noted that there would be a new survey of the resource conducted in 2017 and recommended that the catch limit for *C. gunnari* in Subarea 48.3 of 2 074 tonnes for 2016/17 be carried forward.

C. gunnari in Division 58.5.1

3.120 There was no fishery for icefish for *C. gunnari* in Division 58.5.1 in 2015/16.

3.121 A short-term assessment of *C. gunnari* in Division 58.5.1 was conducted after the 2015 icefish-specific biomass survey PIGE (PoIsson des GlacEs) (WG-FSA-16/53). The area in the south of the survey strata appears to have consistently higher catch rates than in previous years across the three POKER surveys (WG-FSA-14/07).

3.122 A short-term assessment of *C. gunnari* in Division 58.5.1 was conducted after the removal of a high-abundance haul outlier to estimate the demersal biomass of *C. gunnari* in this division. The bootstrap estimated the mean demersal biomass at 81 302 tonnes for the northeast shelf and 0 tonnes for the Skiff Bank, with a one-sided lower 95% confidence interval of 49 268 tonnes for the northeast shelf. The harvest control rule, which ensures 75% biomass escapement after a two-year projection period, yielded a catch limit of 12 130 tonnes for 2016/17.

3.123 Scientific Committee noted that France intended to conduct a pelagic trawl fishery for *C. gunnari* in Division 58.5.1 in the 2016/17 CCAMLR season.

Management advice

3.124 The Scientific Committee agreed that a catch limit of 12 130 tonnes for *C. gunnari* in Division 58.5.1 in 2016/17 would be consistent with the CCAMLR decision rules.

C. gunnari in Division 58.5.2

3.125 Details of this fishery and the stock assessment of *C. gunnari* are contained in the Fishery Report, and discussion by WG-FSA is in Annex 7, paragraphs 3.16 to 3.22.

3.126 The fishery for *C. gunnari* in Division 58.5.2 operated in accordance with CM 42-02 and associated measures. In 2015/16, the catch limit for *C. gunnari* was 482 tonnes. Fishing was conducted by one vessel and the total reported catch up to 14 September 2016 was 469 tonnes.

3.127 Australia conducted a random stratified trawl survey in Division 58.5.2 during April 2016 (WG-FSA-16/23). The density of *C. gunnari* was five times that of 2015 and nearly three times the average.

3.128 A short-term assessment was conducted using the generalised yield model (GYM), with a one-sided bootstrap lower 95% confidence bound of total biomass of 3 955 tonnes of ages 1+ to 3+ fish from the 2015 survey and fixed model parameters. Estimates of yield indicated that 561 tonnes of *C. gunnari* could be taken in 2016/17 and 402 tonnes in 2017/18, allowing 75% escapement of biomass after two years.

Management advice

3.129 The Scientific Committee recommended a catch limit for *C. gunnari* in Division 58.5.2 in 2016/17 of 561 tonnes and of 402 tonnes in 2017/18.

Toothfish assessments

Dissostichus eleginoides in Subarea 48.3

3.130 Details of this fishery and the stock assessment of *D. eleginoides* are contained in the Fishery Report, and discussion by WG-FSA is in Annex 7, paragraphs 3.23 and 3.24.

3.131 The fishery for *D. eleginoides* in Subarea 48.3 operated in accordance with CM 41-02 and associated measures. In 2015/16, the catch limit for *D. eleginoides* was 2 750 tonnes. Fishing was conducted by six vessels using longlines and the total reported catch was 2 195 tonnes.

Management advice

3.132 The Scientific Committee noted that its previous advice for *D. eleginoides* in Subarea 48.3 is biennial, and that the catch limit in 2016/17, as specified in CM 41-02, is 2 750 tonnes.

D. eleginoides in Subarea 48.4

3.133 Details of this fishery and the stock assessment of *D. eleginoides* are contained in the Fishery Report, and discussion by WG-FSA is in Annex 7, paragraphs 3.25 and 3.26.

3.134 The fishery for *D. eleginoides* in Subarea 48.4 operated in accordance with CM 41-03 and associated measures. The catch limit for *D. eleginoides* in Subarea 48.4 in 2015/16 was 47 tonnes. The total reported catch by two vessels was 41 tonnes.

Management advice

3.135 The Scientific Committee noted that its previous advice for *D. eleginoides* in Subarea 48.4 is biennial, and that the catch limit in 2016/17, as specified in CM 41-03, is 47 tonnes.

D. mawsoni in Subarea 48.4

3.136 Details of this fishery and the stock assessment of *D. mawsoni* are contained in the Fishery Report, and discussion by WG-FSA is in Annex 7, paragraphs 3.27 to 3.33.

3.137 The fishery for *D. mawsoni* in Subarea 48.4 operated in accordance with CM 41-03 and associated measures. The catch limit for *D. mawsoni* in Subarea 48.4 in 2015/16 was 39 tonnes. The total reported catch by two vessels was 28 tonnes.

3.138 Noting that the observed short residence time for tagged *D. mawsoni* on the seamounts in Subarea 48.4 is similar to 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 (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 would indicate a 2016/17 yield of 38 tonnes for *D. mawsoni* in Subarea 48.4.

Management advice

3.139 The Scientific Committee recommended that the catch limit for *D. mawsoni* in Subarea 48.4 should be set at 38 tonnes for 2016/17.

D. eleginoides in Subarea 58.6 and Divisions 58.5.1 and 58.5.2

D. eleginoides in Division 58.5.1

3.140 Details of this fishery and the stock assessment of *D. eleginoides* are contained in the Fishery Report, and discussion by WG-FSA is in Annex 7, paragraphs 3.132 to 3.136.

3.141 The fishery for *D. eleginoides* in Division 58.5.1 is conducted in the French exclusive economic zone (EEZ). In 2015/16, 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 31 July 2016 was 3 814 tonnes.

3.142 The Scientific Committee noted an updated stock assessment of *D. eleginoides* within the French EEZ in Division 58.5.1, which included new von Bertalanffy growth parameters and catch-at-age data, a new tag shedding rate parameter and the inclusion of estimated removals due to depredation.

Management advice

3.143 The Scientific Committee noted that the catch limit set by France of 5 050 tonnes in 2016/17 was consistent with the CCAMLR decision rules in the model runs presented.

3.144 No new information was available on the state of fish stocks in Division 58.5.1 outside areas of national jurisdiction. The Scientific Committee, therefore, recommended that the prohibition of directed fishing for *D. eleginoides*, described in CM 32-02, remain in force in 2016/17.

D. eleginoides in Division 58.5.2

3.145 Details of this fishery and the stock assessment of *D. eleginoides* are contained in the Fishery Report.

3.146 The fishery for *D. eleginoides* in Division 58.5.2 operated in accordance with CM 41-08 and associated measures. In 2015/16, the catch limit for *D. eleginoides* was 3 405 tonnes. Fishing was conducted by four vessels using bottom trawls and longlines, and the total reported catch up to 14 September 2016 was 1 341 tonnes.

Management advice

3.147 The Scientific Committee noted that its previous advice for *D. eleginoides* in Division 58.5.2 is biennial, and that the catch limit in 2016/17, as specified in CM 41-08, is 3 405 tonnes.

D. eleginoides in Subarea 58.6 (French EEZ)

3.148 Details of this fishery and the stock assessment of *D. eleginoides* are contained in the Fishery Report, and discussion by WG-FSA is in Annex 7, paragraphs 3.137 and 3.138.

3.149 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. In 2015/16, the catch limit for *D. eleginoides* was 1 000 tonnes. Fishing was conducted by seven vessels using longlines and the total reported catch up to 31 July 2016 was 534 tonnes.

3.150 The Scientific Committee noted an updated stock assessment of *D. eleginoides* at Crozet Islands (Subarea 58.6 inside the French EEZ), which included, inter alia, estimates of whale depredation and new von Bertalanffy growth parameters estimated from Kerguelen age data.

Management advice

3.151 The Scientific Committee noted that the catch limit set by France of 1 300 tonnes in 2016/17 was consistent with the CCAMLR decision rules.

3.152 No new information was available on the state of fish stocks in Subarea 58.6 outside areas of national jurisdiction. The Scientific Committee, therefore, recommended that the prohibition of directed fishing for *D. eleginoides*, described in CM 32-02, remain in force in 2016/17.

Fish and invertebrate by-catch

3.153 The Scientific Committee noted discussions by WG-FSA around fish by-catch in the krill fishery based on a review using data from SISO and commercial data (WG-FSA-16/04; Annex 7, paragraphs 6.1 to 6.4), showing that the estimated total annual mass of fish by-catch in a 300 000 tonnes krill fishery would be 370 tonnes, comprising 40% *C. gunnari* and 30% *Lepidonotothen larseni*.

3.154 The Scientific Committee recalled that the discussions around the need to progress the issue of fish by-catch in the krill fishery have been held for many years, and that, as this item is fragmented across several working groups, progress has been slow. It welcomed the review and noted that this review summarised the location of fish by-catch in the krill fishery and made progress on an issue that has not progressed for a long time.

3.155 The Scientific Committee noted that the catches of fish were predominantly <10 cm and the same species and size classes as those reported in the diet of krill-dependent predators. The Scientific Committee recalled that scaling up total fish by-catch estimates from observer samples from continuous trawl vessels may not reflect the catch period (see Annex 6, paragraphs 2.18 to 2.22). It concluded that the systematic data collection of fish by-catch in the krill fishery now allows to quantify fish by-catch, and may enable more effective monitoring of population dynamics of those finfish species taken in the krill fishery.

3.156 The Scientific Committee noted that WG-FSA-16 highlighted the need for correct species identifications in finfish by-catch, including for the early juvenile stages of species that closely resemble each other (e.g. ocellated icefish (*Chionodraco rastrospinosus*) and crocodile icefish (*C. hamatus*)), for which correct identification remains difficult. It encouraged Members to continue to refine tools available to vessels and observers to provide accurate identification and quantification of by-catch.

3.157 The Scientific Committee requested that the Secretariat provide an annual update on finfish by-catch in the krill fishery to WG-FSA.

3.158 The Scientific Committee further suggested a workshop focussing on fish by-catch in fisheries to progress work on spatial and temporal patterns. In view of the discussions on krill and the risk analysis model (paragraphs 3.55 to 3.111), a focus workshop should be considered in the short-term, rather than medium-term, time frame in order to contribute to the risk assessment.

3.159 The Scientific Committee considered work that examined potential relationships between historic fishing on nototheniid taxa and Antarctic shag (*Phalacrocorax bransfieldensis*) by studying shag diets (WG-EMM-16/P09). The results were consistent with observations by the US AMLR Program and the German demersal fish program around the South Shetland Islands over a period of 30 years. The Scientific Committee noted the suggestion by WG-FSA-16 (Annex 7, paragraph 6.5) that tagging marbled rockcod (*Notothenia rossii*) recruits on their way to the offshore adult population could improve understanding of their two-stage life cycle.

3.160 Dr Barrera-Oro thanked the Scientific Committee for considering this work. He noted that Argentina had previously used a tagging program on juvenile specimens of *N. rossii*, a stock going through recovery, but not using electronic tags. This work primarily contributed to the validation of ageing of *N. rossii*. He thanked WG-FSA for the suggestion on how to develop this research further, but highlighted that, as the South Shetland Islands (Subarea 48.1) are currently closed to finfish fisheries, tag recaptures would be entirely reliant on research cruise vessels.

3.161 The Scientific Committee acknowledged that, should tagging of fish in this region be considered further, any such programs would need to be linked to other national programs to maximise the potential for recovery of tagged fish.

3.162 The Scientific Committee noted work on skates around the Kerguelen Plateau (WG-FSA-16/P03) and results from a by-catch data collection plan in the Ross Sea (Annex 7, paragraph 6.7) before considering discussions by WG-FSA-16 on CM 33-03. It noted that the discrepancy between the spatial scales applying to catch limits for *Dissostichus* spp. and by-catch in fisheries for *Dissostichus* spp., can result in a lack of clarity on the actual by-catch limit for a research block, as well as catch limits for by-catch actually being higher than the target species in some areas, without any formal assessments supporting these limits (Annex 7, paragraphs 6.11 to 6.15).

3.163 The Scientific Committee endorsed the recommendation from WG-FSA-16 (Annex 7, paragraph 6.14) to remove the absolute limits and applying percentage thresholds, including extending the 16% catch limit in place for *Macrourus* spp. to the category ‘all other species combined’, so that by-catch limits are:

(i) skates and rays: 5% of the catch limit of *Dissostichus* spp.
(ii) *Macrourus* spp.: 16% of the catch limit for *Dissostichus* spp.
(iii) all other species combined: 16% of the catch limit for *Dissostichus* spp.

3.164 The Scientific Committee recognised that other consequential changes, including to move-on rules, would need to be introduced into CM 33-03 and that careful scrutiny for consistency with rules applying within management areas needs to be employed.

3.165 The Scientific Committee agreed to the request by WG-FSA that the Secretariat separately report by-catch of sleeper sharks in compiling Fishery Reports to enable monitoring whether retention of infrequently caught dead sleeper sharks (Somniosidae) can potentially trigger a by-catch limit in management areas with low catch limits for *Dissostichus* spp.

3.166 The Scientific Committee noted that CM 23-04 states 'The catch of all target and by-catch species must be reported by species'. Catches of some taxa are, however, often reported at genus or family level as in many species it is difficult to identify to species level, and recommended that the relevant wording in CM 23-04 'The catch of all target and by-catch species must be reported by species' be changed to 'The catch of all target and by-catch species must be reported by species, or to the lowest taxonomic level possible (e.g. species or genus)'.

3.167 The Scientific Committee noted discussions by WG-FSA-16 (Annex 7, paragraph 6.21) on current CCAMLR data collection methods and protocols, and endorsed the recommendation that the Secretariat use an e-group that includes national technical coordinators and representatives from those Members that submit commercial fishing data to the Secretariat to discuss changes to all CCAMLR data collection forms.

New and exploratory finfish fisheries

Exploratory fishery notifications in 2016/17

3.168 Members' notifications to fish in exploratory fisheries for *Dissostichus* spp. in 2016/17 were presented in CCAMLR-XXXV/BG/05 Rev. 1. The Scientific Committee agreed that such a paper on fishery notifications may not be necessary in the future, since the CCAMLR website (www.ccamlr.org/en/fishery-notifications/notified) provides up-to-date information regarding Members' participation in new and exploratory fisheries, and also contains links to associated metadata such as vessel details.

Making activities targeting toothfish consistent with CCAMLR's regulatory framework

3.169 CCAMLR-XXXV/14 and BG/09 presented a proposal to make research fishing activities that target toothfish consistent within CCAMLR's regulatory framework. This work followed a paper presented by the Chair of the Scientific Committee last year (CCAMLR-XXXIV/17 Rev. 1), and an agreement by the Commission that there were analogous research activities targeting toothfish that have the same review process but are either conducted under conservation measures, or under an agreement by the Commission, which is only captured in its report text. Given the confusion and lack of transparency this can cause, the Commission had requested that the Secretariat work with Members in the intersessional period to resolve this inconsistency through the revision of existing conservation measures and the creation of new conservation measures (CCAMLR-XXXIV, paragraph 9.21).

3.170 The proposals in CCAMLR-XXXV/14 and BG/09 indicated that, in general, all necessary components for resolving inconsistencies already exist within the current conservation measures. Some small changes would be required, e.g. to the preliminary paragraphs of CM 21-02 such that this conservation measure applies to all research activities targeting toothfish, along with the establishment of a clear hierarchical structure between conservation measures. In addition, the annex in CM 24-01 would be moved into CM 41-01.

3.171 The Scientific Committee agreed that the proposed changes would:

(i) increase the transparency in the scientific advice provided by the Scientific Committee and its working groups

(ii) increase the efficiency of the Scientific Committee and its working groups via the establishment of a single framework for evaluating research activities in accordance with Article II

(iii) allow for a broader consideration of ecosystem effects of fishing.

3.172 The Scientific Committee agreed that a common approach to reviewing and managing research oriented to the following points (CM 21-02, paragraph 1ii) would assist the Scientific Committee in giving consistent and transparent advice on the research that will contribute to:

(i) evaluation of the distribution, abundance and demography of the target species, leading to an estimate of the fishery’s potential yield

(ii) review of the fishery’s potential impacts on dependent and related species

(iii) allowing the Scientific Committee to formulate and provide advice to the Commission on appropriate harvest catch levels, as well as effort levels and fishing gear, where appropriate.

3.173 Dr Kasatkina noted that the CCAMLR regulatory framework was the subject of discussion during the Commission last year (CCAMLR-XXXIV, paragraphs 9.11 to 9.21) and focused on the following proposals that were taken:

(i) It was suggested that a glossary of terms that describes the nomenclature and terminology would be beneficial in establishing a common understanding among Members. It also was suggested that a mechanism or procedure, utilising the agreed terminology, be established to support the revision and adoption of conservation measures (CCAMLR-XXXIV, paragraph 9.14).

(ii) A workshop for more detailed consideration regulatory framework and by streamlining fishery was suggested. The report of this workshop should be presented for consideration by WG-EMM and WG-FSA (CCAMLR-XXXIV, paragraph 9.17).

3.174 Dr Kasatkina noted that the above mentioned proposals were not taken.

3.175 The Scientific Committee noted that the proposal had been circulated to all Members participating in exploratory fisheries intersessionally for comments and referred the issue to the Commission.

3.176 The Scientific Committee noted that the proposed changes may also require the re-categorisation of some areas in which directed fishing on taxa is currently prohibited (CM 32-02, Annex 32-02/A).

3.177 The Scientific Committee recommended that the species being targeted be specified (i.e. *D. mawsoni* or *D. eleginoides*) in the title and text of conservation measures, rather than *Dissostichus* spp. that is currently present in all relevant conservation measures. This change will provide clarity to the Commission and any external parties on which species was being targeted and managed in particular areas. For example, in CM 41-09, which specifies the limits for the exploratory toothfish fishery in Subarea 88.1, '*Dissostichus* spp.' would be replaced with '*D. mawsoni*'. In this case, for the purpose of CMs 23-07 and 23-04, any *D. eleginoides* caught would count towards the overall catch limit for *D. mawsoni*, and 'by-catch species' would be defined as any species other than *Dissostichus* spp.

Long-distance movements of toothfish

3.178 The Scientific Committee noted that the report on long-distance movements of tagged *D. eleginoides* and *D. mawsoni* (WG-FSA-16/25 Rev. 1) was a useful summary to inform stock hypotheses, and that the Secretariat should present such a summary biennially to WG-FSA.

Local biomass estimates of *D. mawsoni* and *D. eleginoides*

3.179 The Scientific Committee noted that WG-SAM and WG-FSA had developed a common approach to estimate local biomass in research blocks in Subareas 48.6 and 58.4. This approach included estimating biomass using a CPUE by seabed area analogy method and a Chapman tag-recapture estimator (Annex 5, paragraph 2.28). These two methods were used in WG-FSA-16/27 to estimate biomass in each research block. Based on these biomass estimates, catch limits were calculated by multiplying each estimate by the 4% exploitation rate. The resulting catch limits were presented in Annex 7, Table 1. The Scientific Committee recalled that in the past the lower of the two values had been used in formulating advice (SC-CAMLR-XXXIII, Annex 7, paragraph 5.123iv).

3.180 The Scientific Committee noted that during WG-FSA-16, biomass was estimated for the new proposed research block in Division 58.4.1 (research block 5841_6) as well as for the survey areas in Subareas 48.2 and 48.4. The Scientific Committee noted that after the WG-FSA-16 meeting, checks of the calculations established that the total seabed area, instead of the fishable seabed area, had been used in the calculation of toothfish biomass. The revised estimates were presented to the Scientific Committee in SC-CAMLR-XXXV/BG/38 Rev. 1.

3.181 The Scientific Committee thanked the Secretariat for the considerable amount of work done on developing the biomass estimates for WG-FSA and also for the timely correction of the estimates produced during WG-FSA-16.

3.182 The Scientific Committee noted that:

(i) biomass estimates using a CPUE by seabed area analogy method and a Chapman tag-recapture estimator were point estimates with likely bias and no measure of precision

(ii) often large differences exist between biomass estimates for *D. mawsoni* when calculated using the agreed CPUE by seabed area analogy method and the Chapman tag-recapture estimator

(iii) the proposed catch limits in several research blocks were substantially lower than those in previous seasons

(iv) such a reduction in catch limits may compromise existing research plans in some areas.

3.183 The Scientific Committee noted that, for the reasons listed above, WG-FSA-16 had been unable to reach consensus on most research catch limits in Subareas 48.6 and 58.4 (Annex 7, paragraphs 4.31 to 4.33).

3.184 Given the uncertainties associated with the current biomass estimates and the disparity between the results of the two methods, the Scientific Committee recommended that research catch limits from the 2015/16 season be brought forward to the 2016/17 season.

3.185 The Scientific Committee agreed that this 'roll-over' of current catch limits should apply to the forthcoming season only, and not constitute a precedent for future situations where there is disagreement between methods for calculating catch limits.

3.186 The Scientific Committee also agreed that where WG-FSA provides alternative advice regarding research catch limits, these alternatives be supported with scientific rationale to allow the Scientific Committee to evaluate each option.

3.187 The Scientific Committee requested that WG-SAM and WG-FSA:

(i) evaluate how species- or area-specific factors may influence biomass estimates by the CPUE by seabed area analogy method and a Chapman tag-recapture estimator

(ii) develop approaches to incorporate uncertainty associated with biomass estimates, including through bootstrapped estimates

(iii) develop approaches to determine the more appropriate method, or develop an approach that can combine CPUE by seabed and tag-recapture data into a single estimate of biomass, from which advice on catch limits can be provided.

3.188 The Scientific Committee noted the need to consider whether catches may impact on fish stocks over the entire period of a research program. The Scientific Committee noted that it is important that the catch limit for a research plan is sufficient so that the agreed research objectives can be fulfilled.

3.189 The Scientific Committee recalled that research plans shall be reported in accordance with the standardised guidelines and formats provided in CM 24-01, Annex 24-01/A. The Scientific Committee noted that clear statements addressing the following points in format 2 of CM 24-01/A are required in order for the Scientific Committee and its working groups to evaluate the need for, and appropriateness of, research plans:

(i) a timeline and milestones for how and when the data will meet the objectives of the research (e.g. lead to a robust estimate of stock status and precautionary catch limits) (CM 24-01/A, paragraph 3d) (SC-CAMLR-XXXIV, paragraph 3.229)

(ii) a justification of the proposed catch limits, noting 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 (CM 24-01/A, paragraph 4a)

(iii) an evaluation of the impact of the proposed catch on stock status (CM 24-01/A, paragraph 4b)

(iv) details of dependent and related species and the likelihood of their being affected by the proposed fishery (CM 24-01/A, paragraph 4b).

3.190 The Scientific Committee noted that this process would facilitate the assessment of the suitability of new proposals, and the progress of existing research programs.

Subarea 88.1

3.191 The exploratory fishery for *D. mawsoni* in Subarea 88.1 operated in accordance with CM 41-09 and associated measures. In 2015/16, the catch limit for *Dissostichus* spp. was 2 870 tonnes, including 40 tonnes set aside for the Ross Sea shelf survey, and 100 tonnes set aside for the Ross Sea winter survey. Fishing was conducted by 13 vessels using longlines, and the total reported catch was 2 684 tonnes. A total of 19 vessels have notified to fish in 2016/17.

3.192 The Scientific Committee noted the continued monitoring of CCAMLR fisheries for overcapacity and agreed that although there was no indication of an excess in capacity at the current time, the Secretariat should continue to monitor the number of vessels notifying and then subsequently fishing in a subarea in each year, in order to detect any increasing trend (Annex 7, paragraph 3.37).

3.193 The Scientific Committee noted the successful completion of the 2016 Ross Sea shelf longline survey, and noted that the Commission had already approved the 2017 survey with a catch limit of 40 tonnes (CCAMLR-XXXIV, paragraph 5.34). It also welcomed the successful completion of the first winter survey which had caught spawning *D. mawsoni* for the first time in this area and the probable capture of fertilised *D. mawsoni* eggs using a plankton net.

3.194 The Scientific Committee noted progress by WG-FSA to describe metrics of various fishing activities in order to evaluate patterns in the data recorded by fishing vessels and observers (Annex 7, paragraphs 3.58 to 3.68, and 3.90 to 3.94). The Scientific Committee agreed that to develop statistical models describing the fishing process, information would be needed on vessel freezing capacity and fish processing rates and requested that the Commission consider this matter.

3.195 The Scientific Committee considered that the purpose of the analyses of fishing activity data was to identify potential errors in the data or inconsistencies among the different variables recorded. It noted that fishing activities may be influenced by the areas fished, the size of the fish caught and ice conditions, as well as effects of individual vessel characteristics and metrics of vessel performance. It agreed that all these factors should be accounted for in analyses of patterns in fishing activities so that conclusions can be made about how well the data fit with expectations.

3.196 The Scientific Committee welcomed the development of methods to use archival satellite tags to understand toothfish movement and behaviour patterns.

Management advice

3.197 The Scientific Committee recommended that the current catch limit for *D. mawsoni* in Subarea 88.1 and SSRUs 882A–B of 2 870 tonnes be carried forward for the 2016/17 season, including 40 tonnes set aside for the Ross Sea shelf survey, with the survey catch taken from the catch limit for SSRUs 881J and L.

Subarea 88.2

3.198 The exploratory fishery for *D. mawsoni* in Subarea 88.2 operated in accordance with CM 41-10 and associated measures. In 2015/16, the catch limit for *Dissostichus* spp. was 619 tonnes. Fishing was conducted by nine vessels using longlines, and the total reported catch was 618 tonnes. A total of 17 vessels have notified to fish in 2016/17.

SSRUs 882A–B

3.199 A second multi-Member survey in the northern region of SSRUs 882A–B was proposed by Australia, New Zealand, Norway and the UK, and discussed and considered to be an appropriate design by WG-SAM and WG-FSA (WG-SAM-16/15; Annex 5, paragraphs 4.21 to 4.29; Annex 7, paragraphs 3.101 to 3.106).

3.200 Dr Kasatkina recalled that the results of the first year of the two-year longline survey for toothfish in the northern Ross Sea region (SSRUs 882A–B north) showed anomaly high CPUE values, reaching to 5 280 kg/1 000 hooks (SC-CAMLR-XXXIV, Annex 6, paragraph 4.102). At the same time, the high catches were obtained from greater depths (1 900 m or more) outside the main area of *D. mawsoni* distribution.

3.201 Dr Kasatkina emphasised that it was not provided satisfactory analysis to clarify the sources of this high questionable CPUE and correspondent catches. Analysis of the VMS data with reported haul locations was not conducted also.

3.202 Dr Kasatkina stated that analysis of survey SSRUs 882A–B was uncompleted and this analysis does not meet the recommendations of the Scientific Committee and Commission (SC-CAMLR-XXXIV, paragraph 3.201; SC-CAMLR-XXXIV, Annex 5, paragraph 4.29; CCAMLR-XXXIV, paragraph 5.41).

3.203 Dr Kasatkina made the following statement on surveys in SSRUs 882A–B:

> 'Russia cannot support the proposal for a second step of longline survey of toothfish in the northern Ross Sea region (SSRUs 882A–B) in the 2016/17 season. Survey data in the northern region of SSRUs 882A–B from the first step in 2015 should be placed into quarantine until a satisfactory analysis of the high CPUE records has been completed.'

3.204 The Scientific Committee noted that the considerable discussion concerning the proposal did not result in consensus advice. The proposal was not supported by Dr Kasatkina because the analyses of data from the first survey provided were considered by Dr Kasatkina to be inadequate, and Dr Kasatkina proposed that the data from this survey should be quarantined.

3.205 The Scientific Committee recalled that this issue had been discussed at length by both WG-SAM and WG-FSA, and specifically Annex 7, paragraphs 3.104 to 3.106, where WG-FSA, apart from Dr Kasatkina, agreed that the analyses submitted to, and reviewed by, WG-SAM (Annex 5, paragraphs 4.5 to 4.20) and WG-FSA (Annex 7, paragraphs 3.58 to 3.106), had not indicated any unusual patterns in the data from the survey conducted in the north of SSRUs 882A–B independently by New Zealand, Norway and the UK with observers from South Africa and Spain. Consequently, there was no case for the quarantining of data collected by the five Members.

3.206 Dr Kasatkina noted that the reports of WG-FSA and WG-SAM did not contain sufficient information to convey to Members the results of the reviews. She requested that more detail be made available to her and other interested Members. She noted that the approach in working groups for discussing and reporting different views on these analyses needs improvement.

3.207 The Scientific Committee noted the future work of WG-SAM, recommended by WG-FSA, to develop analytical approaches for quality-checking of fishery data (Annex 7, paragraphs 3.90 to 3.94) may help resolve differences of view on this matter. It agreed that WG-SAM be requested to progress this work (Annex 7, paragraph 3.92) and encouraged Members to work collaboratively and make contributions on this work to WG-SAM (Annex 7, paragraph 3.94).

3.208 The Scientific Committee considered this issue further in 'Future work'.

3.209 The Scientific Committee noted that the design of the proposal for a survey in the southern region of SSRU 882A by Russia was considered appropriate for the stated objectives, but that the requested list of milestones for the proposal and the time in which they were expected to be delivered (Annex 5, paragraph 4.34) were not made available to WG-FSA until late in the meeting and were therefore not reviewed. Further, the Scientific Committee requested the status of proposed partner proponents of the research, and how the information collected would be used to provide management advice.

3.210 Dr Jones underscored that the special research zone (SRZ) in the proposed Ross Sea Region MPA specifically includes objectives with respect to the understanding of toothfish distribution and movement and largely overlaps with Russia's proposed study area. The management approach envisioned within the SRZ is an alternative to the Russian proposal for research fishing in SSRU 882A south. Just as last year, Dr Jones believed that the choice between the approach envisioned within the Ross Sea region MPA proposal and the approach envisioned by Russia is ultimately a choice for the Commission.

3.211 Dr Kasatkina noted that previous research and tagging of toothfish in the area was conducted by Russia and was reported to the Scientific Committee and the data were available to be used. She also noted that its proposed survey in the southern region of SSRU 882A includes sampling requirements that exceed the observer sampling requirements specified in CM 41-01 and is consistent with the Ross Sea region fisheries data collection plan (WG-FSA-15/40).

3.212 Dr Kasatkina highlighted there is only the Russian research program for investigation in the SSRU 882A for the 2016/17 season. Monitoring and research plan in the proposed Ross Sea region MPA was not submitted for the season 2016/17 as well as for future years. Comparison analysis between Russian program and the above said program is not possible. At the same time Russian program will provide important information for understanding toothfish distribution and for the spatial population model (SPM) in the Ross Sea region.

SSRUs 882C–H

3.213 The Scientific Committee reiterated its request for Members to contribute to providing ages for the developing stock assessment in SSRUs 882C–H (SC-CAMLR-XXXII, paragraph 3.169) (see also paragraphs 3.241 and 3.242).

3.214 The Scientific Committee also considered increasing the tagging rate in SSRUs 882C−H and noted that in contrast to most research plans, fishing in the area was Olympic, and that increasing the rate above three tags per tonne may result in poor tagging performance. The Scientific Committee also considered that in the future, removing the time pressures caused by an Olympic fishery may be achieved by setting aside catch for individual vessels.

Management advice

3.215 The Scientific Committee considered that the results from the previous two-year research approach to constrain fishing to four areas in SSRUs 882C–G was providing information necessary to develop the stock assessment and that the current catch limits in SSRUs 882C–H were consistent with CCAMLR's precautionary approach. The Scientific Committee recommended that the research program in SSRUs 882C–H be extended by a further two years. Specifically:

(i) SSRUs C, D, E, F and G: 419 tonnes total only in the research blocks (as defined in CM 41-10, Annex 41-10/A) with no more than 200 tonnes taken in any one research block

(ii) SSRU H: 200 tonnes.

3.216 The Scientific Committee recommended that the tagging rate in the north (SSRU 882H) should be increased to 3 fish per tonne of catch to provide a consistent rate throughout the area, and to increase the numbers of tags recovered annually.

3.217 Dr Kasatkina presented SC-CAMLR-XXXV/09 on assigning appropriate research catch limits to vessels undertaking research fishing in SSRUs of Subareas 88.1 and 88.2 that are closed to fishing. She recalled that the Scientific Committee requested that Members develop and submit new proposals under CM 24-01 to deliver effort-limited surveys in the Ross Sea region (SC-CAMLR-XXXII, paragraph 3.76iv). The Russian paper (SC-CAMLR-XXXV/09) proposed that research catch limits be set for all closed SSRUs in the Ross Sea. According to CCAMLR regulations, an overall assessment is carried out for the stock in the Ross Sea once every two years. The stock in closed SSRUs is also assessed. It proposed that a standing research catch limit be set for closed SSRUs that can be assigned to a vessel notifying to conduct research in a particular SSRU. Therefore, the overall catch limit for Subarea 88.1 would not be taken and will be used only by fishing vessels operating under the Olympic system.

3.218 The Scientific Committee thanked Russia for their proposal and noted that the closed SSRUs are considered part of the Ross Sea stock. It recalled its advice that research catches must be included within the catch limit derived from the stock assessment for the Ross Sea area to be consistent with Article II of the Convention (SC-CAMLR-XXXIV, paragraph 3.220).

3.219 The Scientific Committee also noted that structured scientific research in the area would improve understanding of the life history of toothfish. A process for the development of research proposals in closed areas has been agreed and implemented by the Scientific Committee and its working groups. The process establishes a methodology for the establishment of initial research catch limits during the initial exploratory phase and later during the research block stage. There is no requirement for a fixed catch limit based on historic catch.

Research to inform current or future assessments in 'data-poor' fisheries (e.g. closed areas, areas with zero catch limits and Subareas 48.6 and 58.4) notified under Conservation Measures 21-02 and 24-01

Subarea 48.2

Chilean proposal

3.220 The Scientific Committee noted the discussion at WG-FSA on a plan by Chile to continue the longline research survey for *Dissostichus* spp. in Subarea 48.2 (WG-FSA-16/34), and that the vessel proposed for research activities in 2016/17 was the same vessel that failed to meet tagging requirements and did not include the species composition of *Macrourus* spp. by-catch in 2015/16.

3.221 The Scientific Committee agreed that the advice from WG-SAM-16 regarding this proposal was clear and that the proponents of this research had not followed this advice in full and, therefore, was unable to support the proposed extension of the Chilean survey in 2016/17. The Scientific Committee requested that Chile prepare another proposal for this research and present this to WG-SAM-17.

Ukrainian proposal

3.222 The Scientific Committee noted the results from the first two years of a three-year longline survey undertaken by Ukraine (WG-FSA-16/50) that aimed to estimate the status of *Dissostichus* spp. in Subarea 48.2, and considered a revised plan for a third year of Ukrainian research in this subarea (WG-FSA-16/49). It was noted that 534 toothfish have been tagged during the previous two years in this subarea.

3.223 The Scientific Committee noted the deliberations relative to revising precautionary research catch limits from the CPUE by seabed area method for this effort-limited survey (Annex 7, paragraphs 4.53 and 4.54), including new calculations made during the course of the meeting (SC-CAMLR-XXXV/BG/38 Rev. 1, Table 2), and that WG-FSA could not adequately evaluate all methods of calculating research catch limits. It recalled that new information based on seabed area calculations for Subareas 48.6 and 58.4 requires further work to be undertaken at WG-SAM-17 prior to use for providing advice (Annex 7, paragraph 4.65).

3.224 In line with this recommendation, the Scientific Committee recommended that the research catch limit of 75 tonnes in Subarea 48.2 from the 2015/16 season be brought forward to the 2016/17 season to allow Ukraine to finish this research.

3.225 In recalling the flowchart describing key aspects of prospecting, biomass estimation and assessment (SC-CAMLR-XXXII, Annex 6, Figure 10), the Scientific Committee recommended that WG-SAM-17 consider the methodology and assumptions underlying this figure and update it as necessary to provide a reference paper that can be used by future research proponents.

UK survey

3.226 The Scientific Committee noted a proposal by the UK for a three-year longline survey to develop *Dissostichus* spp. stock hypotheses and connectivity between Subareas 48.2 and 48.4, and improve the available data on bathymetry and associated distributions of benthic by-catch species.

3.227 Dr Kasatkina recalled the discussion during WG-FSA (Annex 7, paragraphs 4.57 to 4.62) that toothfish catch and its length compositions may depend on gear type. She noted that multiple surveys provided by vessels of Chile, Ukraine and UK in Subarea 48.2 aimed at population structure of *D. eleginoides* and *D. mawsoni* will be conducted using two gear-types with significant differences in hook numbers for individual vessels.

3.228 Dr Kasatkina proposed to investigate impact of different longline gears on catch and their length and species composition in toothfish fishery. She noted that such investigations may be conducted by using CCAMLR data as well as by in situ observations.

3.229 The Scientific Committee noted that the main objectives in the UK proposal are different to those in the proposals by Chile and Ukraine, the objectives in the research proposed by the UK are not related to catch rates or by-catch rates, and that there is no spatial overlap with the research being undertaken by Ukraine. The Scientific Committee recalled research undertaken by Australia and Japan on BANZARE Bank that compared species compositions of catches obtained using trotline and autoline gear types and found them to be very similar.

3.230 The Scientific Committee recalled the first evidence of illegal, unreported and unregulated (IUU) fishing activity (retrieval of gillnets by Ukraine in 2015/16) in Subarea 48.2, and underlined the need to develop methods that can incorporate uncertainty arising from the unknown IUU catches into the stock assessment models.

3.231 The Scientific Committee recommended that the survey commence in 2016/17. Noting that the catch limits proposed by the survey proponents were lower than the catch limit suggested by the seabed analogy method, the Scientific Committee recommended 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, and that these limits were sufficiently precautionary to allow the survey to proceed in 2016/17.

3.232 Based on the stock hypothesis that the established fishery in Subarea 48.4 is likely to be the northern component of a larger stock of *D. mawsoni* distributed across Subareas 48.2 and 48.4, the Scientific Committee recommended that the catch limit for this survey area should be considered separate from the catch limit in the established fishery for *D. mawsoni* in Subarea 48.4.

Subarea 48.5

3.233 The Scientific Committee noted a Russian proposal for a three-year longline survey in the eastern region of the Weddell Sea (WG-FSA-16/15 Rev. 1). The survey proposed to collect biological data and undertake tagging to estimate the stock status of *D. mawsoni* in Subarea 48.5.

3.234 The Scientific Committee recalled Annex 5, paragraph 4.71, and noted that it had yet to have the opportunity to review an analysis it had previously requested (SC-CAMLR-XXXIII, paragraph 3.232; SC-CAMLR-XXXIV, paragraphs 3.271 and 3.272) on the catch rates in Subarea 48.5 observed in the surveys undertaken by Russia in 2013 and 2014.

3.235 The Scientific Committee further recalled that the situation with the Subarea 48.5 survey proposal has not changed since 2014 (SC-CAMLR-XXXIII, paragraphs 3.230 to 3.233), and that WG-FSA was still unable to evaluate this research proposal in its current or previous formats. The Scientific Committee referred to the discussions at WG-SAM-15 (SC-CAMLR-XXXIV, Annex 5, paragraph 4.10) recommending that the data concerned remain quarantined until such time that a complete analysis has been undertaken and submitted for consideration by WG-SAM, WG-FSA and the Scientific Committee.

3.236 Dr Kasatkina drew the attention of the Scientific Committee to a Commission background paper (CCAMLR-XXXV/BG/29 Rev. 1) on the matter of previous Russian survey activities undertaken in Subarea 48.5.

3.237 The Scientific Committee noted that this report (CCAMLR-XXXV/BG/29 Rev. 1) had not been presented to the Scientific Committee for consideration.

Dissostichus spp. in Divisions 58.4.1 and 58.4.2

3.238 The exploratory fisheries for *Dissostichus* spp. in Divisions 58.4.1 and 58.4.2 operated in accordance with CMs 41-11 and 41-05 respectively, along with associated conservation measures, in 2015/16. In 2015/16, the catch limit for *Dissostichus* spp. was 660 tonnes in Division 58.4.1 and 35 tonnes in Division 58.4.2. Fishing in Division 58.4.1 was conducted by three vessels using longlines, with the total reported catch up to 14 September 2016 of 402 tonnes. No fishing had been conducted in Division 58.4.2 to 14 September 2016. Details of these fisheries are contained in the Fishery Reports.

3.239 The Scientific Committee noted that five vessels, one each from Australia, France, Japan, the Republic of Korea and Spain, have notified their intention to participate in the exploratory fishery for *Dissostichus* spp. in Divisions 58.4.1 and/or 58.4.2 in 2016/17, and that WG-FSA-16 reviewed a joint research plan prepared by these Members (Annex 7, paragraphs 4.111 to 4.120).

3.240 The Scientific Committee noted that WG-FSA-16 had also reviewed papers on:

(i) the recent history of exploratory fishing in these divisions (WG-FSA-16/30)

(ii) diet composition of *D. mawsoni* inferred from fatty acid and stable isotope analyses (WG-FSA-16/06)

(iii) occurrence of perfluorinated compounds in muscle tissues of *D. mawsoni* (WG-FSA-16/07)

(iv) results of a PSAT study on *D. mawsoni* in the Mawson Sea (WG-FSA-16/08)

(v) an analysis of age and growth of *D. mawsoni* in Division 58.4.1 (WG-FSA-16/58).

3.241 The Scientific Committee discussed the merit in having a coordinated and/or centralised ageing program for *D. mawsoni* in the CCAMLR area, and considered potential mechanisms to facilitate the funding and implementation of such a program.

3.242 The Scientific Committee agreed that such a program is likely to facilitate the accumulation of *D. mawsoni* age data, and improve otolith reading consistency and precision across the CCAMLR area. The Scientific Committee suggested that the Secretariat work with interested Members in the intersessional period to develop a proposal for consideration by WG-FSA, the Scientific Committee and SCAF in 2017, to develop a centralised and/or coordinated ageing program for otoliths collected, particularly by Members without ageing capability. Such a proposal should include information about:

(i) the number of otoliths that would need to be processed and aged to meet the objectives of dependent research programs

(ii) an analysis of the likely costs to conduct the ageing

(iii) an evaluation of cost-recovery options

(iv) suitable institutions that could be commissioned to conduct the ageing

(v) the degree to which a coordinated and/or centralised ageing program could complement existing programs

(vi) strategies for the validation of age data and the use of reference sets.

3.243 The Scientific Committee also recalled a previous CCAMLR exchange program of otoliths, scales and bones of four Antarctic fish species (Kock, 1989) as an example of a validation ageing process.

Management advice

3.244 The Scientific Committee agreed that the research plan in WG-FSA-16/29 is appropriate to achieve the research objectives (listed in Annex 7, paragraph 4.116).

3.245 The Scientific Committee endorsed the recommendation from WG-FSA-16 (Annex 7, paragraph 4.118) that the new proposed research block 5841_6 be opened on an interim basis, with results to be reviewed by WG-SAM and WG-FSA in 2017.

3.246 The Scientific Committee recommended that the catch limits for these divisions remain unchanged for 2016/17 (Table 6), and supported the initial catch allocation scheme developed by the research proponents (Table 7). The Scientific Committee further recommended that the combined catch limit that was set for the Spanish depletion experiment and the Australian research in an overlayed grid survey in SSRU 5841G for 2015/16 (SC-CAMLR-XXXIV, Table 2) be applied to the proposed research block 5841_6, which has been designed around the previous research grid.

3.247 The Scientific Committee agreed that Members shall confirm whether they intend to pursue research by SC CIRC by 1 January 2017. If any Members are not able to confirm that they will pursue research, their allocation will be evenly redistributed amongst the other notifying Members that have confirmed they will pursue research. If any Members have not commenced research fishing by 28 February 2017, their allocation will also be evenly redistributed amongst the other Members that have commenced research fishing, or in another way agreed by all of these other Members.

D. eleginoides in Division 58.4.3a

3.248 The exploratory fishery for *D. eleginoides* in Division 58.4.3a operated in accordance with CM 41-06 and associated measures. In 2015/16, the catch limit for *D. eleginoides* was 32 tonnes and no fishing had been conducted to 14 September 2016. Details of this fishery and the stock assessment are contained in the Fishery Report.

3.249 The Scientific Committee noted that the variable timing of fishing in Division 58.4.3a towards the end of the fishing season can create a situation where the vessels can fish the catch limits for two fishing seasons back-to back within the same voyage. The Scientific Committee noted that:

(i) such a seasonal fishing pattern could cause a high fishing mortality on the fish stock within a short period

(ii) this should be considered when making assumptions about the timing of natural mortality and tag recapture within models that utilise tagging data

(iii) tagged fish were unlikely to mix between release in the first fishing season and recapture in the subsequent season.

3.250 The Scientific Committee recommended intersessional consideration of a monthly time step in tag-recapture models to estimate biomass that can account for variable timing of fishing and that a minimum period of time at liberty between tagging and recapture of fish should be introduced (such as the six months currently used in the toothfish assessment in Division 58.5.1). The Scientific Committee also recommended that further investigations on the implications of double fishing mortality in fish stocks during a short time be undertaken in the intersessional period, such that the potential for spatial and temporal concentration of fishing mortality can be considered when setting catch limits.

Management advice

3.251 The Scientific Committee supported the continuation of the proposed research in Division 58.4.3a and recommended that the catch limit for this division remain unchanged at 32 tonnes for 2016/17.

D. eleginoides Divisions in 58.4.4a and 58.4.4b

3.252 The Scientific Committee noted that one French- and one Japanese-flagged longline vessel had notified to conduct research fishing in Division 58.4.4b in 2015/16 under CM 24-01, with a research catch limit for *D. eleginoides* of 25 tonnes in research block 5844b_1 and 35 tonnes in research block 5844b_2 (SC-CAMLR-XXXIV, paragraphs 3.265 and 3.267). Fishing was conducted by both vessels, with the total reported catch up to 14 September 2016 of 35 tonnes.

3.253 The Scientific Committee noted that WG-FSA-16 had reviewed WG-FSA-16/33 Rev. 1 which presented the revised research plan for the 2016/17 toothfish fishery in Division 58.4.4b by Japan and France.

Management advice

3.254 The Scientific Committee supported the continuation of this research program and recommended that the catch limit for this division remain unchanged at 25 tonnes in research block 5844b_1 and 35 tonnes in research block 5844b_2 for 2016/17.

D. mawsoni in Subarea 88.3

3.255 The Scientific Committee agreed to one Korean-flagged vessel conducting research fishing in Subarea 88.3 in 2015/16 under CM 24-01, with a total research catch limit for *D. mawsoni* of 171 tonnes across five research blocks in 2015/16 (SC-CAMLR-XXXIV, paragraph 3.288). Research fishing took place in February and March 2016 with a catch of 106 tonnes of *D. mawsoni* (WG-SAM-16/29).

3.256 The Scientific Committee noted that WG-SAM-16 reviewed the results from research activities undertaken by the Republic of Korea (WG-SAM-16/29) and the proposal for continuation of this research (WG-SAM-16/11). No issues were identified with these submissions at WG-SAM-16.

Management advice

3.257 The Scientific Committee supported the proposal presented by Korea, and recommended its advice from 2015 (SC-CAMLR-XXXIV, paragraph 3.290) on this research proposal would remain in place such that the priority for research should be research blocks 883_3 (with a catch limit of 31 tonnes) and 883_4 (52 tonnes) given the previous tagging in those areas. Research block 883_5 (38 tonnes) would be a secondary priority, with research blocks 883_1 (21 tonnes) and 883_2 (29 tonnes) a tertiary priority, should ice conditions allow.

Dissostichus spp. in Subarea 48.6

3.258 The exploratory fishery for *Dissostichus* spp. in Subarea 48.6 operated in accordance with CM 41-04 and associated measures. In 2015/16, the catch limit for *Dissostichus* spp. was 538 tonnes. Fishing was conducted by two vessels using longlines, and the total reported catch up to 14 September 2016 was 240 tonnes. Fishing was carried out in research blocks 486_1 to 486_4, with the catch limit reached in research blocks 486_3 and 486_4. A total of 40 tagged *D. mawsoni* and four tagged *D. eleginoides* were recaptured, including eight between-season tag recaptures from research block 486_3 and 11 between-season tag recaptures from research block 486_4.

3.259 Japan, South Africa and Uruguay have proposed to conduct research fishing in Subarea 48.6 in 2016/17. The research proposals were reviewed by WG-SAM-16 (Annex 5, paragraphs 3.23 to 3.41) and WG-FSA-16 (Annex 7, paragraphs 4.79 to 4.86). The Scientific Committee noted that the research proponents had dropped research block 486_1 as requested by WG-SAM and would now focus on research blocks 486_2, _3 and _4 during 2016/17. Research fishing would now focus primarily on *D. mawsoni* which should be reflected in the target species of the conservation measure for this area.

3.260 The Scientific Committee welcomed the progress made on the development of a hypothetical life cycle for *D. mawsoni* in Subarea 48.6 and also on the development of a preliminary integrated assessment for research block 486_2 (Annex 5, paragraph 3.24 and Annex 7, paragraphs 4.87 to 4.89). However, it noted that it was difficult to forecast the time required to achieve a full stock assessment of the subarea and that the Commission should have a realistic expectation about how long this might take. It further noted that this needs to be taken into account when considering uncertainty and setting precautionary catch limits in these areas.

3.261 The Scientific Committee noted the prevalence of IUU fishing in this subarea in recent years and that WG-FSA-16 had discussed how to incorporate the uncertainty arising from the unknown IUU catches into the stock assessment model for research block 486_2 (Annex 7, paragraphs 4.88 to 4.91). It noted that the lack of knowledge about IUU catches had also limited the development of CASAL stock assessments in Divisions 58.4.3a and 58.4.4 (e.g. SC-CAMLR-XXXIV, Annex 7, paragraphs 5.25 to 5.30).

3.262 The Scientific Committee considered that this was a matter which needed to be addressed with some urgency and agreed that this would be a useful focus topic for WG-SAM-17. It requested WG-SAM consider the following questions:

(i) Can the likely estimates of IUU catches in these locations be bounded?

(ii) How can recent trends in stock size be used in management advice?

(iii) How can uncertainty in IUU be incorporated into the assessment?

(iv) Is there a precautionary harvest rate that can be used until a formal stock assessment can be carried out?

(v) How can progress be made from the estimation of toothfish biomass for a research block to the development of a stock assessment for an entire division or subarea, and is additional data required to facilitate this?

3.263 The Scientific Committee noted that the research proponents had indicated that a proposal to extend research block 486_2 and to develop a new research block on the continental shelf region would be submitted to WG-SAM-17 (Annex 7, paragraph 4.96).

3.264 The Scientific Committee recalled discussions held during the Scientific Committee Symposium concerning the desire to reduce the frequency of reviews of research plans (SC-CAMLR-XXXV/12) and recommended to have a stable research design throughout the entire period of a research program. It also recommended that WG-SAM-17 develop performance metrics for research plans against which the progress of a research plan is reported each year.

3.265 The research proponents informed the Scientific Committee that they will collaborate on their offshore and onshore activities. They also noted that their scientists would work collaboratively during the intersessional period and bring forward a coordinated multi-Member plan to WG-SAM-17. They noted that the 12 PSATs would be deployed across all four research blocks and would be programmed to pop up after one year.

Management advice

3.266 The Scientific Committee agreed that research in this subarea should focus on *D. mawsoni* in research blocks 486_2 to 486_5 and that the catch limits for 2016/17 for this subarea be brought forward from 2015/16. Specifically:

- research block 486_2 170 tonnes
- research block 486_3 50 tonnes
- research block 486_4 100 tonnes
- research block 486_5 190 tonnes.

3.267 The location of research blocks to be used in exploratory and research fishing in 2016/17 are shown in Figure 4.

Incidental mortality arising from fishing operations

4.1 The Scientific Committee noted a data collection framework suitable for use across different fisheries interacting with odontocetes (WG-FSA-16/09) providing basic guidelines for observer programs that are new to depredation data collection or who wish to expand their observation efforts and data collection. The Scientific Committee recommended that the Secretariat provide this guide as a reference on the CCAMLR website.

4.2 The Scientific Committee noted an update of depredation estimates in the fisheries around Kerguelen and Crozet Islands building on previous work using the CPUE method using a small-scale spatial cell grid to study spatial variation in depredation rates. It noted that this approach allowed the estimation of a catch loss time series in these fisheries for the first time and would prove useful for other fisheries in the future. Additionally, that an apparent decrease in fish losses due to depredation around Crozet Islands may be associated with the introduction of mitigation measures such as short lines, faster hauling times and strict move-on rules which would also prove useful in evaluating which management measures are most effective and inform management strategies in other fisheries.

4.3 The Scientific Committee noted that the Coalition of Legal Toothfish Operators (COLTO) held a workshop on depredation that brought together researchers, fishers and industry from Southern Ocean toothfish fisheries and the Alaskan sablefish fishery having experience in depredation from odontocetes. The workshop included discussion on longline fisheries mitigation methods, data collection and effects on stock assessments. Key outcomes included the establishment of a COLTO-funded postdoctoral fellowship to study depredation and depredation mitigation measures worldwide; the production of guidance documents on mitigation methods for stakeholders, and a collaborative framework for experimentally testing and scientifically evaluating mitigation methods. The Scientific Committee welcomed this collaboration and noted that such collective efforts were comparable with the successful approach used by the Working Group on Incidental Mortality Associated with Fishing (WG-IMAF).

4.4 The Scientific Committee encouraged continuing engagement in the CCAMLR Depredation e-group as a means to exchange information and for collaboration. The Scientific Committee thanked COLTO for initiating the workshop, acknowledging that it set a useful precedent and enabled an excellent conduit for effective exchange of information between industry and science.

4.5 The Scientific Committee noted WG-FSA discussions in response to a request from CCAMLR-XXXIV to report on the requirements of vessel-specific hook markings as a means of identifying the origin of recovered offal containing hooks, or hooks found in seabird colonies

(CCAMLR-XXXIV, Annex 6, paragraph 223; SC-CAMLR-XXXIV, paragraphs 3.86 and 3.87). Following discussions with those experienced in hook-marking schemes, fishing industry representatives and gear manufacturers, the paper concluded that the administrative, financial and implementation burden would be substantial while the issues of offal discarding and hooks in seabird colonies may still remain unresolved.

4.6 The Scientific Committee recommended that if there are issues with offal discharge as a compliance issue, then this would need to be addressed. However, hooks found in toothfish stomachs may not be definitively indicative of offal discharge as toothfish are apparently capable of 'grazing' along a longline, ripping hooks and bait off and thus ingesting hooks. Similarly, marine mammals may ingest hooks through depredation. Furthermore, hooks as part of clearly identified offal discharge have only been observed on a few occasions. The Scientific Committee acknowledged that feedback from scientific observers deployed in fisheries operating hook-marking schemes suggested that hook-marking had a positive effect on the behaviour of crew and their attitude towards offal management.

4.7 The Secretariat provided an update on incidental mortality of seabirds and marine mammals in CCAMLR fisheries during the 2015/16 season (up to 30 September 2016, Table 8).

4.8 The Scientific Committee noted information on fishing effort and seabird interactions reporting on two pre- and post-season extension trials in Division 58.5.2. One white-chinned petrel (*Procellaria aequinoctialis*) was caught during the new extension trial period (1−14 April 2016), and one grey-headed albatross (*Thalassarche chrysostoma*) was entangled in the streamer line during the trial period 15–30 April 2016. The Scientific Committee recommended that the trial be extended for another season and an update be provided to WG-FSA-17.

4.9 The Scientific Committee noted discussions during WG-EMM (Annex 6, paragraphs 2.23 to 2.25) and WG-FSA (Annex 7, paragraphs 6.46 to 6.49) introducing a new design for the use of a net monitoring cable in the trawl fishery (as described in WG-FSA-16/38). It noted that evolution of technology now presented advantages in the use of a net-monitoring cable such as much finer control over the fishing gear and the opportunities for increasingly sophisticated net monitoring activities.

4.10 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 Scientific Committee noted that the conditions and requirements for such a trial are set out in Annex 7, paragraphs 6.47 and 6.48.

4.11 The Scientific Committee discussed the requirement for the mandatory implementation of two streamer lines and noted that CM 25-02, Annex 25-02/A, specifically applies to longline fisheries and not trawl fisheries. It agreed that during krill trawling operations the following conditions are required during the trial, in order to monitor and mitigate potential interactions with seabirds and marine mammals:

(i) 100% observer coverage for the trial vessel(s)

(ii) the use of a camera monitoring system that records the full aerial length of the cable and the seaward entry point

(iii) the observer(s) conduct IMAF observations on the net monitoring cable twice daily, following the current standard warp strike observer protocols outlined in the SISO krill logbook instructions

(iv) the mandatory use of two streamer lines consistent with the objectives of CM 25-02, Annex 25-02/A, paragraph 1

(v) the ‘snatch block’ (WG-FSA-16/38) should be set so that the distance from the stern of the vessel to the point where the net monitoring cable enters the water is less than 2 m

(vi) that if there are more than three (3) ‘heavy’ bird strikes (www.ccamlr.org/node/74769) on the net monitoring cable, recorded during the warp strike protocol observations, then the vessel will remove the cable, this number of birds being consistent with the mitigation measures given in CMs 41-03 to 41-11.

4.12 The Scientific Committee agreed on the value of undertaking trials with different vessels, including with conventional trawl vessels and continuous trawl vessels. It recommended further discussions on the use of net monitoring cables at both WG-EMM and WG-FSA prior to wider use across the krill fleet.

4.13 The Scientific Committee recommended that the observers provide details of the system and effectiveness of protocols, including safety implications, in their cruise reports and this information be provided to WG-FSA. While the standardised protocols outlined are to be applied at the beginning of the trial, the Scientific Committee considered that observers should have the ability to adapt protocols, if required, to ensure effective data collection and safety are not compromised.

Marine debris

4.14 The Scientific Committee noted SC-CAMLR-XXXV/BG/21 and Annex 7, paragraphs 8.35 to 8.37, which report on the CCAMLR marine debris monitoring program (WG-FSA-16/18) indicating that overall, the occurrence of plastic debris on beaches and in seabird colonies remains an issue in the CAMLR Convention Area.

4.15 The Scientific Committee noted that the CCAMLR program of marine debris monitoring is land-based, and that fishing vessels and scientific observers also record fishing gear lost at sea. However, there was no at-sea monitoring of marine debris in the Convention Area and that this was a far-reaching issue.

4.16 The Scientific Committee also noted that the Southern Ocean Continuous Plankton Recorder (CPR) program from SCAR is part of the Global Alliance of Continuous Plankton Recorder Surveys (GACS) where discussions on the use of CPR for micro-plastics is carried out in a working group and this could provide a particularly important source of data for this work.

4.17 The Scientific Committee recommended that Members further develop collaborative programs for monitoring plastics in the marine environment, including collaboration with other groups (e.g. Committee for Environmental Protection (CEP), SCAR or International Association of Antarctica Tour Operators (IAATO)), in order to collect data which may be used to evaluate the likely impact of plastics on the growth and reproductive success of marine living resources in the Convention Area.

Spatial management of impacts on the Antarctic ecosystem

Bottom fishing and vulnerable marine ecosystems

5.1 The Scientific Committee noted that that there was one notification of a vulnerable marine ecosystem (VME) risk area in Subarea 88.1 during 2015/16, which brings the total number of VME risk areas to 76: 59 in Subarea 88.1, 16 in Subarea 88.2 and 1 in Division 58.4.1. The VME registry can be found at www.ccamlr.org/node/85695.

5.2 The Scientific Committee considered several updates on planned work to study VMEs with camera systems in Subareas 48.1, 48.3, 88.1, 88.2 and Divisions 58.4.1 and 58.4.2 and noted that an Australian vessel undertook a multibeam survey in the Heard Island and McDonald Islands (HIMI) region in 2015/16 to explore volcanic activity, where it detected deep-sea hydrothermal vents (which are considered VMEs). These vents occur in the area protected within the HIMI Marine Reserve.

5.3 The Scientific Committee noted discussions on VMEs during WG-EMM-16 (Annex 6, paragraphs 3.45 to 3.47), particularly in the context of papers submitted to WG-EMM on MPA planning and MPA research and monitoring.

5.4 The Scientific Committee noted the recommendation from WG-EMM that links to the VME registry could be provided in the annotated agendas of the Scientific Committee and its working groups, in order to provide ready access to this information during discussions.

Marine protected areas

Domain 1 – Western Antarctic Peninsula and Southern Scotia Sea

5.5 The Scientific Committee noted discussions during WG-EMM-16 on MPA planning in Domain 1 (Annex 6, paragraphs 3.15 to 3.23), including an informal workshop held on 9 July 2016. This informal workshop presented technical progress made by the planning group led by Argentina and Chile, as well as independent and complementary analyses undertaken by the UK and USA which validate the identification of priority areas for protection. WG-EMM welcomed the progress made, and encouraged all contributors to continue this work.

5.6 Dr M. Santos (Argentina) presented SC-CAMLR-XXXV/02, which noted that the Antarctic Peninsula and Southern Scotia Arc are of particular interest as one of the earth's regions most at risk from the impact of climate change. The paper described progress in conservation planning for this region, following two international workshops, and the analysis of data collected by several Members over the past several decades. International cooperation was highlighted as contributing to progress. It further suggested the establishment of a monitoring program for MPAs using standardised methods based on the CEMP, in which all Members were encouraged to participate. It recommended Members to participate in any stage of discussions with the aim of integrating different points of view and approaches in the selection of candidate MPAs in Domain 1. Dr Santos also expressed her gratitude to ASOC for its contribution to the Domain 1 MPA process in relation to capacity building on the use of systematic conservation tools.

5.7 The Scientific Committee congratulated Argentina and Chile for progress made in Domain 1 planning, based on international datasets covering more than three decades. It particularly welcomed the collaborative efforts and the focus on the impacts of climate change. The involvement of external expert groups, such as Integrating Climate and Ecosystem Dynamics in the Southern Ocean (ICED) and SOOS, was recommended. The Scientific Committee further noted that this region was subject to a number of human activities that must be taken into account as part of the MPA planning process.

5.8 The Scientific Committee also noted that the Domain 1 spatial planning activity coincides and overlaps with other Scientific Committee activities pertinent to this region, such as work on risk analysis for the krill fishery and on FBM. Datasets made available by the Domain 1 planning group could be used to support work in these areas. It was recommended that these activities be integrated, including input from the krill fishing industry.

5.9 Dr Kasatkina congratulated Dr Santos and her co-workers with progress in the process for the designation of an MPA in Domain 1. She noted that the MPA Planning Domain 1 project includes potential fishing grounds and current fishing grounds for the krill fishery and that, as such, it requires special attention. She also noted that the MPA Planning Domain 1 project includes significant areas in the Western Antarctic Peninsula and South Scotia Arc. She proposed that the MPA Planning Domain 1 project should be subdivided into several smaller areas for the further planning process.

South Orkney Islands MPA

5.10 The UK and Norway presented SC-CAMLR-XXXV/BG/28 which summarises research voyages in the South Orkney Islands region in 2015/16. It was noted that nine CCAMLR Members participated in these cruises, and that a significant amount of new data and analyses will be submitted to the Scientific Committee and its working groups as it becomes available. This information will be utilised in the next review of the South Orkney Islands MPA, which is due in 2019.

5.11 The Scientific Committee welcomed the recent research, noting that this information constitutes a progress report which will be incorporated into an MPA Report at the time of the next review.

5.12 Mr L. Yang (China) further raised the concern how to use the scientific data to assess whether the objectives of the MPA have been achieved in the review, without scientific criteria and baseline data.

5.13 Dr Trathan replied that the UK and its collaborators will ensure that the data are analysed and papers presented to WG-EMM and the Scientific Committee in advance of the next review.

Domains 3 and 4 – Weddell Sea

5.14 The Scientific Committee noted discussions during WG-EMM-16 on the development of a Weddell Sea MPA (WSMPA) (Annex 6, paragraphs 3.1 to 3.14), which included recommendations on further work, including the development of a toothfish potential habitat layer, updates to the cost layer and sensitivity analyses to assess a range of protection levels.

5.15 Prof. T. Brey (Germany) presented four scientific background documents in support of the development of an MPA in the Weddell Sea, submitted by Germany (SC-CAMLR-XXXV/01 Rev. 1, BG/11, BG/12 and BG/13). These papers include details of recent work to address the recommendations of WG-EMM-16.

5.16 The Scientific Committee noted that the scientific background to support the development of a WSMPA has been developed continuously during the last four years. The WSMPA scenario development followed the Systematic Conservation Planning approach (Margules and Pressey, 2000). Extensive environmental and ecological datasets (almost 50 000 data files) were compiled (SC-CAMLR-XXXV/BG/12) and analysed, covering a 4.2 million km^2 planning area. More than 70 data layers were produced using diverse modelling techniques and geographic information systems to obtain a representative picture of species' habitats or feeding grounds (SC-CAMLR-XXXV/BG/13). At the same time, general and specific conservation objectives and targets for protection were defined and prioritised with input from two international expert workshops. Finally, the identification of the most important areas for protection in the WSMPA planning area was accomplished using the conservation planning decision-support software Marxan, including a cost layer analysis. Sensitivity analyses have demonstrated that the core areas identified for protection remain stable under a range of conservation target scenarios. The scientific output, including significant contributions by several Members and Acceding States, is represented by 19 CCAMLR documents submitted to WG-EMM or Scientific Committee meetings (e.g. SC-CAMLR-XXXV/BG/11).

5.17 The Scientific Committee congratulated the authors of the four documents on the significant amount of work undertaken, particularly to address the recommendations from WG-EMM-16. The Scientific Committee agreed that the extensive information presented in the four documents (SC-CAMLR-XXXV/01 Rev. 1, BG/11, BG/12 and BG/13) is the best science currently available. It agreed that it provides the necessary foundation for MPA planning in this region, as well being useful for many other purposes. It noted that further work was required to develop these analyses and to identify how they are used in the development of a WSMPA proposal, and encouraged the continuation of this work.

5.18 The Scientific Committee noted the importance of separating scientific questions on the data and analyses relating to the development of the WSMPA proposal, from those relating to management issues. It therefore noted the following additional points for consideration by the Commission:

(i) future management of research fisheries within the proposed WSMPA, in relation to the target levels for protection of toothfish habitat

(ii) consideration of how the outputs of analyses (e.g. Marxan results) are used in the development of management proposals

(iii) consideration of the role that the Scientific Committee may play in developing criteria and indicators to measure the effectiveness of MPA management.

5.19 Dr Kasatkina introduced SC-CAMLR-XXXV/10. She noted that the proposal for the establishment of an MPA in the Weddell Sea described the species composition of fish fauna but there is no mention of the commercial potential of these fish species and future rational use. Russian data on biodiversity clearly showed there are populations of dominant fish species in the Weddell Sea that are of commercial importance or potential commercial importance: *D. mawsoni*, spiny icefish (*Chaenodraco wilsoni*), *P. antarctica* and Antarctic rockcod (*Trematomus eulepidotus*). Potentially commercial species, after further study, could be fished from the family Myctophidae (*Gymnoscopelus* spp.). Long-term surveys and research are needed in order to further determine the commercial potential of these fish species, as well as to assess their stocks and future rational use. She noted that a proposal for the establishment of an MPA in the Weddell Sea should be complemented by these materials. Dr Kasatkina further noted that data on the state of toothfish as an important component of the ecosystem were currently not available, and that habitat suitability model predictions for *D. mawsoni* and modelling the target level of protection for toothfish habitat requires the materials from research programs which should be undertaken in the Weddell Sea.

5.20 Dr Kasatkina noted that the Russian and Soviet research cruises showed that the area of the Antarctic continental slope and shelf inside the Weddell Sea (between 200°W and 300°E) that is proposed to be included in the MPA and may be a potential area for krill fishery in Area 48. Investigations of the krill resources in the Weddell Sea can be conducted by exploratory fisheries.

5.21 Dr Kasatkina noted that the proposed WSMPA boundaries include an area of 1.3 million km², but that this did not consider ice conditions and dynamics. She noted that MPA boundaries should be established in compliance with sea-ice conditions for vessel navigation being a fundamental factor for the successful completion of assigned research tasks in designated areas.

5.22 Dr Kasatkina noted that the wide research program and MPA boundaries require clarification of the research and monitoring plan with detailed descriptions in relation to the responsibilities for, and participation, in the research and monitoring plan. The operationalisation of the WSMPA research and monitoring plan includes two research cruises for research and monitoring activities during 10 years. It provides some grounds for doubt in relation of a proper implementation of assigned research tasks in designated areas. Dr Kasatkina noted that any criteria for assessing of implementation of assigned research tasks in designated areas were not provided in SC-CAMLR-XXXV/BG/11, BG/12, BG/13 and CCAMLR-XXXV/18.

5.23 Mr Yang thanked his German colleagues for providing the scientific background document in support of the development of a CCAMLR MPA in the Weddell Sea, which contains many layers of scientific data, and valued those documents as a good source to understand the Weddell Sea and its ecosystem. He reminded the Scientific Committee that the Scientific Committee has advised the Commission that the whole Convention Area is equivalent to a IUCN category IV MPAs, and the Convention Area is already protected by current conservation measures. Accordingly, the global goals stated in the scientific background documents as a purpose of the proposed MPA have already been met in the CAMLR Convention Area. He further suggested that, in accordance with Article XV of

CAMLR Convention, the establishment of criteria and methods to be used to conserve the biodiversity, and to assess whether the objectives of the proposed MPA have been achieved, as well as to assess the effects of proposed changes in the method, under the Convention with the objective to conserve the marine living resource, where conservation includes rational use, before the establishment of MPAs with such objectives by specific conservation measures. Mr Yang noted from the scientific background documents that the krill data is poor in this area, and many scientific data used in the documents are from a few research conducted in the 20th century, and questioned the rationale the proposed MPA to prohibited the fishing research on krill, the source of scientific data and information on krill for the consideration of the Scientific Committee. He noted that, as a result, China maintained concern on scientific justification of the proposed Weddell Sea MPA in that the potential threat from the consequences of large-scale climate and oceanographic change is low in at least 50 years, and on-site human activities are also low and under effective regulation, according to the background documents in support of the development of Weddell Sea MPA, in particular SC-CAMLR-XXXV/BG/11.

5.24 In response to the emphasis of best available scientific evidence contained in the background documents by several members, Mr Yang called to the attention of the Scientific Committee that the quality of the Scientific Committee’s advice is also an important issue to the Scientific Committee.

5.25 Dr Trathan and Prof. Brey recalled that the Commission had agreed that some areas warranted higher levels of protection and it is a Commission issue as to the level of protection that a particular area receives within the Convention Area.

5.26 Dr Godø noted during the deliberations regarding the Weddell Sea MPA that the Scientific Committee is not the forum for discussion of technical details, and asked the Chair for guidance as to whether the ongoing discussions should rather take place at WG-EMM. The Chair responded that specific scientific issues not properly covered should be revealed if this should take place.

5.27 Dr Godø made the following statement at report adoption:

> ‘We would like to highlight a procedural issue in our considerations of the Weddell Sea MPA proposal by our German colleagues. I would like to refer the Scientific Committee to paragraph 3.10 of the WG-EMM-16 report (Annex 6):
>
> “The Working Group recommended that information specifically on the design and objectives of the fisheries research zones be presented for consideration by WG-FSA and the Scientific Committee.”
>
> After conversations with the Convener of WG-FSA this year, it appears that this recommendation was not carried out and, as such, WG-FSA has not had the opportunity to evaluate the design and objectives of the fisheries research zones in the Weddell Sea MPA. Furthermore, reflecting back on our deliberations here at the Scientific Committee, we do not recall these issues being discussed this week.
>
> We would also like to highlight that there are existing datasets, whose existence have been raised on several occasions since the expert workshop held in Bremerhaven, Germany, in 2013 to the proponents of the Weddell Sea MPA proposal, that are not included in the analysis. These include extensive datasets on flying seabird movement

and demographics in Dronning Maud Land, and southern elephant seal migration and habitat usage of the Dronning Maud Land coast, as well as attendant oceanographic data collected from the same seals. There are also other archival materials from Domain 4 that never have been requested by the proponents.

We are not against this MPA proposal, but in light of the procedural issue and the exclusion of existing datasets that were known to the proponents of the Weddell Sea MPA proposal, we are not sure that best available science have been used, which lead us back to our original intervention (see preambular).'

5.28 Dr S. Hain (Germany) thanked Norway for its statement and clarified some issues:

'Firstly, as already noted during the deliberations of the Scientific Committee this week, we have to distinguish between matters which should be addressed by the Commission and matters which should be addressed by the Scientific Committee. The issue raised by Norway as regards the design and objectives of the fisheries research zones is related to the actual proposal for the Weddell Sea MPA, which will be discussed by the Commission next week.

The issue mentioned by our Norwegian colleagues with respect to datasets, which apparently have not been taken into account in our analyses, comes as a surprise to us. Germany has over the last four years done its upmost to make the process of developing the background documents as transparent as possible. The chapters on flying seabirds and seals have been in the versions of the background document for some time.

We repeatedly asked all Members for relevant data, held two international workshops, maintained a CCAMLR e-group and presented over 19 documents to CCAMLR and the relevant CCAMLR working groups over the last years. The chapters on flying seabirds and seals have been in the versions of the background document for some time, so it is very surprising to me that the omission of data had not been mentioned by our Norwegian colleagues directly to our scientists or at one of the several meetings we had, such as WG-EMM this year.

We will be happy if Norway provides us with additional data and, of course, we will add those data when further developing the proposal for a Weddell Sea MPA conservation measure. The agreement by the Scientific Committee, that the background document is the best science currently available, does not mean that our scientific work will stop. We are very well aware that the measures suggested in the draft Weddell Sea MPA conservation measure have to be scientifically sound and we will ensure that all the relevant experts of all CCAMLR Members will be able to look at the scientific background of these measures.'

Domains 5 and 6 Crozet–Del Cano and Kerguelen

5.29 Prof. P. Koubbi (France) presented an update concerning the extension of the actual natural reserves in the EEZ of Crozet and Kerguelen. The project, which has been validated by the French Minister of Environment, Energy and Seas, is currently under evaluation by the other French ministries and concerns about 250 000 km² for Crozet and 387 000 km² for Kerguelen.

5.30 The ecological analyses presented at WG-EMM indicate that two high-seas areas should be considered to cover the whole range of important bird and marine mammal areas for populations living on both islands. It was noted that climate change will be important to consider as the sub-Antarctic zone will be one of the areas of the Southern Ocean that will be the most impacted by future changes. These areas are:

(i) the area of the Antarctic Polar Front in the South of the Crozet EEZ (Planning Domain 5) where most of Crozet king penguins (*Aptenodytes patagonicus*) are foraging

(ii) the second at the east of the Kerguelen EEZ (Planning Domain 6), an area important, for example, for the foraging of elephant seals.

5.31 The Scientific Committee approved the continuation of research in both sectors based on the pelagic ecoregionalisation and essential areas for top predators. South African, Australian and Indian scientists indicated their willingness to collaborate on this project.

5.32 An e-group on Indian Ocean sub-Antarctic spatial planning has been created on the CCAMLR website, and the Scientific Committee encouraged other Members to participate in the development of the scientific elements for a proposal for designating future pelagic MPAs in the Indian Ocean sub-Antarctic zone of the Southern Ocean.

Domain 8 – Ross Sea

5.33 The Scientific Committee noted discussions during WG-EMM-16 on the Krill Research Zone (KRZ) proposed as part of the Ross Sea region MPA (Annex 6, paragraphs 3.38 to 3.44). It noted that the potential importance of this area to krill and krill predators presents an important opportunity for research.

5.34 The proponents of the Ross Sea region MPA noted that a workshop should be held in the year following adoption of the proposal in order to develop a research and monitoring plan, to include krill research.

Progress on MPA planning

5.35 The Scientific Committee agreed that it would be helpful to compile a table summarising progress and activities being undertaken on MPA planning in each of the MPA planning domains. This information is presented in Table 9.

5.36 ASOC presented CCAMLR-XXXV/BG/26, which examines the progress made to date in the establishment of a representative system of MPAs in the CAMLR Convention Area. For over a decade CCAMLR has been discussing the adoption of MPAs in the CAMLR Convention Area. There was some progress on the adoption of a representative system of MPAs up until 2011, and despite CCAMLR's inability to reach consensus on the adoption of any MPA proposal under discussion since that time, work has continued in other domains. This is a welcome development. However, the proposed MPAs for East Antarctica and the Ross Sea have been diminished in size and in other ways, reflecting a decrease in conservation ambition. In addition, the concept of what an MPA is or does and how it relates to fisheries research and fishing generally has also been compromised. MPAs are intended to be a conservation and biodiversity protection tool, not a fisheries management tool. Unfortunately, MPA discussions at CCAMLR have too often focused on protecting access to fisheries rather than on protecting biodiversity.

5.37 CCAMLR-XXXV/BG/26 made a series of recommendations to CCAMLR. The overall recommendation is that CCAMLR should not further delay in adopting a representative system of MPAs across the nine planning domains, and in doing so ensure that the protection, scientific research and climate change objectives of CM 91-04 are achieved. Responsibility for ensuring that these objectives are achieved rests with each and all of CCAMLR Members. In line with its 2009 commitment, CCAMLR Members must adopt meaningful MPAs across the nine planning domains, starting at this meeting. In line with CM 91-04, these MPAs must be robust, large, representative and ecologically significant, and without any time restrictions. In conclusion, CCAMLR should avoid a continued dilution of ambition, and a clear example of that is duration and these MPAs should be in place for an indefinite period of time. The past few months have seen significant moves globally in the designation of large fully protected MPAs and we hope CCAMLR will follow suit.

5.38 Prof. Koubbi recalled the priority of CCAMLR to create a representative system of MPAs and asked the Scientific Committee to encourage short- and medium-term regional assessments in each planning domain that need to be conducted. This assessment should summarise advances in each planning domain and give an estimation of the consequences of climate change on biodiversity and marine resources. Prof. Koubbi proposed creating an expert group which can work intersessionally with other organisations to achieve this goal.

IUU fishing in the Convention Area

6.1 The Scientific Committee noted the WG-FSA-16 discussion on IUU fishing activities (Annex 7, paragraphs 3.1 to 3.4) and, in particular, noted that there had been an increase in the detection of IUU activities in Subarea 48.6 in the last three years, in particular in research block 486_3 in the area on Maud Rise, and the first detection of IUU activity in Subarea 48.2. In addition, the Scientific Committee noted that the ongoing investigation of IUU catch recovered from the vessel *Andrey Dolgov* (see COMM CIRCs 16/47, 16/54, 16/62 and 16/77) had been identified as *D. mawsoni* and, therefore, was considered likely to have come from within the Convention Area.

6.2 The Scientific Committee also noted that information on IUU removals was important, in particular where IUU catches were likely to form a substantial part of the overall removals from an area, as it was necessary to include those IUU catches into a stock assessment so that an estimate of B_0, and hence stock status, could be estimated (Annex 7, paragraph 4.92).

CCAMLR Scheme of International Scientific Observation

7.1 The Scientific Committee considered the krill sampling design paper discussed by WG-SAM (WG-SAM-16/39) and the advice given by WG-EMM (Annex 6, paragraphs 2.50 to 2.55). The WG-EMM Convener clarified that the recommendations outlined in Annex 6, paragraph 2.53, were for the consideration of WG-EMM and WG-SAM.

7.2 The Scientific Committee considered the formation of a dedicated SISO Working Group, recommended by WG-FSA, noting that SISO requirements are relevant to a number of working groups and that changes in data forms and instructions to observers are often delayed (Annex 7, paragraphs 5.1 to 5.14). It was proposed that the development of terms of reference for this group should include a review of the recommendations from the previous SISO review (SC-CAMLR-XXXII/07 Rev. 1).

7.3 The Scientific Committee considered the matter of observer coverage in the krill fishery discussed by WG-EMM. WG-EMM-16/63 advocated for 100% observer coverage to potentially reduce uncertainties in *E. superba* stock status, while WG-EMM-16/11 followed the request of WG-EMM-15 (SC-CAMLR-XXXIV, Annex 6, paragraph 2.34; SC-CAMLR-XXXIV, paragraph 7.5) and produced a metric of fishing days with an observer on board to describe actual levels of observer coverage in the krill fishery.

7.4 There was an extensive discussion between Members on the desired level of observer coverage in the krill fishery and the objectives that would be achieved by having 100% observer coverage. Several Members noted that there were questions regarding the distribution of krill predators, changes in the geographic operations of fleet, risk analysis for MPA proposals and FBM considerations that may potentially be answered by mandatory observer coverage.

7.5 Dr Zhao noted that current observer coverage in the krill fleet is very high (92%) (WG-EMM-16/11) and considered that it was more important to focus on the quality of the data being collected rather than the quantity. Due to their vessels being at sea for up to eight months at a time, China has a policy of a minimum of two observers on its vessels to ensure high data quality. Dr Zhao also noted that 100% coverage is not necessary as observer data has considerable geographic overlap due to vessels conducting their activities in close proximity.

7.6 The Scientific Committee noted an additional recommendation from WG-EMM requesting information on what is preventing some vessels from reaching 100% coverage and suggested this be carried through as a recommendation to the Commission. It also noted that there were issues related to the Standing Committee on Implementation and Compliance (SCIC) for which observer coverage is necessary and that having coverage lacking in some vessels increases the overall risk.

7.7 The Scientific Committee noted that although progress has been made in the management of the krill fishery, without sufficient data the expansion of the krill fishery could not be efficiently managed. This would be an impediment to FBM and the development of the fishery.

7.8 Dr Kasatkina noted that an analysis of gear type effects on catch rates had not been undertaken and considered this to be in the size of the species catches an important factor in krill dynamics. Dr Kasatkina proposed to research the statistical characteristics of the size and species composition of catches paying special attention to inter-vessel variability of these characteristics when vessels are operating in the same area of the fishery.

7.9 The Scientific Committee encouraged an analysis of observer data from krill fishing vessels that are in close proximity as this may provide clarity on differences in fishing gear and also assist in the design of observer sampling in the krill fishery.

7.10 The Scientific Committee noted the discussion at WG-EMM on the abundance of salps and their correlation with other environmental indicators and endorsed their recommendation that observers record whether they were present or absent in the 25 kg samples collected for analysis of finfish by-catch (Annex 6, paragraphs 2.85 to 2.90).

7.11 The Scientific Committee noted that so far observer data have not been used for setting catch limits for the spatial and temporal operation of the krill fishery and furthermore there is no specific proposal to use the data. Meanwhile, recently krill fishing vessels changed their operation pattern drastically but reasons why they did so remain unknown. Understanding fishing vessels behaviours is an important component for development of FBM. Therefore, current scientific observer program should be improved to be useful for krill fishery management.

7.12 Dr Watters noted that the quality of observer data and the level of observer coverage were separate issues and it was desirable to have maximum levels of both. He also commented that if lack of observers was preventing 100% observer coverage on vessels, then international observers could be employed to fill any gaps and offered an observer for deployment on Chinese krill vessels. Dr Zhao thanked Dr Watters for his offer which will be discussed intersessionally.

Climate change

8.1 The Scientific Committee noted discussions during WG-EMM-16 on the topic of climate change and related data collection and information exchange, including the development of priority questions relating to climate change (Annex 6, paragraphs 6.8 to 6.28).

8.2 Co-conveners Drs Grant and Penhale introduced SC-CAMLR-XXXV/07, which reported on the second Joint SC-CAMLR–CEP Workshop, held in May 2016 in Punta Arenas, Chile, immediately prior to the Antarctic Treaty Consultative Meeting (ATCM) 2016. The excellent support of the Chilean hosts of the workshop was noted by the Co-conveners as they introduced the paper, which included the Co-conveners' report of the workshop, as well as a summary of discussions held at the CEP in Santiago, Chile, and also at WG-EMM-16 in Bologna, Italy.

8.3 Members of the CEP agreed that the Joint SC-CAMLR–CEP Workshop had been valuable in further enhancing cooperation and information sharing between the two committees on climate change, environmental monitoring and other matters of mutual interest. It welcomed the report and endorsed the recommendations arising, particularly recommendations for increased cooperation among the CEP, SC-CAMLR and SCAR and their subsidiary bodies.

8.4 WG-EMM also agreed that the workshop had been a productive and valuable opportunity to share information and consider issues of common interest. It discussed a range of topics arising from the workshop, including:

(i) development of enhanced links with SCAR and related programs, including ICED and SOOS, to aid in the work of the Scientific Committee

(ii) data and information exchange, including the utility of CEMP data in climate change research

(iii) the CEP's Climate Change Response Work Program (CCRWP), presented in Table 3 of the WG-EMM-16 report (Annex 6), which identifies relevant questions, activities and tasks. This document may be useful in the development of the Scientific Committee work plan

(iv) recommendation 2 from the workshop, which discussed the development of priority questions in relation to climate change. The Working Group identified three initial questions related to potential changes in the krill population and the accessibility of krill fishing areas over the next 2–3 decades and noted that further information from SCAR, ICED, SOOS and others would assist in addressing these questions.

8.5 The Co-conveners, in considering the joint workshop report and subsequent advice from WG-EMM, suggested that the Scientific Committee could focus on further discussion of:

(i) recommendations 1 to 4 on interactions with SCAR and related programs, and the subsequent WG-EMM discussions on the articulation of key questions, and mechanisms for improved dialogue and collaboration

(ii) recommendations 5 to 7 on practical mechanisms for enhanced cooperation between SC-CAMLR, CEP and SCAR, including the engagement of appropriate and relevant experts

(iii) recommendations 8 to 10 on data access and data sharing, and the subsequent WG-EMM discussions on information exchange, metadata and standard datasets.

8.6 The Scientific Committee congratulated the Co-conveners for their work in preparing for, and conducting, the workshop and noted that the workshop report provided useful guidance as the Scientific Committee plans its program of work in coming years. The workshop discussions were seen to highlight the importance of collaboration among the CEP, SC-CAMLR and SCAR to advance progress in the area of climate change and associated research and monitoring. Discussions at WG-EMM and in the margins of the SCAR Open Science Meeting progressed the themes of the workshop. The Scientific Committee endorsed the recommendations from the joint workshop report.

8.7 The CEP Chair, Mr E. McIvor, expressed his thanks to the Co-conveners of the joint workshop, as well as to the Chilean hosts of the workshop, the members of the CEP and SC-CAMLR, and representatives of external bodies who participated in the workshop. He noted that the CEP had earlier endorsed all workshop recommendations and has taken steps for implementation. An important aspect of the CEP's work will be how to manage and implement the CCRWP and how to increase collaboration and communication with SCAR and SC-CAMLR.

8.8 It was noted that the joint workshop recognised that the Antarctic Environments Portal (www.environments.aq), developed through collaboration among a number of Antarctic Treaty countries and SCAR, was an important means of bringing the best available research knowledge to the attention of Antarctic policy makers. The portal provides independent scientific summaries of new or emerging issues. All scientific information available through the portal is based on published, peer-reviewed science and has been through a rigorous editorial process. The committee was encouraged to make further suggestions for topics to be included in the portal.

8.9 The Scientific Committee highlighted further collaboration with SCAR with regard to exchange of metadata pointing to various datasets provided through SCAR efforts such as the Antarctic Master Directory.

8.10 Dr Grant introduced CCAMLR-XXXV/13 Rev. 1 on the draft conservation measure proposal which aims to promote and facilitate scientific research in newly exposed marine areas following ice-shelf retreat or collapse around the Antarctic Peninsula. Dr Grant noted that the proposal by the EU and its Member States was considered by the Scientific Committee and the Commission in 2015. The proposal was agreed by most Members at that time to have scientific merit, and to be an appropriate and practicable response to an important issue that was originally identified at the 2010 Antarctic Treaty Meeting of Experts on Climate Change.

8.11 In response to specific requests for clarification raised by the Scientific Committee and Commission in 2015, suggested improvements to the proposed mechanism of establishing Special Areas were presented and discussed at WG-EMM (Annex 6, paragraphs 3.48 to 3.52). Dr Grant outlined the changes made in response to Members. First, the definitions of ice-shelf collapse and retreat have been clarified in the proposed conservation measure. Additionally, the proposed conservation measure also sets out a new two-stage process for establishing Special Areas for Scientific Study. An initial two-year period (stage 1) would begin immediately following notification of a collapse or retreat. The available data and proposed boundaries would then be considered in detail by WG-EMM and the Scientific Committee. Once agreed by the Commission, the proposed Special Area would be established for a 10-year period (stage 2), and its details appended to the conservation measure as an annex. However, if no agreement is reached after the initial two-year period, then the stage 1 Special Area would expire.

8.12 During both stage 1 and stage 2, the same provisions would apply, including a moratorium on fishing activities, except for scientific research fishing activities undertaken in accordance with the conditions set out in the draft conservation measure.

8.13 Dr Grant concluded by noting that the adoption of the proposed conservation measure would provide a valuable mechanism to facilitate scientific research, including research fishing as appropriate, to improve an understanding of marine habitats and processes in newly exposed areas. Dr Grant welcomed views of the Scientific Committee on the scientific aspects of the revised proposal, and encouraged the Scientific Committee to consider recommending adoption of this conservation measure by the Commission.

8.14 A number of Members thanked Dr Grant for addressing questions that arose in discussions over the past year and stated that they saw no further scientific issues that needed to be addressed prior to discussion in the Commission. The importance of monitoring was addressed, with the observation that fishing vessels could provide important data in areas following ice-shelf collapse or retreat. It was noted that techniques such as bottom surveys using cameras on longlines, collection of temperature profiles, etc. conducted by fishing vessels under agreed controls could add data that is often difficult to collect by scientific programs.

8.15 Several administrative issues were raised in discussion. These included questions on how to address a case in which continued collapse or retreat occurs within stages 1 or 2 of the period of scientific study, on how an areal extent component could be incorporated into the definition of collapse, and whether further baseline mapping of individual ice shelves would improve the process.

8.16 The Scientific Committee agreed that such questions may fall into the category of administrative issues, which were better dealt with by the Commission. It agreed to forward the proposal to the Commission.

8.17 ASOC, noting the clarifications provided by Dr Grant in response to questions posed in the past year, expressed its support for the proposed conservation measure, in that it provided an important opportunity to conduct research directly related to climate change and was a concrete example of CCAMLR taking action to address climate change in the Convention Area.

8.18 Oceanites Inc. presented CCAMLR-XXXV/BG/14, which described the outcomes of the first Future of Antarctica Forum that Oceanites convened and held from 28 February to 9 March 2016 in the Antarctic Peninsula. Participants included representatives from government and the tourism and fishing industries, all of whom actively engaged in discussions that noted the importance of distinguishing the direct and interactive effects of climate change, fishing, tourism and national operations on ecosystems in the Antarctic Peninsula region for improved environmental management. Noting that the 22 years of data collected through the Oceanites’ Antarctic Site Inventory (ASI) project was an important database to underpin studies of climate change, Oceanites accepted the challenge of establishing a new, international interdisciplinary effort to examine these interactive effects. This work will advance by ongoing ASI data collection, continued development of the Mapping Application for Penguin Populations and Projected Dynamics tool (MAPPPD), collaborations with Stony Brook University and Oxford University, and with Aker BioMarine to independently analyse the company’s krill fishing catch/effort data vis-a-vis data on penguin breeding/foraging locations and climate change impacts in the Antarctic Peninsula.

8.19 Oceanites also introduced CCAMLR-XXXV/BG/15, which reported on the MAPPPD project which aims to provide a common platform of data on Antarctic penguin abundance and distribution that includes traditional field surveys but also leverages the increasing use of satellite imagery for population assessment. MAPPPD includes a database for Adélie, gentoo, chinstrap and emperor penguins, as well as an initial population model developed for Adélie penguins. When complete, it will include population models for all four of these species, tools for multiple population models to be compared, and the generation of ensemble model forecasts. Members were informed that MAPPPD would be demonstrated in the margins of the Scientific Committee meeting and encouraged those with additional datasets to contribute to MAPPPD efforts. These data and their population models will be available for review by the Scientific Committee.

8.20 The Scientific Committee complimented Oceanites. for the work presented in its two papers and noted that the ASI includes an extensive set of observations that will complement

CEMP sites. Noting that the ASI sites are areas not often studied by national programs, the decades-long population data is of particular interest. The publicly available nature of MAPPPD was viewed positively by Members. Responding to a question as to whether MAPPPD planned to develop regional population models, Oceanites responded that MAPPPD is a tool that would allow for regional models, but that funding constraints may preclude such model development. Regardless, MAPPPD models will be available online, and new models can be uploaded into the MAPPPD website.

8.21 Dr Constable, on behalf of Australia and Norway, briefly introduced CCAMLR-XXXV/BG/22 which presented the initial results of the Intersessional Correspondence Group (ICG) which considered approaches for enhancing consideration of climate change impacts in CCAMLR. He noted that a discussion of the ICG results, which drew heavily on the Joint SC-CAMLR–CEP Workshop and subsequent discussions in the CEP and in WG-EMM, would be held in the margins of the meeting. The ICG is planned to continue during the 2016/17 intersessional period.

8.22 ASOC introduced CCAMLR-XXXV/BG/24 which provided comments and recommendations related to the Joint SC-CAMLR–CEP Workshop. ASOC, noting that the workshop was timely and important, supported the recommendations arising from the workshop and encouraged the Scientific Committee to begin implementing them at this meeting through the development of a climate change response work plan by 2018, close collaboration with the CEP and SCAR (including a request that SCAR submit climate change updates to SC-CAMLR), making CEMP and other CCAMLR data more accessible to the broader community, linking discussions on climate change to work in the MPA context, developing a response to ocean acidification, and encouraging fishing vessels to assist in data collection in the Southern Ocean.

8.23 The Scientific Committee referred to discussions in WG-EMM which addressed the development of key questions related to climate change (Annex 6, paragraphs 6.22 to 6.28 and Table 3), which could be addressed in collaboration with the CEP and SCAR, ICED and SOOS, including participation in future workshops such as the Third International Krill Symposium and the ICED Workshop both to be held in 2017.

8.24 It was noted that issues not addressed by WG-EMM included climate change impacts in a spatial sense, such as the identification of hotspots in the Southern Ocean where climate change impacts are expected to be greatest. The Scientific Committee was encouraged to develop timelines for work in the short/medium/long periods, including an update of status and trends of marine species and food webs, so that timely advice can be provided to the Commission. Such work could provide valuable input to the 2018 Marine Ecosystem Assessment of the Southern Ocean Conference.

Scientific research exemption

9.1 The Scientific Committee noted that advice on research proposals for longline research surveys for *Dissostichus* spp. is provided in paragraphs 3.220 to 3.266. Scientific research exemptions for trawl surveys are considered below.

Subareas 48.1 and 48.2

9.2 The Scientific Committee noted five papers tabled at WG-FSA-16 that reported on the results and proposal for a Chilean research survey around Elephant Island and the South Orkney Islands in Subareas 48.1 and 48.2, which included the results of a hydroacoustic survey, analysis of bird assemblages, analysis of spawning patterns of notothenioids, a report on a cetacean survey, and a proposal for the continuation of research on fish distribution in 2016/17 around Subareas 48.1 and 48.2.

9.3 It was noted that there were proposed changes made to the proposal during WG-FSA-16, but that these changes lacked clarity in rolling over catch limits which were set based on the particular design of the research plan, the long-term objectives of the research and their relevance to CCAMLR work, as well as concerns about spatial scale in which the research is proposed to be conducted.

9.4 The Scientific Committee thanked Chile for presenting the revised plan and recommended that a further revised research plan addressing the aforementioned issues be presented to WG-SAM-17 and WG-FSA-17 for a full re-evaluation, due to the limited time available to investigate various changes that have been made to the plan.

9.5 In recalling the results of the trawl survey undertaken by Chile in 2015/16, the Scientific Committee noted the wide disparity in the proposed sampling design (WG-SAM-15/12) that was agreed by the Scientific Committee (SC-CAMLR-XXXIV, paragraph 9.1) and the location of the stations subsequently carried out during the survey (WG-SAM-16/19). It was emphasised that all proposed survey designs should be carried out as specified unless there are logistical constraints, such as icebergs, that prohibit completing the planned sampling design.

9.6 The Scientific Committee requested that the Commission provide advice as to how to address situations in which there is a considerable deviation between the agreed research plans and what is subsequently carried out.

Subarea 48.3

9.7 The Scientific Committee noted the proposal by the UK for a randomised stratified trawl survey in Subarea 48.3 during January/February 2017 that had been distributed as SC CIRC 16/60.

Division 58.5.2

9.8 The Scientific Committee noted that Australia intends to conduct its annual randomised stratified trawl survey in Division 58.5.2 in 2017.

Cooperation with other organisations

CEP

10.1 The CEP Observer to SC-CAMLR presented SC-CAMLR-XXXV/BG/09 as part of an annual update that covers five areas of mutual interest identified in the second Joint CEP–SC-CAMLR Workshop (held from 23 to 27 May 2016 in Santiago, Chile) (paragraphs 8.2 to 8.8). The CEP reviewed the CCRWP and noted the actions taken and increased cooperation by SCAR, SC-CAMLR, national Antarctic programs and other relevant organisations related to research and monitoring. The CEP also reviewed issues relating to spatial management and ecosystem and environmental monitoring, discussing progress on a method for assessing the sensitivity of sites to tourism and the use of unmanned aerial systems for ecosystem monitoring. Additionally, as the lead body on non-native species, the CEP is updating a non-native species manual to identify and prevent arrival of non-native species, contributed by the Intersessional Contact Group and found at www.ats.aq/documents/recatt/att608_e.pdf.

10.2 The Scientific Committee thanked the CEP Observer for the presentation and noted that its five-year work plan divided into themes would be a useful template for the Scientific Committee's strategic plan. It was also suggested that a reference to CCAMLR's contribution to the CEP be included in its plan and vice versa so that tasks in areas of joint interest can be identified.

10.3 The CEP agreed to work with the Scientific Committee in order to identify linkages in the work of the two communities and to increase efficiency related to such work.

SCAR

10.4 Prof. M. Hindell, the SCAR Observer, presented SC-CAMLR-XXXV/BG/26 and made the following statement:

> 'SCAR and CCAMLR have a long history of cooperation, and have recently met on several occasions to strengthen the relationship by identifying current questions of mutual interest. The importance of mutually beneficial interactions and information exchange was reaffirmed at meetings of the two groups at the Joint CEP–SC-CAMLR Workshop on Climate Change in Punta Arenas, Chile (see SC-CAMLR-XXXV/07), and less formally at the recent SCAR Open Science Conference held in Malaysia. Additionally, this year SCAR has four visitors to SC-CAMLR.
>
> The effective engagement between SCAR and CCAMLR was highlighted at WG-EMM-16, with papers presented by several SCAR subsidiary bodies and affiliated groups. While there is a diverse range of SCAR research currently underway that is relevant to SC-CAMLR, here we restrict our focus to a few key areas, with an emphasis on those that have been identified as priorities or key areas of interest. Some of the more relevant outputs and/or activities include the development of priority variables for observing dynamics and change in the Southern Ocean, a broad-scale analyses of Antarctic animal tracking data, a research voyage around the South Orkney Plateau, Southern Ocean ecosystem dynamics and environmental change, changes in macro-zooplankton populations in the West Antarctic Peninsula and analyses of past and future melting Antarctic ice sheets.

WG-EMM-16 identified several important areas of research and articulated some specific research questions, with climate change related research and krill population dynamics emerging as key areas of interest. Here we provide three examples of recent research activities that have considerable potential to assist and inform discussion and decision-making in SC-CAMLR:

(i) The Retrospective Analyses of Antarctic Tracking Database, an initiative led by the SCAR Birds and Marine Mammals Expert Group, with international partners, has brought together tracking data from 38 biologists from 11 different countries to accumulate the largest animal tracking database in the world.

The importance of this work in relation to krill population modelling has already been recognised at the recent WG-EMM-16 meeting. Although this initiative is still in the relatively early stages of data collation, ongoing data analyses will be undertaken in the context of CCAMLR statistical subareas, allowing areas with good data coverage to be identified. This will assist CCAMLR Members to identify areas in the future that might benefit from further research. RAATD has recently secured French-based funding to develop these data and associated analyses through biannual workshops for the next 2.5 years and will continue to keep SC-CAMLR informed of progress.

(ii) Trends in summer abundance of major taxa of macro-zooplankton, including krill, along the Western Antarctic Peninsula over two decades (1993–2013), and their relationship with environmental parameters, have now been comprehensively assessed (Steinberg et al., 2015). This assessment was divided into three areas, north, south and far south, all of which occur in CCAMLR Statistical Subarea 48.1.

Understanding krill population dynamics is a key area of interest for management of the krill fishery. These long-term data are from CCAMLR Statistical Subarea 48.1, an area that is not only important for krill fisheries, but also for other stakeholders. In this context these data can potentially assist with integrated management of the region, and assist CCAMLR Members in their decision-making. The study also identifies important links to environmental variables.

(iii) Antarctica could contribute to up to 1 m of global sea level rise by 2100, and over 15 m by 2500 if global CO_2 emissions maintain their current trajectory. Much of this sea-level rise will come from the ice sheets that form the boundary between Antarctica and the Southern Ocean. Predicted changes include the loss of ice shelves, thinning and retreat of glaciers and massive meltwater production on ice sheet surfaces by mid-this century. Over longer time periods, this study also predicts the loss of extensive areas of ice sheet and the eventual collapse of the West Antarctic Ice Shelf within 250 years.

The implications of these predictions are likely to be dramatic. Ocean warming, melting ice sheets and the altered ocean chemistry associated with these changes will affect Southern Ocean ecosystems, fish stocks and habitat available across all CCAMLR statistical subareas. This reinforces the importance of research into the links between species targeted by fisheries and environmental parameters associated with a changing climate.’

10.5 The Scientific Committee thanked SCAR for its report and commitment to working with CCAMLR, noting that the report contained useful updates on SCAR's extensive range of activities relevant to the work of the Scientific Committee.

10.6 The Scientific Committee suggested that in developing a strategic work plan for the Scientific Committee and its working groups, there is a reference to relevant SCAR activities when appropriate.

10.7 SCAR informed the Scientific Committee that the SCAR Biology symposium to be held in Belgium (10 to 14 July 2017) next year could incorporate CCAMLR-related workshops surrounding the meeting.

Reports of observers from other international organisations

COLTO

10.8 SC-CAMLR-XXXV/BG/23 summarised the first depredation workshop held by COLTO. The workshop brought together researchers, fishers and industry representatives from Southern Ocean toothfish fisheries and the Alaskan sablefish fishery with experience in depredation from odontocetes.

10.9 The workshop resulted in an enhanced understanding on the current state of depredation in toothfish fisheries, as well as a vision of what is required in the short to medium term to better understand and evaluate depredation. Such requirements include a standardised base set of data collection so that, in the future, data can be analysed and compared between geographic locations.

10.10 The reliable monitoring of depredation and non-depredation events appeared as the most important task to be implemented, with additional key data to collect including the number of depredating whales and photo-identification data, potential deployment of satellite tracking devices on whales and the use of acoustics to monitor depredation events.

10.11 The Scientific Committee thanked COLTO for its work on depredation and agreed to continue engagement in the CCAMLR Depredation e-group as a means to exchange information and collaboration, with formation of a mailing list for marine mammal depredation (mm-depredation@jiscmail.ac.uk), which also allows non-CCAMLR researchers to exchange information.

10.12 COLTO made the following statement:

> 'This year the COLTO tag draw was conducted by Mr O. Urrutia (Chile), the Chair of SCIC. The winners are:
>
> 1. $400 – Recaptured on the vessel *Shinsei Maru No. 3* on 18 May 2016 in Subarea 48.6 and was tagged on 22 March 2015 also by the *Shinsei Maru No. 3*, 31 km from the site of recapture

2. $350 – Recaptured on the vessel *Shinsei Maru No. 3* on 3 January 2016 in Subarea 48.6 and was tagged on 8 March 2015 on the *Koryo Maru No. 11* also in Subarea 48.6, less than 1 km from the point of recapture

3. $250 – Recaptured on the vessel *Argos Georgia* on 20 December 2015 in Subarea 88.1 and was tagged on 20 January 2015 on the vessel *Seljevaer* also in Subarea 88.1, at a distance of 85 km from the site of recapture.

Congratulations to the crew and officers of the many fishing boats who voluntarily participate in the mark-recapture processes, and return tags when located, to help understand the stock dynamics of toothfish better.'

10.13 The Scientific Committee thanked COLTO for its continued support for the tag lottery draw, noting that this raised the profile of the importance of tagging in the work of CCAMLR.

SPRFMO

10.14 Mr Dunn presented SC-CAMLR-XXXV/BG/32 as an update on the exploratory fishing for toothfish by the New Zealand vessel *San Aspiring* in the South Pacific Regional Fisheries Management Organisation (SPRFMO) area. The survey is part of a two-year program that will culminate in a report submitted to SPRFMO and CCAMLR for consideration.

10.15 The Scientific Committee thanked New Zealand for its report and looked forward to receiving further information on the exploratory fishing of toothfish outside the Convention Area.

IWC

10.16 The Scientific Committee considered SC-CAMLR-XXXV/BG/33, which presented a plan developed by the Steering Group of the Joint SC-CAMLR–IWC Workshop (as endorsed by SC-CAMLR-XXXIV, paragraphs 10.24 to 10.26) to hold a Joint SC-CAMLR–IWC Workshop focusing on multi-species models of the Antarctic marine ecosystem. At SC-CAMLR-XXXIV it was agreed to plan the workshop in two parts, 2017 and 2018 (SC-CAMLR-XXXIV, paragraph 10.26) with terms of reference endorsed by the Scientific Committee (SC-CAMLR-XXXIV, paragraph 10.27) to guide the two SC-CAMLR–IWC Modelling Workshops.

10.17 The 2017 workshop would review outcomes from the joint workshop held in 2008, assess progress since then and highlight information on species interactions that are of mutual interest to CCAMLR and IWC, as well as initiate discussion on the purpose and the types of multispecies models that are needed by both organisations.

10.18 The Scientific Committee considered the proposal for the joint workshop and suggested that engagement in the 2017 workshop may be more appropriate through remote conferencing.

SCOR

10.19 The Scientific Committee on Oceanic Research (SCOR) presented SC-CAMLR-XXXV/BG/35 on behalf of SCAR and SCOR, which provides an overview of the five-year implementation strategy for SOOS. SCAR and SCOR have undertaken an independent international review for this implementation strategy and are in the process of developing implementation and regional working groups to coordinate regional observation programs. The implementation strategy will review the standardisation of observation data and coordination of observation activities. SCOR expressed its interest in continuing participation and enhancing engagement with the work of the Scientific Committee.

10.20 India thanked SCOR for the presentation and expressed its desire to participate in relation to observation programs in the Southern Indian Ocean.

10.21 Australia encouraged external bodies to submit implementation plans like SOOS and suggested that the CCAMLR website should include a registry of external organisations and activities completing work relevant to CCAMLR along with a description of current and ongoing work as well as points of contact. It was noted that points of contact should include researchers completing work on a range of scientific parameters, including biology, chemistry and physics.

10.22 The Scientific Committee noted the potential role of SOOS for developing CCAMLR activities, noting:

(i) a large stream of data in relation to FBM will be available soon

(ii) collaboration with the SCAR data management community and the Standing Committee on Antarctic Data Management (SCADM)

(iii) SOOS is organising regional working groups to collect data at suitable regional scales that would be appropriate, also for use by CCAMLR

(iv) Members should review SOOS data in order to identify relevant datasets that may contribute to the work of the Scientific Committee, specifically data relating to climate change that may be incorporated into CCAMLR work.

10.23 Dr A. Van de Putte (Belgium) informed the Scientific Committee that he was currently the SCADM chief officer and invited Members to engage with SCADM for data-sharing purposes.

ARK

10.24 ARK presented SC-CAMLR-XXXV/BG/19 and made the following statement:

> 'ARK thanks the Commission for its invitation to CCAMLR-XXXV and reminded Members that the aim of ARK is to assist the krill fishing industry to work with CCAMLR to ensure the sustainable management of the fishery. ARK now has five companies in its membership with more companies currently considering invitations to join ARK. Over 80% of the current krill catch is being taken by ARK Members.

In regard to ARK's intersessional activities, ARK has made funds available for the purchase of two full acoustic calibration kits for use by ARK members participating in the krill fishery and will discuss the deployment and use of these kits with CCAMLR scientists during CCAMLR-XXXV. ARK has also initiated correspondence with IAATO with the aim of furthering understanding between the fishing and the tourism industries and together we are preparing booklets that IAATO can provide to their member companies, which provide information on the krill fishery and its management.

A number of issues were discussed at the 2016 meeting of WG-EMM where some input from ARK might be helpful:

(i) ARK supports the subdivision of the trigger level in Area 48, which avoids the concentration of fishing effort in small areas and assists with meeting the requirements of CCAMLR's Article II. The current subdivision creates some issues for the fishing industry and ARK suggests that any future subdivision takes into account the operational needs of the fishery, where possible. ARK recognises that any changes to the subdivision of the trigger level should be based on sound research and on discussions with the fishing industry.

(ii) The development of feedback management will require the involvement of the krill fishery and ARK suggests that discussions on the role of industry should occur early in the development process. ARK may be able to provide a useful forum for discussing the implications of FBM to the fishing industry and in future ARK could take on a coordinating role if this were viewed to be helpful.

ARK will hold a half-day workshop in association with the 3rd International Krill Symposium being held in Scotland, from 12 to 16 June 2017, and seeks input from CCAMLR scientists on topics that could be addressed by a broad group of scientists and the krill fishing industry at the meeting. ARK again thanks CCAMLR and looks forward to working with CCAMLR in the intersessional period.'

10.25 The Scientific Committee thanked ARK for its presentation and encouraged its continued support and involvement in the research of the Scientific Committee.

ASOC

10.26 ASOC made the following statement with regard to SC-CAMLR-XXXV/BG/30:

'As there is a growing body of important and relevant science being conducted, we face the challenge of how this knowledge gets to those that need it to make critical management decisions. WWF Tracking Antarctica is our first biennial report synthesising the latest science in Antarctica and the Southern Ocean. It identifies and explains critical threats such as climate change on Antarctic biodiversity including krill, whales, seals and seabirds. We highlight progress made on IUU fishing and identify sustainable solutions to adapt to global change. We do this using clear and concise language visualising topics using infographics to highlight key messages. The report is an attempt to provide science packaged for policy makers. But, we have an opportunity to engage the 38 000 Antarctic tourists who are requesting more information about how this science is generated and get to know the people who are producing it. WWF Tracking Antarctica is available on the Apple APP store and in a few weeks, will be released for Android. The app will be updated periodically with new content. We are keen to tell your stories and highlight the latest research finding to a wider audience.'

10.27 The Scientific Committee thanked ASOC for its presentation and commitment to communicating research to the wider public.

10.28 ASOC made the following intervention:

'ASOC submitted background papers relevant to the work of the Scientific Committee on a variety of issues, including on the progress made to date in the establishment of a representative system of marine protected areas in the CAMLR Convention Area, the Joint CEP–SC-CAMLR Workshop on Climate Change and Monitoring, the need to retain CM 51-07 and the remaining challenges in the management of the Antarctic krill fishery.

ASOC continues to highlight the need to advance the work on MPAs by agreeing this year on the proposals that have been already evaluated by this Committee. Regarding the Joint CEP–SC-CAMLR Workshop on Climate Change and Monitoring, ASOC provides some suggestions for implementing the recommendations of this workshop immediately to address the urgent threats from climate change and ocean acidification.

While the Scientific Committee continues to work towards the development of a feedback management system in the Antarctic krill fishery, we encourage this Committee to provide clear advice to the Commission on the need to retain CM 51-07 and to establish seasonal buffer no-take areas close to penguin colonies during the breeding season. The latter would be important to contribute to reducing the possibility of mortality events like the one that occurred on gentoo penguins during the last austral summer in Cuverville Island, Neko Harbor and Biscoe Point in the southwestern Bransfield Strait.

Finally, as one of the founding members, ASOC would like to call attention to the activities of the Antarctic Wildlife Research Fund (AWR). As we reported during our lunch event yesterday, AWR opened its second call for proposals on 18 March and closed on 17 June 2016. Two projects were selected out of 14 that were submitted, both of them focusing on the issue of krill flux which this Committee has recognised as one of the important information gaps and sources of uncertainty in the management of the krill fishery.'

IUCN

10.29 IUCN made the following statement:

'IUCN and the US Government organised the World Conservation Congress in Hawaii from 1 to 10 September 2016. The members, 1 300 governments and NGOs, agreed on the target of 30% of the world ocean to be set aside for management as marine protected areas. It is noted that CCAMLR is very far from this target.

A new report on Ocean Warming was launched by IUCN at the WCC including a chapter on Antarctic Ocean warming: portals.iucn.org/library/sites/library/files/documents/2016-046_0.pdf.

On 4 to 10 September 2017 the government of Chile and IUCN are organising the International Marine Protected Areas Congress 4 in La Serena, Chile. This will be a good opportunity to discuss progress on Antarctic MPAs and learn from other experiences both in other high-seas areas and more broadly across the world oceans.'

FAO

10.30 FAO presented SC-CAMLR-XXXV/BG/39 on the ABNJ Deep Seas Project and made the following statement:

'CCAMLR has been involved in the design and development of the ABNJ Deep Seas Project and contributes to a range of project activities. The Project has produced a range of publications that will be available in 2016/17, including: a review of the international legal and policy instruments related to deep-sea fisheries and biodiversity conservation in the ABNJ; technical papers on the biology and assessment of alfonsino and orange roughy; the second edition of the Worldwide Review of Bottom Fisheries in the High Seas; and a report on best practices in VME encounter protocols and impact assessments. Activities relevant to CCAMLR that will be undertaken over the next 12 months include: a review of traceability in deep-sea fisheries; a review of rights-based management; an examination of monitoring control and surveillance practices; and a characterisation of decent work practices related to deep-sea fisheries. The project will also trial the use of electronic monitoring systems on deep-sea fishing vessels operating in the ABNJ to collect information on VMEs. The ABNJ Deep Seas Project looks forward to continuing its partnership with CCAMLR Members in pursuit of improved fisheries management and biodiversity conservation in the deep seas.'

10.31 The Scientific Committee thanked FAO for its presentation and continued engagement with CCAMLR.

ACAP

10.32 ACAP made the following statement:

'First of all, the Agreement on the Conservation of Albatrosses and Petrels (ACAP) would like to thank CCAMLR for the invitation to attend the Scientific Committee meeting. ACAP appreciates the work done by the Scientific Committee in refining and maintaining an effective implementation of conservation measures concerning seabirds. CCAMLR has been, and is still, considered by our agreement 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 area of the Commission are also distributed in adjacent waters. ACAP continues its work in these areas to promote the adoption and implementation of seabird conservation measures, as well as to better understand the magnitude and nature of by-catch. One of these ACAP species, the white-chinned petrel, presents an interesting and challenging case study due to its intense association with fishing vessels and diving capabilities, making it one of the most difficult species to deter from fishing operations. This is why the white-chinned petrel can be considered an umbrella species; maintaining minimum levels of by-catch in this vulnerable species will likely result in very low by-catch levels in many other threatened species. In this regard, it would be important to keep monitoring the incidental mortality events in this (and other) species to better understand the nature and variables involved in the by-catch, whether seasonal-phenological, environmental, operational, or a combination of these.

The ACAP Secretariat would like to explore the possibility that the Scientific Committee or the CCAMLR Secretariat would present a paper at our next meeting of the Seabird Bycatch Working Group (in September 2017) updating the information on by-catch levels registered in recent years, as well as difficulties and lessons learned in implementing conservation measures that would feed into the work of ACAP and could be used in other interactions with fisheries administrations.

Finally, at its last meeting, the ACAP Advisory Committee welcomed the renewal of the MoU signed with CCAMLR in November 2015. In this regard, the Secretariat wishes to reaffirm its commitment to work with the CCAMLR Secretariat to continue the current cooperation and explore possible mechanisms and areas to make this interaction even more productive, for example, through a more active participation in the Working Groups.'

10.33 The Scientific Committee welcomed the renewal of the MoU with ACAP and also looked forward to continuing the positive engagement between the respective Secretariats.

Future cooperation

10.34 The Scientific Committee noted that the Secretariat has engaged in initial consultations with the Secretariats of the Southern Indian Ocean Fisheries Agreement (SIOFA), the South East Atlantic Fisheries Organisation (SEAFO) and SPRFMO that operate toothfish tagging programs in areas adjacent the Convention Area in order to discuss how they may share data on toothfish tagging programs where such data exchange may help to reduce duplication of effort and develop efficiency in management. The Secretariat undertook to keep Members aware of further developments in this work.

10.35 Dr Constable announced that, in addition to the meetings of relevance to the Scientific Committee as listed in SC-CAMLR-XXXV/BG/15, a second symposium on the joint research on the Kerguelen Plateau will be held by France and Australia from 13 to 15 November 2017 in Hobart, Australia, and invited all those interested in the science and policy relating to the management of the sub-Antarctic region to attend.

Budget for 2017

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). The Science Manager advised the Scientific Committee that under the current zero growth budget (i.e. in which there is no provision for annual inflation) there was limited capacity for the General Fund to accommodate additional expenditure. Under this funding scenario, in which there is a forecast of a diminishing General Fund, the Scientific Committee should not necessarily anticipate a business as usual approach to expenditure.

11.2 The Scientific Committee agreed to fund two scientific scholarships (paragraph 13.28) each of up to A$30 000 over two years resourced from the General Science Capacity Fund.

11.3 The Scientific Committee also requested SCAF to consider:

(i) the proposal for Species Profiles (Annex 7, paragraphs 8.26 to 8.31)

(ii) the funding requests for support for experts to attend the Joint SC-CAMLR–IWC Workshop (paragraphs 10.16 to 10.18)

(iii) a mechanism to fund the attendance of working group conveners and the Scientific Committee Chair as a means to facilitate burden sharing among Members.

11.4 The Scientific Committee agreed that the data management systems redevelopment work outlined by the Secretariat in SC-CAMLR-XXXV/BG/25 Rev. 1 and discussed in Annex 7 (paragraphs 7.1 to 7.11) was central to the role and function of the Secretariat and the Scientific Committee and, therefore, requested that this should be a priority for additional resources to assist in a more timely completion of the work.

Advice to SCIC and SCAF

12.1 The advice to SCAF is summarised in Item 11. 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 the criteria to assess the suitability of toothfish tagging in CM 41-01, Annex 41-01/C, paragraph 2(ii), seabird by-catch mitigation in CMs 25-02 and 25-03 and on the identification of patterns, rather than simply the identification of high values, in the analysis of catch data.

Scientific Committee activities

Priorities for the work of the Scientific Committee and its working groups

CCAMLR Scientific Committee Symposium

13.1 The Scientific Committee Chair, Dr Belchier, briefly summarised the outcomes of the CCAMLR Scientific Committee Symposium, held at the CCAMLR Secretariat, Hobart, Australia, on 13 and 14 October 2016 (SC-CAMLR-XXXV/12). It was noted that scientists from 17 Member countries and Observers from ACAP, ARK, ASOC, the CEP and SCAR were in attendance.

13.2 The Symposium discussions addressed the work of the Scientific Committee and its working groups, noting that workloads of the working groups continued to increase annually, limiting time at meetings for consideration of strategic priorities. Discussions also noted that several topics were often referred between working groups, resulting in insufficient attention.

13.3 The Scientific Committee Chair highlighted the range of issues on which scientific advice was provided to the Commission:

(i) Fisheries (krill, *D. eleginoides*, *D. mawsoni*, *C. gunnari*) –

Priorities for scientific research and advice include:

(a) yield
(b) direct effects (e.g. by-catch, VMEs)
(c) indirect effects.

(ii) Conservation and change –

Priorities for scientific research and advice include:

(a) spatial management
(b) climate change
(c) observation and research capability.

13.4 Following the discussion of these themes, participants were asked to consider the following strategic questions:

(i) What is the key advice we need to provide to the Commission?

(ii) When are the results needed?

(iii) What are the 'risks' of not providing advice in a given year?

(iv) Is the current working group structure appropriate to efficiently undertake the work of the Scientific Committee?

(v) How can external groups assist the work of the Scientific Committee and by which mechanism?

13.5 The Symposium identified several common themes and topics as priority work areas of the Scientific Committee through small group discussions:

(i) Krill FBM and ecology –

(a) need to ensure there is a forum for discussion of krill ecology and biology

(b) objectives for krill FBM need to be clear in order to implement operational management of the krill fishery.

(ii) Stock assessments –

(a) several toothfish assessments provide stable biomass estimates through time and could potentially be reviewed less frequently

(b) a need to develop a range of approaches to data-limited fishery assessments, including advice from other bodies.

(iii) Research surveys and data collection –

(a) identification of priorities for research with sufficient lead time to facilitate engagement with national Antarctic programs

(b) ensuring appropriate data acquisition and management processes.

(iv) Ecosystem interactions and climate change –

(a) recognition that this is an expansive area of science, and engagement with external expert groups would greatly facilitate progress in CCAMLR.

13.6 The Symposium agreed that a strategic review of the priorities of the Scientific Committee is necessary in order to streamline the workflow of the Scientific Committee and its working groups, and to develop a multi-year work plan in order to set short-, medium- and long-term work priorities.

13.7 The Scientific Committee thanked Dr Belchier and the Secretariat for their efforts in organising the Symposium and all of the participants for their contribution to its successful outcomes.

Scientific Committee priorities

13.8 In reflecting on the outcomes from the Symposium, the Scientific Committee agreed that a work plan with short-, medium- and long-term objectives was required and that this should be developed in the intersessional period by the Scientific Committee Chair and Vice-Chairs and the working group conveners as the foundation for a strategic work plan (paragraph 13.16).

13.9 The Scientific Committee considered the CEP five-year work plan presented by Mr McIvor, and agreed that it would form a useful template for the development of an intersessional work plan.

13.10 Dr Constable noted that the CEP template contained themes and suggested that an agreement on themes and relevant context under each theme would be useful in providing structure to the work plan.

13.11 Dr Darby suggested that intersessional work incorporate priorities of data management in relation to the data redevelopment currently being completed, suggesting extra funds and resources should be allocated to the redevelopment.

13.12 The Scientific Committee also noted the need for broader engagement with the global scientific community. Potential joint workshops and integration of medium to long-term work priorities by organisations such as SCAR or SCOR, with operational support potentially provided by COLTO or ARK, were suggested.

13.13 The Chair of the Scientific Committee noted that the Symposium identified a huge workload for WG-EMM spanning multiple themes, resulting in difficulties for a single convener covering a complete agenda. The WG-EMM Convener recommended multiple conveners for any future meeting and had approached individuals who may be appropriate for these roles (paragraph 15.3).

13.14 Norway commented on the reporting procedure during the working group meetings and suggested a procedure be developed to reduce lengths of reports and to increase the efficiency of meeting operations.

13.15 The Scientific Committee discussed the review of plans for the research activities targeting toothfish, noting that the review process can be very time-consuming for the working groups. To alleviate this workload, some Members suggested that the review period for research plans for data-poor fisheries that were in their later stages of development (such as those in Subareas 48.6 and 58.4), could potentially be reviewed every two years rather than annually. However, the research catch limits would still require review at WG-FSA-17.

13.16 A group comprising the Scientific Committee Chair, Vice-Chairs and working group conveners met to discuss priorities for the coming year for each of the working groups.

13.17 The Scientific Committee outlined its scientific priorities for its work from 2017 to 2019 (Table 1) and requested that the group comprising the Scientific Committee Chair, Vice-Chairs and working group conveners discuss these issues and develop a timeline for their delivery.

13.18 The Scientific Committee agreed that it was essential to recognise that the timescale at which items were addressed did not imply a level of priority and that it was essential that mechanisms were developed for multi-year engagement where specific areas of science are not necessarily considered on an annual timescale.

13.19 For example, it noted that intersessional work will be required to identify how to progress priorities beyond 2017, including spatial management and climate change.

13.20 The Scientific Committee agreed that the group comprising the Scientific Committee Chair, Vice-Chairs and working group conveners would develop a five-year strategic plan for the work of the Scientific Committee that would be developed during the intersessional period via an e-group and would include presentation to, and feedback from, SG-ASAM, WG-SAM, WG-EMM and WG-FSA.

Intersessional activities and future directions

Benchmarking/independent review of CCAMLR stock assessments

13.21 Following the discussion on working group priorities raised during the Scientific Committee Symposium, the UK and then the USA introduced their papers on an independent review process of CCAMLR stock assessments (SC-CAMLR-XXXV/BG/31 and BG/20). Both papers refer to the Commission endorsement and the Scientific Committee's recommendation to develop a process to facilitate independent reviews of CCAMLR stock assessments (CCAMLR-XXXII, paragraph 5.14).

13.22 The UK paper (SC-CAMLR-XXXV/BG/31) detailed the International Council for the Exploration of the Sea (ICES) benchmarking review process for evaluating the data and analyses that form the basis of management advice for stock, specifically noting how this process could be used in CCAMLR. The paper described how in the ICES benchmarking process reviewers are acknowledged experts, invited from outside the ICES community as well as stakeholders to broaden the experience available and enhance credibility and transparency of the process. The goal of a benchmark is agreement on datasets and an assessment structure that will be applied for a fixed period in annual assessment updates. More details of the ICES process are described in WG-SAM-14/16.

13.23 The US paper (SC-CAMLR-XXXV/BG/20) also referred to the ICES benchmarking process as a potential model for the independent review of CCAMLR stock assessments. Further, the paper highlighted how such a process can provide greater transparency and could also be used to provide information on how CCAMLR is achieving, or is likely to continue to achieve, the objectives of Article II.

13.24 The Scientific Committee welcomed the idea of introducing external experts to the CCAMLR working groups in a benchmark process and recommended that the group comprising the Scientific Committee Chair and Vice-Chairs and the working group conveners provide advice on incorporating a process similar to the Center for Independent Experts (CIE) review panel approach into CCAMLR stock assessment reviews to enable the Scientific Committee to provide further advice on the process in 2017.

CEMP Special Fund

13.25 Dr J. Melbourne-Thomas (CEMP Special Fund Management Group Senior Vice-Chair) provided an update on the status of the management group and noted previous advice from WG-EMM and the Scientific Committee that a strategic plan for the fund be developed. She offered to work with the Secretariat during the intersessional period to:

(i) identify priority areas for projects to be supported by the CEMP Special Fund based on recommendations from SC-CAMLR and its working groups (as opposed to the need to develop and maintain a separate strategic plan)

(ii) provide a list of suggestions for current priorities

(iii) further defines roles and composition of the CEMP Special Fund Management Group

(iv) provide a procedure for assessment of proposals for use of the funds

(v) determine a replacement Chair, Senior Vice-Chair and Junior Vice-Chair for the Management Group.

13.26 The Scientific Committee endorsed advice from WG-EMM (Annex 6, paragraph 7.8) that the WG-EMM Convener and CCAMLR Secretariat Science Manager be included as members of the CEMP Special Fund Management Group and looked forward to the appointment of a new management group in time for WG-EMM in 2017.

13.27 The Scientific Committee welcomed SC-CAMLR-XXXV/BG/27 on the camera installation by Ukraine at the Galindez, Petermann and Yalour Islands penguin colonies, which is a CEMP Fund-supported project on establishing a CEMP camera network in Subarea 48.1, and looked forward to a presentation of the results from this project.

CCAMLR Scientific Scholarship Scheme

13.28 The Chair of the Scientific Scholarship Review Panel (Dr Welsford – Senior Vice-Chair of the Scientific Committee) announced that the recipients of the 2016 CCAMLR scholarship were Lic Andrea Capurro (Argentina), who will be working on data analysis and spatial planning in relation to the work in Domain 1, and Yiping Ying (China), who is working on the analysis of fishing activity and the use of CPUE data combined with acoustic data from the krill fishery to study the progressive change of krill density throughout the fishing season.

13.29 Dr Barrera-Oro thanked the review panel for granting a second scholarship to an Argentinean researcher, Ms A. Capurro, who also thanked CCAMLR for the fantastic opportunity. In addition, she thanked the Argentinean Antarctic Programme, her mentor Dr S. Grant and her co-mentor, Dr M. Santos, for their great support.

13.30 Dr Zhao also thanked the review panel for granting a second scholarship to a Chinese researcher. He noted that Dr Wang (recipient 2012), who had attended SG-ASAM and WG-EMM, had recently received a grant from the Chinese Government to work with acousticians at IMR in Bergen, Norway, to further the work that he presented as part of his scholarship.

13.31 The Chair of the review panel thanked the members of the panel for their work in reviewing current applications and, in particular, he thanked those members of the panel from Argentina and China who had recused themselves from discussion of applications in which they had an interest. The review panel noted that the main objective of the scholarship scheme is to promote engagement in the meetings of CCAMLR and, therefore, attendance at those meetings is a key element of the scheme. In situations where a scholarship recipient is unable to attend a meeting that forms part of the funded scholarship, then the reasons for this should be reported to the review panel in order that the panel can make an evaluation of whether any modifications to the schedule of funding of the scholarship is required.

13.32 The Scientific Committee agreed that the CCAMLR Scientific Scholarships Scheme was a very successful mechanism for developing capacity in CCAMLR both in the working groups and in the Scientific Committee.

13.33 The Scientific Committee noted the advice from WG-EMM on the CCAMLR Scientific Scholarship Scheme (Annex 6, paragraphs 7.6 and 7.7), including the request to consider whether applicants from Acceding States should be eligible to apply for scholarships. The Scientific Committee agreed that building capacity in CCAMLR was the main objective of the scheme and that this should include the engagement of scientists from Acceding States and requested the Commission to review this issue.

13.34 The Scientific Committee noted SC-CAMLR-XXXV/08 that included a number of recommendations for the improvement of the operation of the scholarship scheme, including:

(i) the rights and obligations of CCAMLR scholarship recipients

(ii) a clear mechanism for reporting research carried out under the scholarship

(iii) a procedure for situations where a scholarship recipient is unable to attend a meeting that forms part of the funded scholarship

(iv) the procedure for the CCAMLR scholarship recipient to receive the funds awarded.

The Scientific Committee thanked the review panel for incorporating these into the revised terms of reference for the scheme (Annex 8).

Secretariat-supported activities

Data management systems

14.1 The Scientific Committee reviewed the redevelopment of the Secretariat's data management systems and the proposed work plan for 2017 and 2018 (SC-CAMLR-XXXV/BG/25 Rev. 1; see also Annex 7, paragraph 7.7). The work plan incorporated the advice from the Scientific Committee and its working groups on data traceability, system testing and evaluation, user training, data extracts with corresponding metadata and establishing a data management group. The Scientific Committee noted that much of the development that has been undertaken to date was essential foundational work with limited visibility and impact on current data users. However, data users can expect improvements in data integration, quality assurance, documentation and ease of use as the new system is progressively rolled out, and prototype data extracts and metadata will be available to working groups and data users for evaluation in 2017. The Scientific Committee thanked the Secretariat for the considerable amount of work that has been achieved to date and recognised the challenges it faced in redeveloping the entire Secretariat's data management systems.

14.2 The Scientific Committee agreed that high-quality data are essential to all aspects of its work and noted the discussion and endorsed the advice on issues related to data management this year at WG-SAM (Annex 5, paragraphs 2.15 to 2.20, 2.51 to 2.54, 5.7, 5.14, 5.15 and 6.8), WG-EMM (Annex 6, paragraphs 6.18 to 6.21) and WG-FSA (Annex 7, paragraphs 7.3 to 7.9).

14.3 The Scientific Committee noted that the proposed work plan (SC-CAMLR-XXXV/BG/25 Rev. 1) was focused in 2017−2018 on the development of systems and data extracts to support toothfish stock assessments. However, the Scientific Committee identified additional priorities for the management of acoustic data and spatial data to support the work of SG-ASAM and WG-EMM, and the further development of a portal to support archiving of stock assessments and data used in those assessments.

14.4 The Scientific Committee also encouraged greater collaboration with organisations such as SCAR (SCADM) and related programs such as SOOS, ICED and Biodiversity.Aq to draw on spatial data expertise and develop synergies in data management.

14.5 The Scientific Committee noted the increased length of time that it was taking to implement the project and discussed the level of Secretariat resources allocated to the redevelopment. The Scientific Committee requested that further consideration be given to whether the allocation of additional resources would assist in a more timely completion of the work.

14.6 The Scientific Committee also agreed that a detailed work plan would be essential for the data warehouse implementation by the Secretariat to better understand the project milestones and contribute to setting priorities and implementing relevant elements of the work.

14.7 The Scientific Committee endorsed the Working Groups' advice to establish a Data Management Group to provide strategic and expert advice on the development of the Secretariat's data management systems, including advice on data standards, quality assurance, and data extracts and products (Annex 5, paragraph 2.20; Annex 6, paragraph 6.21).

14.8 The Scientific Committee agreed to establish an intersessional e-group to develop the terms of references for the Data Management Group, and outline how that group would conduct its business, including schedule of work, membership, convenership and meeting and reporting arrangements. The e-group was requested to update the Scientific Committee and its working groups throughout 2017 on progress on this item.

Proposal for Global Environment Facility funding

14.9 Dr A. Makhado (South Africa), on behalf of the Global Environment Facility (GEF) Eligible CCAMLR Member Countries (GECMCs) and the Secretariat, provided a brief update on the status of the proposal for GEF funding (SC-CAMLR-XXXV/BG/22). Chile, India, Namibia, South Africa and Ukraine have endorsed the proposal, and the GEF Secretariat undertook a preliminary review of the proposal in April 2016 and advised that the participation of four GECMCs could justify a reduced budget of US$7 million over four years. The project was revised in response to this advice and technical advice received from the GEF Secretariat, and submitted to the GEF Secretariat in August 2016. The proposal, in the format of a GEF project identification form (PIF), is available from the Secretariat on request.

14.10 Since WG-EMM-16, the GEF Secretariat has cleared the project for consideration in the GEF's future program of work. This approval allows the project to be considered for inclusion among the recommendations from the GEF Secretariat for funding to the next meeting of the GEF Council in 2017. It is a highly competitive process with other large projects vying for funding under the International Waters Focal Area, and the decision of the GEF Secretariat regarding projects to be included in the work program for consideration by the Council is expected in the first quarter of 2017.

14.11 The Scientific Committee thanked the GECMCs and Secretariat for advancing this proposal, and noted that if the project is approved by the GEF Council for inclusion in the work program, the GEF will make available a Project Preparatory Grant (PPG) to fund the drafting of a full project document. This 18-month task will involve national-level consultations within GECMCs to confirm priority actions for support under the project. Other CCAMLR Members will also be involved in these consultations to assist with the identification of multilateral collaborative activities which may be included among priority activities nominated for support.

Election of Vice-Chair

15.1 Dr Welsford's term as Vice-Chair ended with this meeting and the Scientific Committee sought nominations for a new Vice-Chair. Mr R. Sarralde Vizuete (Spain) was unanimously elected to the position for a term of two regular meetings (2017 and 2018). A very warm welcome was extended to the incoming Vice-Chair who thanked the Committee for this honour.

15.2 The Scientific Committee thanked Dr Welsford for his excellent contribution to the work of the Scientific Committee and noted that this contribution would continue in his role as Convener of WG-FSA.

Convener of WG-EMM

15.3 As the outgoing Convener of WG-EMM, Dr Kawaguchi announced to his great pleasure that Dr M. Korczak-Abshire (Poland) had agreed to be the new Convener of WG-EMM. The Scientific Committee welcomed Dr Korczak-Abshire and warmly thanked Dr Kawaguchi for his careful and considered guidance of WG-EMM.

Future work

Attributed statements in the report of the Scientific Committee and working groups

16.1 The Scientific Committee noted the discussion in the report of WG-FSA on attributed statements (Annex 7, paragraph 10.2). It recalled that the entire report of the Scientific Committee and its working groups is available to the public and reflect on the reputation of the CCAMLR. In doing so, it agreed that:

(i) the Scientific Committee and its working groups present the best scientific evidence available in their reports

(ii) Members with different views should provide scientific commentary to support their views, including why the other views cannot be supported.

16.2 The Scientific Committee considered the nature of reporting from working groups in relation to:

(i) the presentation of different views

(ii) the presentation of attributed statements in a way that makes it clear that they do not reflect the views of the meeting

(iii) views that are not scientifically based.

16.3 The Scientific Committee reiterated that, where consensus cannot be achieved, the Committee shall set out in its report all views advanced on the matter under consideration, as set out in the Rules of Procedure of the Scientific Committee, to facilitate proper understanding of the various views.

16.4 The Scientific Committee agreed that use of attributed statements should be minimised. It recommended that in future where attributed statements were required, working group and Scientific Committee reports should follow the same process as the Commission and those statements should be presented in quotation marks and prefaced with the words 'xxxx made the following statement'. These statements should be in italics.

16.5 The Scientific Committee also recommended that the introduction to its reports include an explanation as to the presentation of italicised statements and greyed advice paragraphs.

Adoption of the report

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

Close of the meeting

18.1 At the close of the Scientific Committee meeting, Dr Constable gave the following statement:

> 'Thank you for giving me a few minutes at this late hour to address the Scientific Committee.
>
> I assure everyone that this is my last intervention.
>
> As you may have guessed, if you have not already heard the rumours, this is my last meeting of CCAMLR in my current capacity. It is, genuinely, with great sadness that I leave you.
>
> CCAMLR has been a passion of mine since I joined the CCAMLR community in 1986.
>
> In fact, my fantastic partner and wife, Sharon, refers to Camilla as "the other woman". She has not known me without Camilla – 31 CCAMLR cycles.
>
> I would like to thank you, the Scientific Committee, for giving me the time and patience to contribute to your work. I have made many friends from all over the globe, and value greatly all my colleagues. I feel I have had great fortune and privilege in being able to work with you, and in the shadows of many other great contributors to marine conservation, fisheries and management.

I would like to thank the interpreters for putting up with 19 years of my incessant interventions.

I would also like to thank the Secretariat for their great service, great spirit and persistence in delivering the needs of CCAMLR.

I congratulate Members for contributing to the recent rejuvenation of CCAMLR with many young and enthusiastic scientists, and also for improving the gender balance (although this has some way to go), and for reinvigorating the important agenda of this committee. It is now a far cry from the smoke filled room of the Casino.

I am not moving away from CCAMLR, just a change in emphasis. I will be working in the external groups that we have all agreed that the Scientific Committee needs to connect with.

A great challenge facing CCAMLR is to be able to adapt to climate change.

I will now be focussing on assessing the status and trends of Southern Ocean habitats, species and food webs. I hope you can join me in this work and at the conference in April 2018.

I am also focussing on working with SCAR, SCOR and SOOS to help benchmark Southern Ocean ecosystems in 2022. All this work is oriented toward understanding what CCAMLR will be facing in 20–50 years. Again, I hope you will consider helping with that endeavour.

I would like again to thank you all for the fantastic opportunity to shape my career and to be able to contribute to a world-leading Scientific Committee.

I also want to thank you all for your collective innovation, foresight and incredible endeavour. I hope to continue to contribute from afar.

Once again, it has been an honour and a privilege to work with you. I would like to wish you well and best wishes for the future.

Thank you.'

18.2 In response to the announcement, Dr Watters thanked Dr Constable for his substantive and enduring contribution to CCAMLR; he also recalled how much he had enjoyed working with Dr Constable as a colleague and friend.

18.3 Dr Zhao thanked Dr Constable for his contribution to CCAMLR and, in particular, for his kindness in sharing knowledge of CCAMLR, his work in the margins of meetings that has been instrumental in bringing agreements in difficult issues and acting as a true mentor to those that are new to the CCAMLR system.

18.4 On behalf of the Scientific Committee, Dr Welsford presented an original hard copy of the Report of The Fifth Meeting of the Scientific Committee (1986), the first Scientific Committee attended by Dr Constable, which was signed by the current Members of the Scientific Committee.

18.5 Dr R. Werner (ASOC), on behalf of the NGO community, thanked Dr Constable for his legendary contribution to CCAMLR that was characterised by his endurance and commitment over a huge range of issues.

18.6 The Scientific Committee sang 'For he's a Jolly Good Fellow'.

18.7 Dr Belchier thanked all participants for their patience and engagement that had helped him through the slightly daunting task of chairing the Scientific Committee for the first time. He thanked all involved in supporting the work of the Scientific Committee and looked forward to presenting the report to the Commission.

18.8 On behalf of the Scientific Committee, Dr Zhao thanked Dr Belchier for his skilful chairing and exceptional patience in dealing with difficult issues as it was only this patience that had allowed the meeting to reach a successful conclusion.

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Table 1: Proposed prioritisation for the Scientific Committee and its intersessional meetings from 2017 to 2019.

Meeting	Year	Main task
SG-ASAM	2017	Automated processing of acoustic data from fishing vessels
	2018	Survey design implementation
	2019	Links with WG-SAM and WG-EMM on methods and survey design
WG-EMM	2017	Operationalising FBM in Subarea 48.1 – Risk assessment and data layers from Domain 1 Planning/CEMP monitoring and Domain 1 MPA
	2018	Ecosystem impact of the krill fishery, including the use of CEMP data and fish by-catch development of data layers from the krill fishery
	2019	Using geospatial data and analysis to examine krill flux
WG-SAM	2017	Biomass estimation including estimation uncertainty. Review of fishery survey plans
	2018	Tag-based biomass estimation, spatial distribution and the transition from research blocks to assessment at the larger scale.
	2019	Links with SG-ASAM and WG-EMM on methods and survey design
WG-FSA	2017	Regular integrated assessments (toothfish and icefish). Research block catch limits
	2018	Transitioning from local biomass estimates to integrated assessments
	2019	To be confirmed
Workshops	2017	SISO – take up recommendations of 2013 review. Data quality and updates to operations of the scheme
	2018	Spatial planning data analysis
Venue/timing	2017	SG-ASAM – March/April, China
	2017	WG-SAM, WG-EMM and SISO workshop – Argentina June/July
	2018	SG-ASAM?
	2018	WG-SAM, WG-EMM and spatial management workshop – UK June/July
Meetings involving external collaborators		
	2017	ICED 2017 workshop (including questions from WG-EMM-16), Third International Krill Symposium
	2018	CCAMLR–IWC
	2019	SG-ASAM, WG-SAM and WG-EMM joint workshop
	2020	SCAR Fish (mesopelagic) theme

Table 2: Distribution of the trigger level for scenarios based on historical catch distributions plus a scenario for all catch to be taken from Bransfield Strait. Catches (thousand tonnes) are calculated as the alpha level multiplied by the trigger level of 620 000 tonnes. The adjusted catches (thousand tonnes) for a scenario give catches for each area that would result in the regional risk of the scenario being equal to the baseline regional risk (calculated by pro-rating the alphas for a scenario in order to achieve a regional risk equal to the baseline). The total catch indicates what the total catch for Subareas 48.1, 48.2, 48.3 and 48.4 that would correspond to the regional risk indicated. See Table 3 for definitions.

Scenario		Regional risk		Distribution in Subarea 48.1				Subareas				Total catch
#	Name	R_risk	R_relative	Bransfield	Drake	Pelagic	E_W	48.1	48.2	48.3	48.4	
	Alpha											
2	Catch 2013–2016	0.650		0.430	0.057	0	0.075	0.562	0.205	0.233	0	
3	Catch 2010–2013	0.625		0.362	0.114	0.001	0.054	0.531	0.26	0.21	0	
4	Catch 2000–2010	0.48		0.076	0.202	0.002	0.006	0.286	0.429	0.285	0	
5	Catch 1990–2000	0.679		0.01	0.595	0.017	0.011	0.633	0.147	0.221	0	
6	Catch 1980–1990	0.823		0.001	0.763	0.055	0.005	0.824	0.176	0	0	
7	Bransfield only	0.942		1	0	0	0	1	0	0	0	
	Catches											
2	Catch 2013–2016	0.65	1.68	266	35	0	47	349	127	145	0	620
3	Catch 2010–2013	0.625	1.61	224	70	1	34	329	161	130	0	620
4	Catch 2000–2010	0.48	1.24	47	125	1	4	178	266	177	0	620
5	Catch 1990–2000	0.679	1.75	6	369	10	7	392	91	137	0	620
6	Catch 1980–1990	0.823	2.13	1	473	34	3	511	109	0	0	620
7	Bransfield only	0.942	2.43	620	0	0	0	620	0	0	0	620
	Adjusted catches											
2	Catch 2013–2016	0.387	1	159	21	0	28	208	76	86	0	369
3	Catch 2010–2013	0.387	1	139	44	0	21	204	100	81	0	384
4	Catch 2000–2010	0.387	1	38	101	1	3	143	214	142	0	500
5	Catch 1990–2000	0.387	1	3	210	6	4	224	52	78	0	353
6	Catch 1980–1990	0.387	1	0	222	16	2	240	51	0	0	292
7	Bransfield only	0.387	1	255	0	0	0	255	0	0	0	255

Table 3: Distribution of the trigger level for scenarios based on Conservation Measure (CM) 51-07, along with the resulting catches from the trigger level of 620 000 tonnes. Adjusted catches for a scenario give catches for each area that would result in the regional risk of the scenario being equal to the baseline regional risk. The scenarios relate to the following: 'CM_' indicates the scenario based on CM 51-07. '_25' or '_35' indicate scenarios where Subarea 48.1 has 25% or 35% of the trigger level with the remaining subareas divided according to the relative proportions in other subareas according to the existing conservation measure. Catches between seasons and between small-scale management units (SSMUs) in groups of SSMUs (either subareas or, in Subarea 48.1, within subarea groups) for Subareas 48.1, 48.2 and 48.3 are divided according to the catch distributions of the most recent period in the fishery. Subarea 48.4 is divided between pelagic and island SSMUs according to the proportion of the subarea in each SSMU. Regional risk (R_risk) is the accumulated risk across Area 48 of localised effects on predators and krill. Relative risk (R_relative) is the regional risk relative to the baseline regional risk. For Subarea 48.1, Bransfield includes Bransfield SSMUs, Drake includes Drake Passage plus Elephant Island SSMUs, Pelagic is the pelagic SSMU, and E_W includes the East and West SSMUs. 'even481' relates to having one third of the catch in each of Drake Passage SSMUs (including Elephant Island), Bransfield Strait SSMUs and the Pelagic Area, with no catch in the other SSMUs in Subarea 48.1. 'current481' indicates distribution amongst SSMUs according to the most recent fishing period. 'D&B' is where half the catch from Subarea 48.1 is taken from the Drake Passage SSMUs and half from the Bransfield Strait SSMUs.

Scenario		Regional risk		Distribution in Subarea 48.1				Subareas				Total catch
#	Name	R_risk	R_relative	Bransfield	Drake	Pelagic	E_W	48.1	48.2	48.3	48.4	
	Alpha											
8	CM_even481_25	0.467		0.083	0.083	0.083	0	0.25	0.32	0.32	0.11	
9	CM_current481_25	0.457		0.191	0.025	0	0.034	0.25	0.32	0.32	0.11	
10	CM_D&B_481_25	0.466		0.125	0.125	0	0	0.25	0.32	0.32	0.11	
11	CM_even481_35	0.532		0.117	0.117	0.117	0	0.35	0.28	0.28	0.09	
12	CM_current481_35	0.518		0.267	0.035	0	0.047	0.35	0.28	0.28	0.09	
13	CM_D&B_481_35	0.53		0.175	0.175	0	0	0.35	0.28	0.28	0.09	
	Catches											
8	CM_even481_25	0.467	1.21	52	52	52	0	155	198	198	68	620
9	CM_current481_25	0.457	1.18	118	16	0	21	155	198	198	68	620
10	CM_D&B_481_25	0.466	1.20	78	78	0	0	155	198	198	68	620
11	CM_even481_35	0.532	1.37	72	72	72	0	217	174	174	56	620
12	CM_current481_35	0.518	1.33	166	22	0	29	217	174	174	56	620
13	CM_D&B_481_35	0.53	1.37	109	109	0	0	217	174	174	56	620
	Adjusted catches											
8	CM_even481_25	0.387	1	43	43	43	0	129	165	165	57	514
9	CM_current481_25	0.387	1	100	13	0	18	131	168	168	58	525
10	CM_D&B_481_25	0.387	1	64	64	0	0	129	165	165	57	515
11	CM_even481_35	0.387	1	53	53	53	0	158	126	126	41	451
12	CM_current481_35	0.387	1	124	16	0	22	162	130	130	42	463
13	CM_D&B_481_35	0.387	1	79	79	0	0	158	127	127	41	452

Table 4: Baseline distribution of the trigger level based on density of krill and risk of effects on predators and krill in small-scale management units (SSMUs). See Table 3 for definitions.

Scenario		Regional risk		Distribution in Subarea 48.1				Subareas				Total catch
#	Name	R_risk	R_relative	Bransfield	Drake	Pelagic	E_W	48.1	48.2	48.3	48.4	
1	Baseline Alpha			0.001	0.002	0.044	0.002	0.049	0.456	0.434	0.061	
	Catches			1	1	28	1	31	283	269	38	620
	Local catch-weighted risk	0.387	1	000.1	000.1	0.018	0.002	0.022	0.168	0.184	0.013	

Table 5: Local relative catch-weighted risks for groups of small-scale management units (SSMUs) in Subarea 48.1 and for Subareas 48.1, 48.2, 48.3 and 48.4 for each scenario shown in Tables 2 and 3. These local relative catch-weighted risks are the local catch-weighted risks divided by the local catch-weighted risk for that area in the baseline scenario (Table 4). See Table 3 for definitions.

Scenario		Local relative risk within Subarea 48.1				Local relative risk by subarea				Relative regional risk
#	Name	Bransfield	Drake	Pelagic	E_W	48.1	48.2	48.3	48.4	
2	Catch 2013–2016	392	56	0	33.5	23.41	0.32	0.44	0	1.68
3	Catch 2010–2013	340	93	0.06	24.5	21.91	0.39	0.42	0	1.61
4	Catch 2000–2010	67	161	0.06	2.5	10.64	0.64	0.76	0	1.24
5	Catch 1990–2000	9	513	0.78	5	24.82	0.23	0.52	0	1.75
6	Catch 1980–1990	1	710	2.89	2.5	34.95	0.32	0	0	2.13
7	Bransfield only	942	0	0	0	42.82	0	0	0	2.43
8	CM_even481_25	76	82	4.44	0	10.82	0.51	0.6	2.54	1.21
9	CM_current481_25	174	25	0	15	10.41	0.51	0.6	2.54	1.18
10	CM_D&B_481_25	114	124	0	0	10.82	0.51	0.6	2.54	1.20
11	CM_even481_35	106	115	6.22	0	15.18	0.44	0.53	2.08	1.37
12	CM_current481_35	244	35	0	21	14.55	0.44	0.53	2.08	1.33
13	CM_D&B_481_35	159	173	0	0	15.14	0.44	0.53	2.08	1.37

Table 6: Biomass estimates based on the methods agreed to at WG-SAM-16 (Annex 5, paragraph 28) and presented in WG-FSA-16/27 and SC-CAMLR-XXXV/BG/38 Rev. 1, catch limits for the current season, catch that has been taken in the past three years and the proposed catch limits based on the two biomass estimates provided in this table with the 4% exploitation rate applied. TOA – *Dissostichus mawsoni*; TOP – *D. eleginoides*.

Research block	Species	CPUE by seabed area estimated biomass – three year median CPUE (tonnes)	Chapman estimated biomass most recent (tonnes)	Catch limit current 2016 season (tonnes)	Catch 2014 (tonnes)	Catch 2015 (tonnes)	Catch 2016 (tonnes)	Catch limit CPUE by seabed area (4%)	Chapman catch limit (4%)
486_2	TOA	600	9369	170	95.22	82.20	83.16	24	375
486_3	TOA	182	4456	50	49.92	48.86	49.74	7	178
486_4	TOA	870	5147	100	0	56.45	99.18	35	206
486_5	TOA	2039	n/a	190	0	0	0	82	n/a
5841_1	TOA	911	831	80	0	0	79.68	36	33
5841_2	TOA	841	6909	81	54.15	15.40	42.57	34	276
5841_3	TOA	1052	5285	233	0	71.33	65.81	42	211
5841_4	TOA	149	n/a	13	0	9.95	12.10	6	n/a
5841_5	TOA	286	404	35	0	25.70	34.91	11	16
5841_6	TOA	1209	n/a	90	24.34	0	84.23	48	n/a
5842_1	TOA	291	n/a	35	0	9.62	0	12	n/a
5843a_1	TOP	1740	1310	32	32.08	15.19	0	70	52
5844b_1	TOP	481	351	26	12.00	18.22	0	19	14
5844b_2	TOP	509	765	35	14.94	16.33	0	20	31

Table 7: Allocation of catch limits (tonnes) for 2016/17 in Divisions 58.4.1 and 58.4.2 by research block. AUS − Australia; ESP – Spain; FRA – France; JPN – Japan; KOR – Republic of Korea.

Division	SSRU	Research block	Catch allocation (tonnes)						Catch limit 2016/17
			AUS	ESP	FRA	JPN	KOR	Total	
58.4.1	C	5841_1			26.5	26.5	26.5	79.5	80
		5841_2	40.5	40.5				81.0	81
	E	5841_3	30.0	30.0	60.5	73.5	38.5	232.5	233
		5841_4			13.0			13.0	13
	G	5841_5					35.0	35.0	35
		5841_6	45.0	45.0				90.0	90
58.4.2	E	5842_1	35.0					35.0	35
Total			150.5	115.5	100.0	100.0	100.0	566.0	567

Table 8: Numbers of incidental mortality of seabirds and marine mammals in 2015/16, the reported numbers are those reported by observers (and are the same as those provided in vessel-reported data in Area 48 and Division 58.5.2). The extrapolated number of seabirds uses the number of incidental mortality reported by observers and the percentage of hooks observed, to extrapolate the total number of seabird by-catch for longline fisheries.

	Source	Subarea					Division		Total
		48.1	48.2	48.3	58.6, 58.7 (South African EEZ)	58.6 (French EEZ)	58.5.1 (French EEZ)	58.5.2	
Longline	Seabirds reported			30	3	5	16	2	56
	Seabirds extrapolated			98	6	20	64	4	192
	Marine mammals			0	0	0	0	6	6
Finfish trawl	Seabirds reported			0				1	1
	Marine mammals			0				0	0
Krill trawl	Seabirds reported	8	1	0					9
	Marine mammals	0	0	3					3

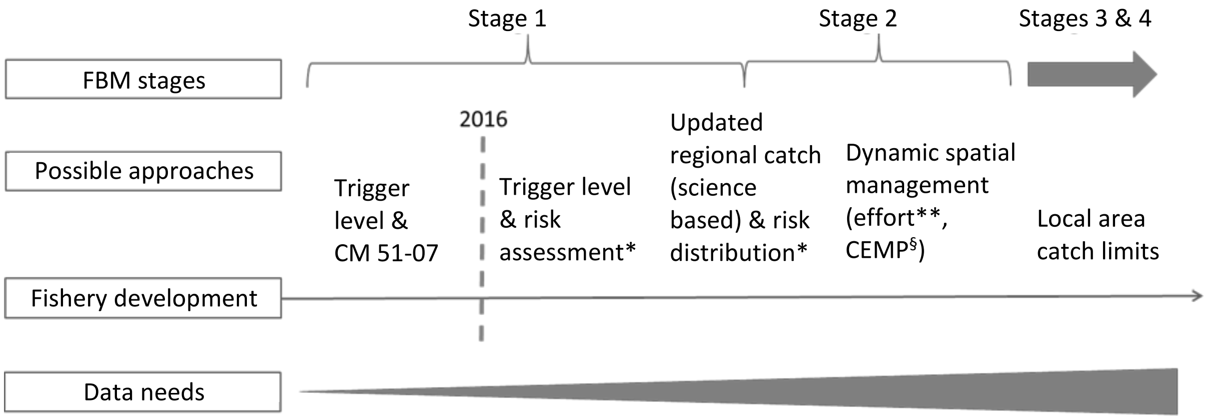
Table 9: Summary of activities being undertaken on MPA planning in each of the MPA planning domains.

Domain	Name	Subarea/division (whole or part)	Current status	Progress/ available documents	Future activities	CCAMLR website/data resources
1	Western Antarctic Peninsula/South Scotia Arc	48.1, 48.2, 88.3	South Orkney Islands southern shelf MPA established in 2009 Domain 1 MPA planning in development (led by Argentina and Chile)	MPA report and draft research and monitoring plan; MPA reviewed in 2014 Domain 1 expert workshops in 2012, 2013 and 2015; informal workshop in 2016	South Orkneys MPA review due in 2019 Domain 1 Planning e-group and data sharing	www.ccamlr.org/node/90101 GIS shapefiles and data layers available via e-group
2	North Scotia Arc	48.3, 48.4				
3	Weddell Sea	48.5, 48.6 south	WSMPA scientific background documents and proposal submitted to Scientific Committee and Commission by the EU (planning process led by Germany)	Expert workshops in 2014 and 2015 Scientific background and proposal documents (see website for full list) Draft conservation measure		www.ccamlr.org/node/90103
4	Bouvet/Maud Rise	48.6 north		2012 Circumpolar Gap Analysis workshop		
5	del Cano/Crozet	58.6, 58.7, 58.4.4	Domain 5 pelagic MPA planning in development by the EU (planning process led by France)	2012 technical MPA workshop 2011 Brest WS-MPA reports	Indian Ocean sub-Antarctic spatial planning e-group	
6	Kerguelen Plateau	58.5, 58.4.3	Domain 6 pelagic MPA planning in development by the EU (planning process led by France)	2011 Brest WS-MPA reports	Indian Ocean sub-Antarctic spatial planning e-group Kerguelen Symposium (Nov 2017)	

(continued)

Table 9 (continued)

Domain	Name	Subarea/division (whole or part)	Current status	Progress/ available documents	Future activities	CCAMLR website/data resources
7	East Antarctica	58.4.1, 58.4.2	EARSMPA proposal submitted to Commission by Australia and the EU Proposal has been iteratively updated since 2012 consistent with Scientific Committee advice and as a result of consultation with Commission Members	MPA planning reference documents (see website for full list) Draft conservation measure		www.ccamlr.org/node/90107 GIS shapefiles and data layers available via webpage
8	Ross Sea region	88.1, 88.2	RSRMPA proposal submitted to Commission by New Zealand and the USA Proposal has been iteratively updated since 2011 consistent with Scientific Committee advice and as a result of consultation with Commission Members	Scientific background and proposal documents (see website for full list) Draft conservation measure		www.ccamlr.org/node/90108 GIS shapefiles and data layers available via webpage
9	Amundsen/ Bellingshausen	88.2, 88.3	2012 Circumpolar Gap Analysis workshop			



* WG-FSA-16/47 Rev. 1, 16/48 Rev. 1, SC-CAMLR-XXXV/BG/36 and BG/37
** SC-CAMLR-XXXV/BG/29 Rev. 1
§ WG-EMM-16/48

Figure 1: Time series of approaches that can be used to progress the four stages of feedback management (FBM), as the krill fishery develops (horizontal arrow). Further detail on these approaches is provided in paragraphs 3.56 to 3.59. Data needs to support FBM increases from stage 1 to stage 4. SC-CAMLR-XXXV (2016) marks the introduction of the approach for risk assessment described in paragraphs 3.67 to 3.74.

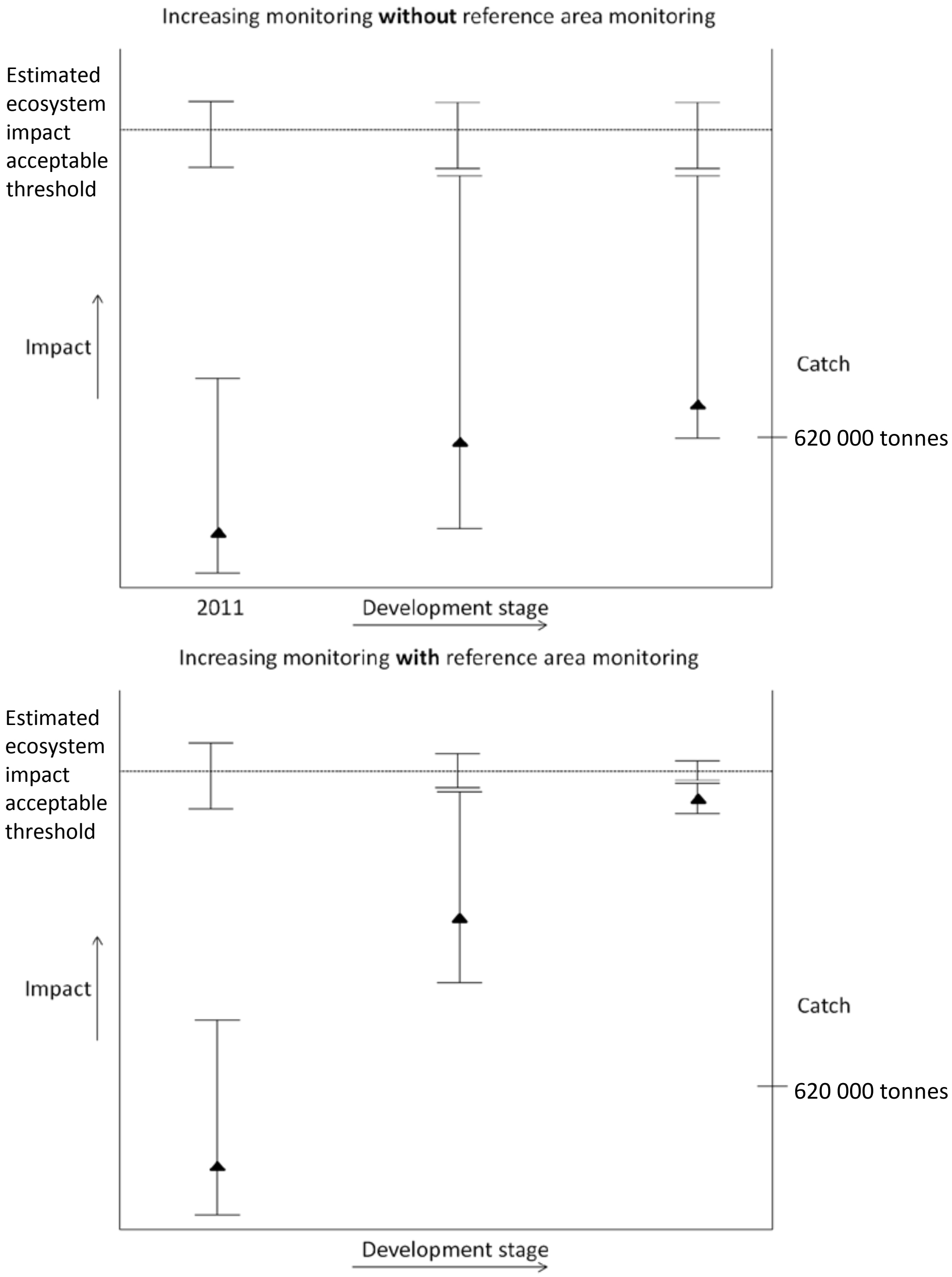


Figure 2: Potential revisions to catch limits and uncertainty under feedback management (FBM). The x-axis characterises possible stages in the development of an FBM approach. The left axis shows the level of impact of a stage in the fishery, which also corresponds to a catch limit (right axis)*. Triangles show the estimate of impact with error bars. The horizontal line shows a putative limit of acceptable impacts. The error bars reflect the degree of understanding as to what this might be and how well it is estimated. Learning more about the system could allow revision of catch limits over time as our understanding increases. Reference area monitoring could allow attribution of ecosystem change to fishery versus other effects. This could reduce the uncertainty in assessments of fishery impacts, potentially allowing the catch to rise further and faster while maintaining a precautionary approach (duplicate of SC-CAMLR-XXX, Annex 4, Figure 4).

* The relationship between impact and catch limit may not be a simple linear relationship as indicated here.

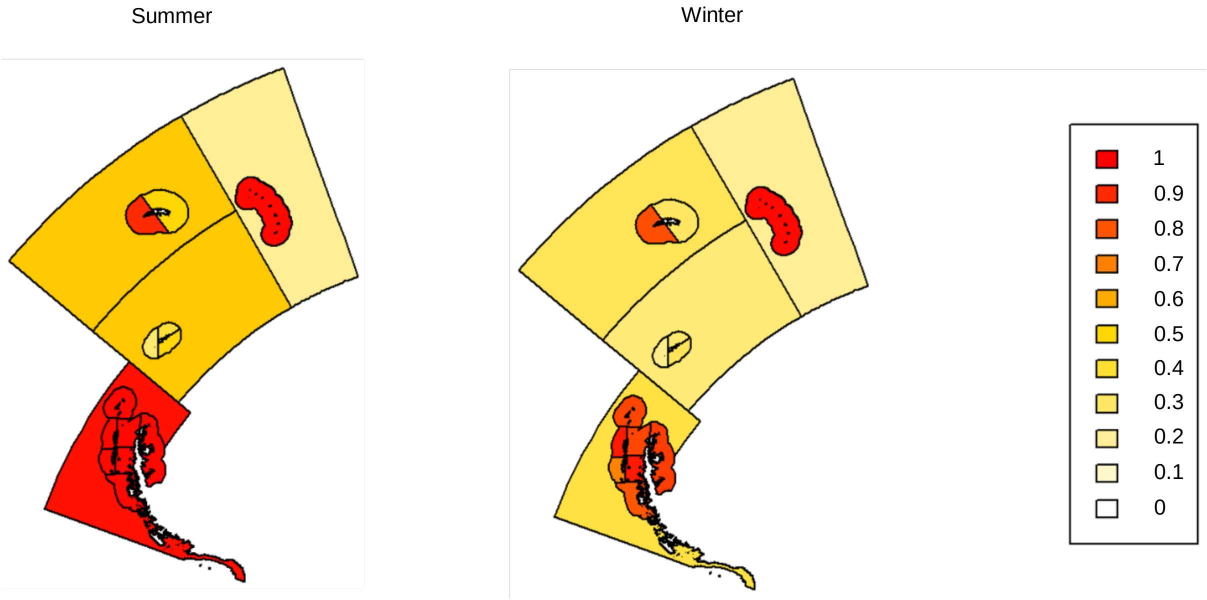


Figure 3: Baseline risk based on distribution of juvenile krill, land-based and pelagic predators in Area 48.

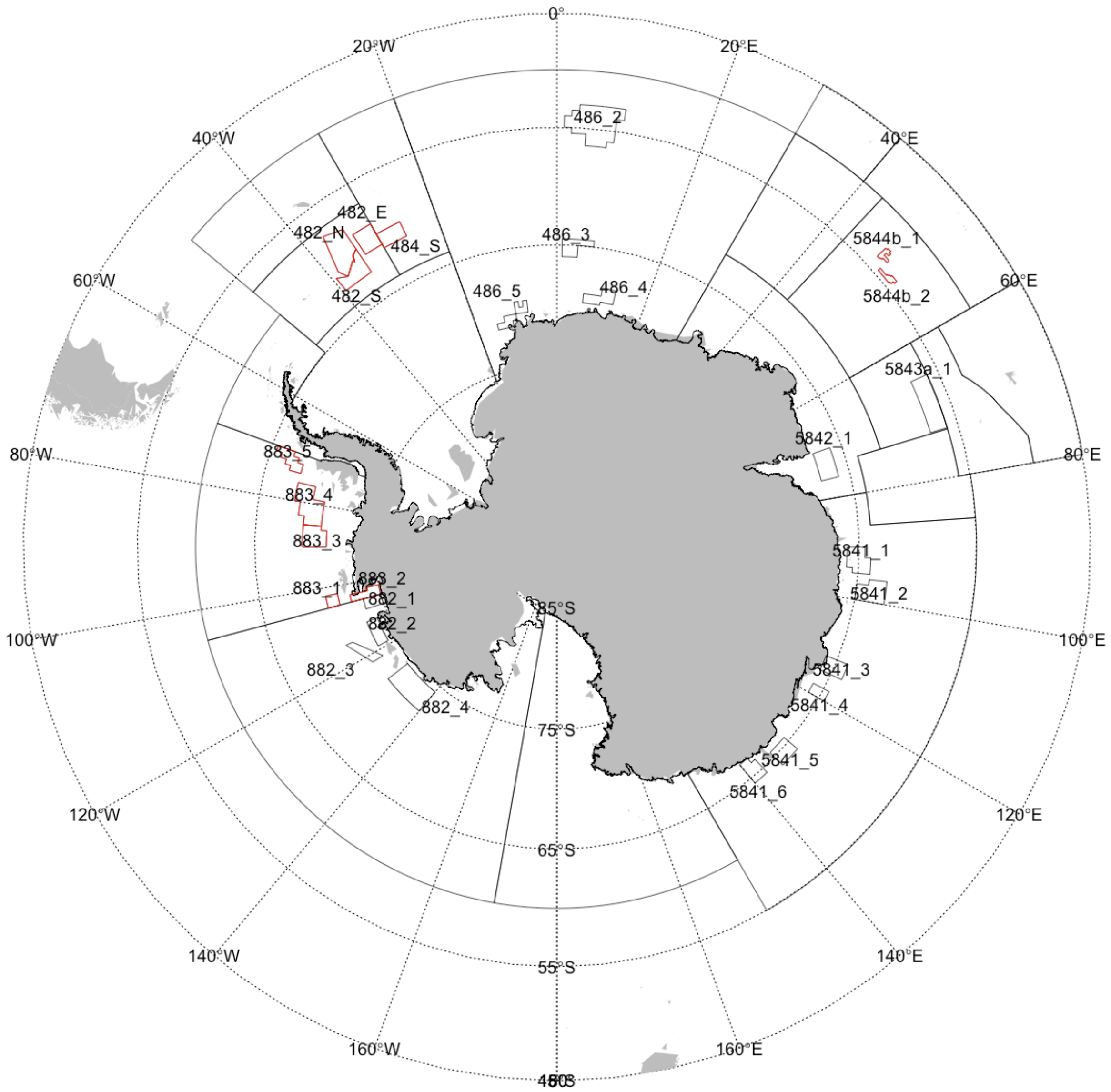


Figure 4: Location of research blocks in Subareas 48.6, 58.4 and 88.2 (black) and in Subareas 48.2, 48.4, 88.3 and Division 58.4.4b (red) in 2016/17.

Annex 1

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Annex 2

List of documents

List of Documents

SC-CAMLR-XXXV/01 Rev. 1	Scientific background document in support of the development of a CCAMLR MPA in the Weddell Sea (Antarctica) – Version 2016 Delegation of Germany
SC-CAMLR-XXXV/02	Progress in the process for the designation of a Marine Protected Area in Domain 1 Delegations of Argentina and Chile
SC-CAMLR-XXXV/03	Report of the Working Group on Ecosystem Monitoring and Management (Bologna, Italy, 4 to 15 July 2016)
SC-CAMLR-XXXV/04	Report of the Working Group on Fish Stock Assessment (Hobart, Australia, 3 to 14 October 2016)
SC-CAMLR-XXXV/05	Report of the Working Group on Statistics, Assessments and Modelling (Genoa, Italy, 27 June to 1 July 2016)
SC-CAMLR-XXXV/06	Report of the Meeting of the Subgroup on Acoustic Survey and Analysis Methods (La Jolla, USA, 21 to 25 March 2016)
SC-CAMLR-XXXV/07	Conveners' Report of the Joint CEP/SC-CAMLR Workshop on Climate Change and Monitoring Delegations of the United Kingdom and the USA
SC-CAMLR-XXXV/08	Proposal by the Russian Federation to amend the CCAMLR Scientific Scholarship Scheme Delegation of the Russian Federation
SC-CAMLR-XXXV/09	The need to allocate a scientific research TAC in closed blocks (SSRUs) in the Ross Sea Delegation of the Russian Federation
SC-CAMLR-XXXV/10	The Weddell Sea MPA (comments and questions regarding documents CCAMLR-XXXIV/BG/37, WG-EMM-16/01, WG-EMM-16/02, WG-EMM-16/03) Delegation of the Russian Federation
SC-CAMLR-XXXV/11	Precautionary management of the Antarctic krill fishery at small spatial scales in the context of regional climate variability: is no data the same as no impact? Delegation of the United Kingdom

SC-CAMLR-XXXV/12	Report of the Chair of the Scientific Committee on the CCAMLR Scientific Committee Symposium (Hobart, Australia, 13 and 14 October 2016)

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SC-CAMLR-XXXV/BG/01	Catches of target species in the Convention Area Secretariat
SC-CAMLR-XXXV/BG/02	Preliminary assessment of the potential for proposed bottom fishing activities to have significant adverse impacts on vulnerable marine ecosystems Delegation of Australia
SC-CAMLR-XXXV/BG/03	Preliminary assessment of the potential for proposed bottom-fishing activities to have significant adverse impacts on vulnerable marine ecosystems Delegation of Japan
SC-CAMLR-XXXV/BG/04	Preliminary assessment of the potential for proposed bottom fishing activities to have significant adverse impacts on vulnerable marine ecosystems Delegation of South Africa
SC-CAMLR-XXXV/BG/05	Evaluación preliminar del riesgo de que las actividades de pesca de fondo propuestas ocasionen graves daños a los ecosistemas marinos vulnerables Delegación de España
SC-CAMLR-XXXV/BG/06	Preliminary assessment of the potential for proposed bottom fishing activities to have significant adverse impacts on vulnerable marine ecosystems Delegation of Norway
SC-CAMLR-XXXV/BG/07	Preliminary assessment of the potential for proposed bottom fishing activities to have significant adverse impacts on vulnerable marine ecosystems Delegation of New Zealand
SC-CAMLR-XXXV/BG/08	Preliminary assessment of the potential for proposed bottom fishing activities to have significant adverse impacts on vulnerable marine ecosystems Delegation of Uruguay
SC-CAMLR-XXXV/BG/09	Committee for Environmental Protection: 2016 Annual Report to the Scientific Committee of CCAMLR CEP Observer to SC-CAMLR (Dr P. Penhale, USA)

SC-CAMLR-XXXV/BG/10	Форма для представления предварительных оценок возможности того, что предложенный донный промысел будет иметь существенное негативное воздействие на уязвимые морские экосистемы (УМЭ) [Pro forma for submitting preliminary assessments of the potential for proposed bottom fishing activities to have significant adverse impacts on vulnerable marine ecosystems (VMEs)] Делегация Украины [Delegation of Ukraine]
SC-CAMLR-XXXV/BG/11	Scientific background document in support of the development of a CCAMLR MPA in the Weddell Sea (Antarctica) – Version 2016 – Part A: General context of the establishment of MPAs and background information on the Weddell Sea MPA planning area Delegation of Germany
SC-CAMLR-XXXV/BG/12	Scientific background document in support of the development of a CCAMLR MPA in the Weddell Sea (Antarctica) – Version 2016 –Part B: Description of available spatial data Delegation of Germany
SC-CAMLR-XXXV/BG/13	Scientific background document in support of the development of a CCAMLR MPA in the Weddell Sea (Antarctica) – Version 2016 – Part C: Data analysis and MPA scenario development Delegation of Germany
SC-CAMLR-XXXV/BG/14	Precautionary management of the Antarctic krill fishery at small spatial scales in the context of regional climate variability: pros and cons of coastal buffers, closed areas and move-on rules Delegation of the United Kingdom
SC-CAMLR-XXXV/BG/15	Calendar of meetings of relevance to the Scientific Committee in 2016/17 Secretariat

SC-CAMLR-XXXV/BG/16	Форма для представления предварительных оценок возможности того, что предложенный донный промысел будет иметь существенное негативное воздействие на уязвимые морские экосистемы (УМЭ) [Pro forma for submitting preliminary assessments of the potential for proposed bottom fishing activities to have significant adverse impacts on vulnerable marine ecosystems (VMEs)] Делегация Российской Федерации [Delegation of the Russian Federation]
SC-CAMLR-XXXV/BG/17	Antarctic krill fisheries management and the need to retain CM 51-07 Submitted by ASOC
SC-CAMLR-XXXV/BG/18	Antarctic krill fisheries management: “What’s next?” Submitted by ASOC
SC-CAMLR-XXXV/BG/19	Report to the Scientific Committee of CCAMLR by the Association of Responsible Krill harvesting companies (ARK) Submitted by ARK
SC-CAMLR-XXXV/BG/20	Independent reviews of CCAMLR stock assessments – a discussion paper Delegation of the USA
SC-CAMLR-XXXV/BG/21	Marine debris and entanglements at Bird Island and King Edward Point, South Georgia, Signy Island, South Orkneys and Goudier Island, Antarctic Peninsula 2015–2016 Delegation of the United Kingdom
SC-CAMLR-XXXV/BG/22	Progress report 3: Proposal for GEF (Global Environment Facility) funding Secretariat
SC-CAMLR-XXXV/BG/23	COLTO Depredation Workshop Submitted by COLTO
SC-CAMLR-XXXV/BG/24 Rev. 1	KRILLBASE: a multinational, circumpolar database of abundance of Antarctic krill and salps A. Atkinson, S. Hill, H. Peat, R. Downie and L. Gerrish
SC-CAMLR-XXXV/BG/25 Rev. 1	Developing the Secretariat’s data management systems CCAMLR Secretariat

SC-CAMLR-XXXV/BG/26	The Scientific Committee on Antarctic Research (SCAR) Annual Report 2015/2016 Submitted by SCAR
SC-CAMLR-XXXV/BG/27	Cameras installation by Ukraine at the Galindez, Petermann and Yalour Islands penguin colonies – CEMP Fund project 'Establishing a CEMP Camera Network in Subarea 48.1' Delegation of Ukraine
SC-CAMLR-XXXV/BG/28	Summary of research voyages in the South Orkney Islands region in 2015/16 Delegations of the United Kingdom and Norway
SC-CAMLR-XXXV/BG/29 Rev. 1	Feedback management through effort regulation Delegation of Norway
SC-CAMLR-XXXV/BG/30	Tracking Antarctica, A New WWF report on the state of Antarctica and the Southern Ocean Submitted by ASOC
SC-CAMLR-XXXV/BG/31	Benchmarking CCAMLR C.D. Darby
SC-CAMLR-XXXV/BG/32	Report on the first year's fishing under New Zealand's exploratory fishery for toothfish within the SPRFMO Convention Area J. Fenaughty and M. Cryer (Draft paper to SPRFMO Scientific Committee Meeting 4, The Hague, 7 to 15 October 2016)
SC-CAMLR-XXXV/BG/33	Plans for Joint CCAMLR-IWC Workshop The Steering Group of the Joint CCAMLR-IWC Workshop
SC-CAMLR-XXXV/BG/34	Preliminary assessment of the potential for proposed bottom fishing activities to have significant adverse impacts on vulnerable marine ecosystems Delegation of the Republic of Korea
SC-CAMLR-XXXV/BG/35	Southern Ocean Observing System (SOOS) Implementation Plan 2015–2020 Submitted by SCAR and SCOR
SC-CAMLR-XXXV/BG/36	Updated assessment of the risks of status quo krill fishing and proposed revisions to Conservation Measure 51-07 Delegation of the USA

SC-CAMLR-XXXV/BG/37	Risk assessment framework for subdividing the krill catch trigger level, including relevant background data and information
SC-CAMLR-XXXV/BG/38 Rev. 1	Research catch limits and estimation of local biomass estimates for effort-based research Subareas 48.2 and 48.4 Secretariat
SC-CAMLR-XXXV/BG/39	Update on the ABNJ Deep Seas Project FAO and CCAMLR Secretariats

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Other Documents

CCAMLR-XXXV/13 Rev. 1	Establishing time-limited Special Areas for Scientific Study in newly exposed marine areas following ice shelf retreat or collapse in Subarea 48.1, Subarea 48.5 and Subarea 88.3 Delegation of the European Union
CCAMLR-XXXV/18	Proposal on a conservation measure establishing the Weddell Sea Marine Protected Area (WSMPA) Delegation of the European Union
CCAMLR-XXXV/30	On interim distribution of the trigger level in the fishery for *Euphausia superba* in statistical Subareas 48.1, 48.2, 48.3 and 48.4 Delegation of Ukraine
CCAMLR-XXXV/31	Amendments to Conservation Measure 51-06 (2014) General measure for scientific observation in fisheries for *Euphausia superba* Delegation of Ukraine
CCAMLR-XXXV/BG/05 Rev. 1	Fishery notifications 2016/17 Secretariat
CCAMLR-XXXV/BG/14	The Future of Antarctica Forum: distinguishing climate change impacts from other impacts in the Antarctic Peninsula Submitted by Oceanites, Inc.
CCAMLR-XXXV/BG/15	Mapping Application for Penguin Populations and Projected Dynamics (MAPPPD) Submitted by Oceanites, Inc.

CCAMLR-XXXV/BG/22	Initial report from the ICG considering approaches for enhancing consideration of climate change impacts in CCAMLR Delegations of Australia and Norway
CCAMLR-XXXV/BG/24	Follow up to the Joint CEP/SC-CAMLR Workshop on Climate Change and Monitoring Submitted by ASOC
CCAMLR-XXXV/BG/26	A representative system of CCAMLR MPAs: Current proposals and beyond Submitted by ASOC
WG-FSA-16/47 Rev. 1	Scientific contribution to the 2016 review of Conservation Measure 51-07: Part 1 – rationale, method and data for a risk assessment framework for distributing the krill trigger level A. Constable (on behalf of the e-group on CM 51-07 WG-EMM review)
WG-FSA-16/48 Rev. 1	Scientific contribution to the 2016 review of Conservation Measure 51-07: Part 2 – outcomes from the application of the risk assessment framework for distributing the krill trigger level in Area 48 A. Constable (on behalf of the e-group on CM 51-07 WG-EMM review)

Agenda for the Thirty-fifth Meeting of the Scientific Committee

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

1. Opening of meeting
   1.1 Adoption of agenda
   1.2 Chair's report

2. Advances in statistics, assessments, modelling, acoustics and survey methods
   2.1 Statistics, assessments and modelling
   2.2 Acoustic survey and analysis methods
   2.3 Advice to 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 Advice from WG-FSA
      3.2.3 Advice to the Commission

   3.3 Fish and invertebrate by-catch
      3.3.1 Status and trends
      3.3.2 WG-FSA advice
      3.3.3 Advice to the Commission

   3.4 New and exploratory finfish fisheries
      3.4.1 Exploratory fisheries in 2015/16
      3.4.2 Notifications for new and exploratory fisheries in 2016/17
      3.4.3 Progress towards assessments
      3.4.4 Advice to the Commission

4. Incidental mortality arising from fishing operations
   4.1 Incidental mortality of seabirds and marine mammals associated with fisheries
   4.2 Marine debris
   4.3 Advice to the Commission

5. Spatial management of impacts on the Antarctic ecosystem

   5.1 Bottom fishing and vulnerable marine ecosystems
      5.1.1 Status and trends
      5.1.2 Advice to the Commission

   5.2 Marine protected areas
      5.2.1 Scientific analysis of proposals for MPAs
      5.2.2 Advice to the Commission

6. IUU fishing in the Convention Area

7. CCAMLR Scheme of International Scientific Observation
   7.1 Scientific observations
   7.2 Advice to the Commission

8. Climate change

9. Scientific research exemption

10. Cooperation with other organisations
    10.1 Cooperation with 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 2016/17

12. Advice to SCIC and SCAF

13. Scientific Committee activities
    13.1 Priorities for the work of the Scientific Committee and its working groups
    13.2 Intersessional activities and future directions
    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 the report of the Thirty-fifth Meeting

18. Close of the meeting.

Annex 4

**Report of the Meeting of the Subgroup
on Acoustic Survey and Analysis Methods**
(La Jolla, USA, 21 to 25 March 2016)

Contents

Report of the Meeting of the Subgroup on
Acoustic Survey and Analysis Methods
(La Jolla, USA, 21 to 25 March 2016)

Introduction

1.1 The 2016 meeting of the Subgroup on Acoustic Survey and Analysis Methods (SG-ASAM) was held at the Southwest Fisheries Science Center, National Marine Fisheries Service, National Oceanographic and Atmospheric Administration (NOAA), La Jolla, USA, from 21 to 25 March 2016, and was convened by Dr C. Reiss (USA). Dr X. Zhao (People's Republic of China) is Co-convener of the Subgroup; however, he was unable to attend the meeting. Dr G. Watters, Director of NOAA's Antarctic Marine Living Resources Program, and Dr Reiss welcomed the participants (Appendix A).

1.2 The Subgroup has been developing methods to use fishing-vessel-based acoustic data to provide qualitative and quantifiable information on the distribution and relative abundance of Antarctic krill (*Euphausia superba*). The 2016 meeting focused on (SC-CAMLR-XXXIV, paragraph 2.24):

- analysis to generate validated acoustic data suitable for further analyses
- analysis to produce specific products from those validated acoustic data.

1.3 The Subgroup recognised that a range of factors, including the timescale between SG-ASAM requesting transect data and the timing of the krill fishery, meant that the only data available from a fishing vessel was collected by the *Saga Sea* as part of the South Orkney survey. As a result of this, the Subgroup agreed to postpone discussion of Agenda Item 3 and to focus on the development of elements of Agenda Item 5, including the understanding of uncertainty in acoustic biomass estimates. The meeting's agenda was adopted (Appendix B).

1.4 The Subgroup recommended that the Secretariat liaise with Members currently fishing and intending to undertake krill fishing activities, shortly after their notifications to participate in the fishery are received, to remind them of the request to collect acoustic data along the nominated transects, if possible. It would also be possible for the Secretariat to contact vessels as they enter a subarea.

1.5 The Subgroup noted that it may be useful to explore mechanisms to incentivise the broad-scale participation in the collection of acoustic data in the krill fishery, for example by allowing extra catch to be available to those vessels that voluntarily undertake surveys or repeated transects.

1.6 Documents submitted to the meeting are listed in Appendix C. The Subgroup thanked the authors of papers for their valuable contributions to the work presented to the meeting.

1.7 This report was prepared by M. Cox (Australia), C. Jones (USA), D. Ramm and K. Reid (Secretariat) and G. Skaret (Norway). Sections of the report dealing with advice to the Scientific Committee are highlighted (see also 'Advice to the Scientific Committee and other working groups').

Protocols for the collection and analysis of krill acoustic data from fishing vessels, with emphasis on Simrad echosounders (EK60, ES60/70)

2.1 The Subgroup noted that no acoustic data for the nominated transects from the fishery for the previous season was made available to the Subgroup, and it was unclear as to whether any vessels have occupied these transects.

2.2 It was noted that there is the potential to more easily collect data on an opportunistic basis along transects outside those set out in SC-CAMLR-XXXIV, Annex 4, Appendix D, Figure 1, by fishing vessels during the course of transiting to/from krill fishing grounds. The Subgroup agreed that is it most desirable for data to be collected from the nominated transect lines, but there is potentially useful information that could be collected from other repeated transects. The Subgroup underlined that, while the dedicated transects serve assessment and distribution purposes, other transects serve only the latter.

Availability of standard sphere calibration to krill fishing vessels

2.3 The Subgroup noted that funding has been made available through the Association for Responsible Krill harvesting companies (ARK) for two full calibration kits for use by ARK members participating in the krill fishery. The Subgroup noted that it may be advantageous for these calibration kits to be kept at a base or station near the krill fishing grounds, such as within Admiralty Bay, or on board a supply vessel where a krill fishing vessel could quickly retrieve the kit for in situ calibration.

2.4 The Subgroup acknowledged this important contribution from ARK and welcomed the engagement of industry in furthering the collection of high-quality acoustic data. The Subgroup also encouraged ARK to investigate ways in which non-ARK members may be able to access the acoustic calibration equipment.

2.5 The Subgroup encouraged Members to develop proposals for funding additional calibration kits through the Antarctic Wildlife Research Fund or other funding bodies.

2.6 It was noted that, while standard spheres or other calibration equipment is essential, consideration should also be given to having a technician train crew members in proper calibration protocols. This sort of training could be arranged while the vessels are in port, or at a base/station where the kits would be kept. Alternatively, there could be one technician who could be available to calibrate the ships if they went to one area at a specific time. It was also noted that CCAMLR could develop a guide and other training material for calibrating acoustics, following other guides such as the ICES calibration protocols for Simrad acoustic systems (Demer et al., 2015). The Subgroup also noted the need to designate a Member point of contact for technical assistance during calibration.

2.7 The Subgroup discussed the relative merits of conducting standard sphere calibrations of fishing vessels in the Antarctic (optimal) versus calibrating vessels in other locations such as the port of departure. The Subgroup noted that changing environmental conditions (water temperature, salinity, or water column backscatter) could all influence the calibrations for the estimation of biomass, and so such possible variability should be minimised whenever possible. In order to develop flexible approaches to where and how frequently standard sphere calibrations are conducted, the Subgroup encouraged Members to investigate transducer sensitivity to changes in condition (e.g. temperature).

Data storage and management

2.8 The Subgroup discussed storage and management of acoustic data, including calibration data, raw data, processed data, summary (output) data and associated metadata. The issue of what level and type of data should be archived at the Secretariat was highlighted as an area for future work.

2.9 The Subgroup tasked the Secretariat with reviewing acoustic data models and portals from other organisations, including Southern Ocean Network of Acoustics (SONA) and Integrated Marine Observing System (IMOS), and assessing how they may be used, adapted and/or accessed by CCAMLR to manage acoustic data.

Analysis of data collected from fishing vessels

Sampling depth

3.1 Although the CCAMLR protocol specifies the depth range over which acoustic sampling should be conducted is down to a maximum of 500 m, the Subgroup acknowledged that the actual depth range of krill monitoring using acoustics, according to the CCAMLR protocol, is typically no more than 250 m due to restrictions in the signal-to-noise ratio (SNR) at greater depths, as a result of signal attenuation with range, on the higher acoustic frequencies.

3.2 The Subgroup noted that median fishing depth in the krill fishery in Subareas 48.1, 48.2 and 48.3 between 2005 and 2015 was approximately 65 m, and 95% of the hauls were made in depths shallower than 200 m (Figure 1). The Subgroup also noted that the depth region in which predator diving depths, krill distribution depths estimated from surveys and trawl depths overlapped and was less than 100 m.

3.3 The Subgroup also noted that there may be seasonal and spatial variability in the depth of fishing that would need to be accounted for in order to determine that this did not bias measures of intra-annual variability.

Survey design

4.1 The Subgroup recalled that in 2015 there were a number of nominated transects for the collection, processing and analysis of acoustic data from the commercial fishery in Subareas 48.1, 48.2 and 48.3 (SC-CAMLR-XXXIV, Annex 4, Appendix D, Table 1 and Figure 1). Collecting data from these transects over differing time periods within a season allows the opportunity to evaluate potentially important within-season features in krill density distribution.

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4.2 SG-ASAM-16/04 presented an analysis of the US AMLR time series of acoustic survey data from Subarea 48.1 to examine the utility of acoustic data collected by fishing vessels along predefined transects. The survey data included in the analysis cover four areas within Subarea 48.1 and cover both early and late summer in the years 1996–2011.

4.3 The biomasses between areas were highly correlated as were those within areas and between survey stages. The patterns over time when comparing the biomass estimated from two random transects to the one based on all transects was similar.

4.4 The Subgroup agreed that the analysis undertaken was very informative about the utility of fishery acoustic data sampling. The Subgroup noted that these results highlighted that occupation of the prescribed repeat transects in Subarea 48.1 is sufficiently robust that an index of krill could be generated to provide information about the seasonal patterns of krill. In addition, these repeat transects provide information over a broader time scale that may well enhance the utility and interpretation of data collected in temporally restricted broad-scale biomass surveys.

4.5 The Subgroup underscored that the value of such data from the fishing vessels as suggested in SG-ASAM-16/04 would not be restricted to potential use in a future feedback management, but could also add greatly to the understanding of dynamics in krill biomass and distribution, in particular intra-annual variability of which there is presently little available information.

Other issues

Data processing procedure for krill density estimation

5.1 SG-ASAM noted the WG-EMM-15 discussion (SC-CAMLR-XXXIV, Annex 6, paragraph 2.59) that highlighted difficulties following the CCAMLR biomass estimation procedure because information was distributed over several years of SG-ASAM meetings. The Subgroup agreed that the CCAMLR biomass estimation procedure should be described in a single document. The Subgroup also agreed that this document should be available online in a form that can be updated to include future developments. The Subgroup identified that version control was going to be important.

5.2 Dr S. Fielding (UK) presented an overview of the method used to calculate B_0 in the 2010 SG-ASAM meeting (SG-ASAM-16/02). The Subgroup discussed the CCAMLR biomass estimate under the following headings: survey design; data collection; acoustic data processing, including target identification; echo integration; conversion of acoustic backscatter to area biomass; and estimation of total biomass. The content of SG-ASAM-16/01, 16/02 and 16/03 informed on the discussion below.

5.3 The Subgroup recognised that, while elements of the procedure are standard methods, such as calculating the nautical area scattering coefficient (NASC) to density conversion factor, there are components of the CCAMLR biomass estimation procedure that can be subjective such as elements of the data processing. The Subgroup recognised that data processing must be sufficiently flexible to account for vessel-specific data characteristics, such as electrical noise.

5.4 The Subgroup noted that there have been numerous advances in acoustic data processing that are relevant to working with data collected from both commercial fishing and research vessels. For example, procedures are now available to estimate SNR, identify surface noise and eliminate multiple seabed echoes. The Subgroup agreed that these advances offer opportunities to improve data quality, reduce data processing time and enable reproducible data processing. The Subgroup agreed that data processing procedures should be compared in order to understand the differences in methods or that the Subgroup needs to develop standardised agreed procedures. The Subgroup agreed that changes need not be applied retrospectively until these differences are understood.

5.5 The Subgroup agreed that an investigation into potential for observation bias caused by diel and seasonal changes in vertical distribution should be carried out and the Subgroup noted that it is important to assess this potential bias as the fishery will collect data continuously.

5.6 The Subgroup noted that there has not been any change to the recommended survey design (e.g. random design coupled to a design-based analysis). However, other elements of survey design may need to be considered to accommodate data from other sources such as fishing vessels.

5.7 SG-ASAM noted that the overall approach outlined in Hewitt et al., 2004 to collect and process data is the current CCAMLR approach, except for one addition where the echosounder transmitted power setting should be set for each frequency to avoid non-linear effects (Korneliussen et al., 2008).

5.8 The Subgroup noted the discussion of WG-EMM-15/17 Rev. 1 (SC-CAMLR-XXXIV, Annex 6, paragraphs 2.53 to 2.58) and the request therein for clarification of the correct orientation parameters identified and that there has been confusion in the implementation of the stochastic distorted-wave Born approximation (SDWBA) to target identification and biomass estimation. The Subgroup recognised that the analysis undertaken in 2010 (SC-CAMLR-XXIX, Annex 5, paragraphs 2.12 to 2.19) represented the current parameterisation of the SDWBA (including *g* and *h* taken from Foote (1990), a fatness correction of 40% applied to the krill shape, and the orientation of krill as a wrapped Gaussian (normal) distribution of orientations ($N(\bar{\theta} = x^\circ$, s.d. = y°) of $N(-20^\circ, 28^\circ)$)). Specifically, the Subgroup identified that in the absence of in situ observations, the krill target strengths (TS) calculated during SG-ASAM-10 should be used.

5.9 The Subgroup recommended further work be carried out on the independent observation of in situ tilt angle distribution and noted that much progress has been made in this regard by Kubilius et al., 2015.

5.10 The Subgroup agreed that the three-frequency krill identification is currently the method employed for the CCAMLR 2000 Krill Synoptic Survey of Area 48 with 120–38 kHz and 200–120 kHz frequency pairs used with length-frequency specific dB difference identification windows.

5.11 The Subgroup acknowledged that an empirical validation of the two-frequency (120−38 kHz) dB identification technique exists (Madureira et al., 1993; Watkins and Brierley, 2002), and in the absence of three-frequency data provides a valid target identification protocol and method to estimate krill density.

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5.12 The Subgroup identified that other frequency combinations should be examined for their efficacy in identifying krill targets in acoustic data, and assess their suitability.

5.13 The Subgroup recalled the WG-EMM-15 discussion of the time-series of krill acoustic estimates from the South Orkney Islands (SC-CAMLR-XXXIV, Annex 6, paragraph 2.223) in which the frequencies varied by vessel and year such that there was no single frequency that could be used in every year to generate a coherent series of krill biomass estimates. The Subgroup agreed that the development of approaches to use a greater range of frequencies would allow the data that has been collected to be used to generate the time-series of krill biomass estimates.

5.14 The Subgroup documented TS for krill lengths between 10 and 65 mm (at 1 mm intervals) for five frequencies (Table 1) so that they can be used to calculate *C* and the dB identification windows.

5.15 The Subgroup recommended an assessment of the utility of wideband (frequency modulated echosounders) for krill identification and density estimation.

5.16 The Subgroup noted that the current protocol estimates krill from the 120 kHz integration results. The Subgroup identified that other frequencies, particularly 70 kHz, may be more suitable and further investigation is required to validate this.

5.17 The Subgroup identified that a SNR could be a more appropriate measure to use to determine the maximum observation range for each acoustic frequency. The Subgroup identified that the SNR calculations of De Robertis and Higginbottom (2007) on a 50-ping by 5 m grid may be an appropriate method and encourages Members to develop and validate procedures for determining the minimum SNR.

Recommendations for future work

5.18 SG-ASAM noted that:

(i) the full implementation of the SDWBA is used to estimate krill TS which in turn is used to calculate the identification windows and the conversion factor to convert NASC to krill density

(ii) in the absence of more information regarding parameterisation of the SDWBA, SG-ASAM agreed that the model output (calculated for a length-frequency range from 10 to 65 mm, and at 38, 120 and 200 kHz frequencies) from the 2010 SG-ASAM analysis should be used (Table 1). In particular, SG-ASAM agreed that the orientation distribution calculated during SG-ASAM-10 (mean, SD) $N(-20°, 28°)$, should be used in the absence of any other independent measures of orientation

(iii) SG-ASAM recommended that the integration depth be changed to 250 m or 5 m above the seabed, whichever is shallower

(iv) SG-ASAM noted that the current protocol estimates krill biomass from the 120 kHz frequency integration results.

5.19 The Subgroup endorsed the approach of using R markdown to document the procedure and recommended that each step in the procedure contain the following: (i) descriptive text; (ii) example R code, and (iii) a worked example. Dr Cox undertook to continue the development of the R markdown template SG-ASAM-16/01 and work with Mr A. Cossio (USA) and Drs Fielding and Skaret to provide an updated version of the R markdown document for submission to WG-EMM-16.

Development of methods for the evaluation of uncertainty in acoustic estimates of krill biomass

5.20 The Subgroup identified the following as general areas of uncertainty:

(i) measurement uncertainty (e.g. calibration, speed of sound/absorption coefficient)

(ii) processing uncertainty (e.g. variability between methods of noise removal, SNR calculation)

(iii) target identification uncertainty (e.g. parameterisation of the SDWBA, particularly orientation, length frequency etc.)

(iv) conversion to biomass uncertainty (e.g. parameterisation of the SDWBA, length-frequency representation of population)

(v) survey uncertainty (e.g. Jolly and Hampton style calculation versus geostatistical).

5.21 The Subgroup acknowledged that issues with data quality will potentially apply to any set of acoustic data collected at sea whether collected on board research or fishing vessels and whether collected with or without scientific supervision.

5.22 The Subgroup noted that guidelines for processing of acoustic data from different platforms are generic, and that the processing steps of such data involve a range of user-dependent decisions, and potentially vary between software. The Subgroup acknowledged that differences in acoustic data processing, particularly addressing issues of noise removal, may potentially have huge influence on the output from the data. The Subgroup further noted that details of individual data processing steps for the removal of noise, integration depth and other aspects of the data processing need to be documented much the same way that both the instrument setup and the acoustic biomass estimation are documented to fully comprehend the decisions made.

5.23 The Subgroup agreed to look at data collected by the Norwegian fishing vessel *Saga Sea* in 2016 during the annual South Orkney Island acoustic biomass survey for a simple comparison of data processing among individuals within the Subgroup. The Subgroup noted that these data were collected as part of a supervised survey.

5.24 The Subgroup undertook a simple comparison of the effect of different processing techniques from different individuals processing the same dataset. Sixteen hours of survey data from the 2016 annual survey off the South Orkney Islands with the *Saga Sea* was distributed among Members to process and integrate down to 500 m (as required in the CCAMLR protocol) and to 250 m and at a horizontal resolution of 1 n mile. Three Members (Australia, UK and USA) used the software Echoview and one Member (Norway) the LSSS.

5.25 Among Members that analysed these data, all noted that they would not normally integrate to 500 m as they did not feel that the 120 kHz had sufficient SNR below 250 m.

5.26 Dr Skaret highlighted that LSSS requires a threshold to be applied to the data for export, and that exported echo integration values from LSSS by default only include full vessel log distance intervals at the selected resolution (in this case 1 n mile). Hence, in this particular case, a large krill swarm at the end of the transect was not included in the Norwegian export, but was included in all the others.

5.27 The Subgroup noted that NASC integrated to 250 m (NASC250m) was of a similar order of magnitude across the suite of methods, but still noted that the different processing methods (Table 2) (whilst undertaking the same descriptive steps) outputted different results, potentially unpredictably.

5.28 Whilst there are marked differences between the four processing results, the Subgroup recognised that the data presented here are from a single frequency, 120 kHz. Also, when identifying krill, it is common practice to use the 'dB difference' to both identify krill and to provide further data screening to remove seabed and sea surface returns. Nevertheless, the Subgroup noted that the significant differences in these processing results highlight the importance of a consistent approach to processing acoustic data.

5.29 The Subgroup recommended a single processing approach is developed and applied to data collected by all fishing vessels. The processing approach should include data quality measures such as SNR, and the proportion of bad and missing data.

5.30 The Subgroup agreed that metrics of acoustic data quality should be developed. The Subgroup encouraged the development of processes to estimate proportion of bad and missing data and the SNR. The Subgroup identified the need to assess statistical techniques that adequately represent uncertainty in data processing decisions and the Subgroup encouraged engagement with appropriate experts to advise on suitable techniques.

5.31 The Subgroup recognised that, while it was essential that the current approach was appropriately documented, CCAMLR needs a review process to ensure that technological and methodological advances in acoustics are incorporated throughout its work where the results are to be used in management.

Advice to the Scientific Committee and other working groups

6.1 The Subgroup agreed that much of the advice in the report was directed towards those Members that were actually engaged in the krill fishery and encouraged those Members and the Secretariat (paragraph 1.4) to communicate the relevant outcomes of the Subgroup meeting to those engaged in the krill fishery.

6.2 Advice to the Scientific Committee on how acoustic data collected by fishing vessels might contribute to FBM would be guided by discussions in WG-EMM.

Adoption of report

7.1 The report of the meeting was adopted.

Close of the meeting

8.1 In closing the meeting, the Convener thanked all participants for their contributions to the work of SG-ASAM and for developing acoustic protocols during the intersessional period. The Subgroup recognised the importance of industry participation in the meeting and thanked Mr H. Leithe (Norway) for participating in the meeting and for his insight into the krill fishing industry. The Subgroup thanked the AMLR team, in particular Jen Walsh, and the Southwest Fisheries Science Center for the excellent support and generous hospitality during the meeting. Dr Jones, on behalf of the Subgroup, thanked Dr Reiss for convening the meeting.

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Table 1: Krill target strength values for five acoustic frequencies for krill lengths of 10 to 65 mm. All target strength model parameters were as specified in SG-ASAM-10 (SC-CAMLR-XXIX, Annex 5).

Krill length (mm)	38 kHz	70 kHz	120 kHz	200 kHz	333 kHz
10.00	–114.21	–104.73	–97.34	–90.30	–85.96
11.00	–111.84	–102.54	–95.32	–88.48	–84.72
12.00	–109.70	–100.55	–93.45	–86.88	–83.78
13.00	–107.74	–98.75	–91.77	–85.46	–83.10
14.00	–105.95	–97.10	–90.27	–84.22	–82.67
15.00	–104.27	–95.57	–88.85	–83.11	–82.49
16.00	–102.74	–94.18	–87.56	–82.13	–82.56
17.00	–101.30	–92.86	–86.36	–81.28	–82.84
18.00	–99.96	–91.61	–85.23	–80.53	–83.31
19.00	–98.71	–90.45	–84.20	–79.88	–83.89
20.00	–97.53	–89.38	–83.27	–79.35	–84.40
21.00	–96.40	–88.36	–82.33	–78.91	–84.56
22.00	–95.36	–87.39	–81.49	–78.55	–84.17
23.00	–94.36	–86.43	–80.72	–78.29	–83.24
24.00	–93.39	–85.56	–79.96	–78.11	–82.05
25.00	–92.48	–84.73	–79.31	–78.02	–80.82
26.00	–91.62	–83.93	–78.66	–78.01	–79.71
27.00	–90.79	–83.18	–78.06	–78.10	–78.77
28.00	–90.00	–82.46	–77.53	–78.26	–78.02
29.00	–89.23	–81.77	–77.01	–78.47	–77.46
30.00	–88.50	–81.08	–76.52	–78.77	–77.09
31.00	–87.76	–80.47	–76.06	–79.07	–76.88
32.00	–87.06	–79.87	–75.68	–79.38	–76.82
33.00	–86.41	–79.27	–75.28	–79.68	–76.89
34.00	–85.77	–78.71	–74.97	–79.86	–77.05
35.00	–85.16	–78.19	–74.65	–79.88	–77.23
36.00	–84.57	–77.66	–74.40	–79.73	–77.40
37.00	–83.97	–77.16	–74.11	–79.37	–77.47
38.00	–83.41	–76.68	–73.90	–78.81	–77.38
39.00	–82.86	–76.23	–73.70	–78.18	–77.12
40.00	–82.35	–75.77	–73.60	–77.46	–76.72
41.00	–81.83	–75.34	–73.46	–76.73	–76.23
42.00	–81.32	–74.95	–73.29	–76.03	–75.72
43.00	–80.82	–74.55	–73.26	–75.37	–75.24
44.00	–80.36	–74.20	–73.18	–74.78	–74.82
45.00	–79.91	–73.83	–73.18	–74.24	–74.48
46.00	–79.45	–73.48	–73.15	–73.76	–74.22
47.00	–79.02	–73.17	–73.15	–73.38	–74.05
48.00	–78.58	–72.84	–73.17	–73.03	–73.93
49.00	–78.18	–72.53	–73.19	–72.77	–73.86
50.00	–77.79	–72.25	–73.28	–72.56	–73.82
51.00	–77.37	–71.96	–73.32	–72.40	–73.77
52.00	–76.99	–71.70	–73.41	–72.32	–73.71
53.00	–76.58	–71.43	–73.53	–72.27	–73.60
54.00	–76.24	–71.16	–73.63	–72.28	–73.46
55.00	–75.88	–70.97	–73.67	–72.34	–73.28
56.00	–75.53	–70.74	–73.75	–72.43	–73.10
57.00	–75.19	–70.55	–73.78	–72.52	–72.88
58.00	–74.89	–70.33	–73.89	–72.61	–72.70
59.00	–74.53	–70.16	–73.82	–72.74	–72.52

(continued)

Table 1 (continued)

Krill length (mm)	38 kHz	70 kHz	120 kHz	200 kHz	333 kHz
60.00	–74.20	–69.97	–73.84	–72.80	–72.35
61.00	–73.89	–69.83	–73.75	–72.86	–72.21
62.00	–73.57	–69.65	–73.61	–72.85	–72.07
63.00	–73.29	–69.52	–73.52	–72.78	–71.93
64.00	–72.99	–69.37	–73.39	–72.66	–71.76
65.00	–72.71	–69.26	–73.06	–72.47	–71.56

Table 2: Australian, Norwegian, UK and US data processing of a transect from the *Saga Sea* survey 2016. Integrated nautical area scattering coefficient (NASC) at 120 kHz mean (quantile range and skewness).

	Australia	Norway	UK	USA
Integrated to 250 m	275	122	381	390
Threshold (dB)	–80	–86	none	none
2.5 percentile	1	27	1	14
97.5 percentile	665	465	1661	1659
Skewness	8.48	10.08	6.80	8.49

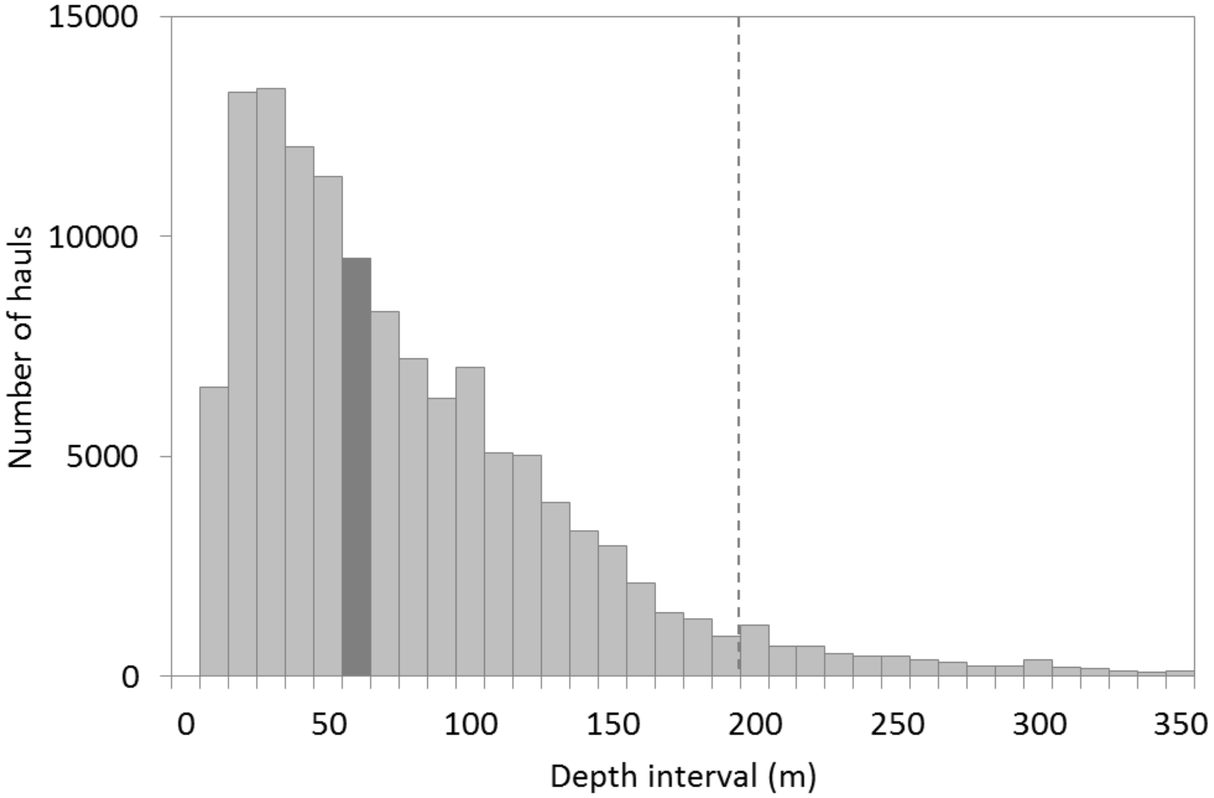

Figure 1: Fishing depth (10-metre interval) of hauls in the krill fishery in Subareas 48.1, 48.2 and 48.3 between 2005 and 2015. Dark bar: median depth; dash line: 95% percentile. Source: C1 effort data.

Appendix A

List of Participants

Subgroup on Acoustic Survey and Analysis Methods
(La Jolla, USA, 21 to 25 March 2016)

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Appendix B

Agenda

Subgroup on Acoustic Survey and Analysis Methods
(La Jolla, USA, 21 to 25 March 2016)

1. Introduction

   1.1 Opening of the meeting
   1.2 Adoption of the agenda

2. Protocols for the collection and analysis of krill acoustic data from fishing vessels, with emphasis on Simrad echosounders (EK60, ES60/70)

   2.1 Protocols for data collection
      2.1.1 Validation of acoustic instrument performance
         2.1.1.1 Methods to improve internal instrument testing
         2.1.1.2 Availability of standard sphere calibration to krill fishing vessels
         2.1.1.3 Other calibration approaches

      2.1.2 Operational instructions for data collection
         2.1.2.1 Review and refine the existing data collection approaches

   2.2 Protocol for data screening and analysis
      2.2.1 Review noise removal algorithms
      2.2.2 Development of automated data processing/analysis algorithm/code
      2.2.3 Data storage and management

3. Analysis of data collected from fishing vessels

   3.1 Analysis to generate validated acoustic data suitable for further analyses
   3.2 Analysis to produce specific products from that validated acoustic data
   3.3 Analysis method for data collected during fishing operations

4. Survey design

5. Other issues

   5.1 Review and clarify the current documentation and instruction protocols for the implementation of the full SDWBA model
   5.2 Development of methods for the evaluation of uncertainty in acoustic estimates of krill biomass

6. Recommendations to the Scientific Committee

7. Adoption of report

8. Close of meeting.

Appendix C

List of Documents

Subgroup on Acoustic Survey and Analysis Methods
(La Jolla, USA, 21 to 25 March 2016)

SG-ASAM-16/01	A procedure for krill density estimation M.J. Cox, S. Fielding and A. Constable
SG-ASAM-16/02	CCAMLR protocol for krill biomass estimation S. Fielding, A. Cossio, M. Cox, C. Reiss and G. Skaret
SG-ASAM-16/03	Matlab code for calculating krill biomass in a survey area A. Cossio, J. Renfree and C. Reiss
SG-ASAM-16/04	Information from repeat acoustic transects to inform feedback management strategies: data for SG-ASAM 2016 C.S. Reiss

Report of the Working Group on
Statistics, Assessments and Modelling
(Genoa, Italy, 27 June to 1 July 2016)

Contents

Report of the Working Group
on Statistics, Assessments and Modelling
(Genoa, Italy, 27 June to 1 July 2016)

Opening of the meeting

1.1 The 2016 meeting of WG-SAM was held in the Sala Lignea at the Biblioteca Berio (Berio Library), Genoa, Italy, from 27 June to 1 July 2016. The meeting Convener, Dr S. Parker (New Zealand), welcomed participants (Appendix A).

1.2 The Working Group was warmly welcomed by Dr M. Vacchi (Institute of Marine Sciences (ISMAR), National Research Council (CNR) and SC-CAMLR Representative) who also outlined local arrangements, Dr A. Meloni (President of the Italian Scientific Commission on Antarctic Research (CSNA), National Antarctic Research Program (PNRA)) who also outlined the history of the Italian Science Program in Antarctica, and Dr O. Leone (Promotion Manager of the Berio Library) who also invited participants to explore the library during the meeting.

Adoption of the agenda and organisation of the meeting

1.3 The meeting agenda was discussed and adopted with a small reorganisation required to facilitate the reporting of discussions (Appendix B).

1.4 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.

1.5 In this report, paragraphs that provide advice to the Scientific Committee and its other working groups have been highlighted. A list of these paragraphs is provided in Item 7.

1.6 The Working Group used the Secretariat's online meeting server to support its work and facilitate the preparation of the meeting report. The use of the meeting server is demonstrated in four training videos which were developed by the Secretariat and are available from the CCAMLR support forum (support.ccamlr.org).

1.7 The report was prepared by M. Belchier (UK), P. Burch and A. Constable (Australia), R. Currey (New Zealand), C. Darby and T. Earl (UK), L. Ghigliotti (Italy), T. Ichii (Japan), C. Jones and D. Kinzey (USA), K. Large (New Zealand), D. Ramm, K. Reid and L. Robinson (Secretariat), R. Sarralde (Spain), M. Söffker (UK), S. Somhlaba (South Africa), G. Watters (USA) and D. Welsford (Australia).

Methods for assessing stocks in established fisheries

Review of progress towards updated integrated assessments

2.1 WG-SAM-16/36 Rev. 1 described recent developments towards an integrated stock assessment for krill in Subarea 48.1. The model was fitted to a 40-year time series (1976 to 2015) of biomass indices and length-composition data from research surveys as well as to catches and length compositions from the krill fishery. A simulated population with parameters estimated from these data was projected 20 years into the future under various candidate levels of catch. The distribution of spawning biomass during the projection period for each level of catch was compared to nine alternative reference points (including the currently accepted reference point of the median unexploited spawning-stock biomass, SSB_0), and catches compatible with the two decision rules for krill were identified for each reference point.

2.2 The Working Group noted that, in its present implementation, too many parameters are likely being estimated within the krill assessment model. The parameter estimates may thus be unstable, particularly as new data are added. It was recommended that retrospective analyses and fits to simulated data be conducted to explore the properties of the estimated parameters. Plotting the marginal likelihoods of parameters that are likely to be confounded could also help identify which parameters are estimable from the available data and clarify model performance. The Working Group further noted that model stability might be enhanced by treating fishery catches as known, rather than estimated, quantities.

2.3 Dr S. Kasatkina (Russia) noted the following with respect to the assessment in WG-SAM-16/38:

(i) The krill model estimates the variability of krill recruitment in Subarea 48.1 assuming that future recruitment will be the same as it was during 1992–2011. It also significantly truncates datasets for forecasting the future distributions of krill spawning biomass in view of ongoing climate changes. This environmental variability impacts on sea-ice coverage that might affect krill productivity and krill larvae. She proposed to supplement recruitment data by those data from the last five years to estimate recruitment trends.

(ii) The krill model does not consider the krill movements into Subarea 48.1 by geostrophic flux that will significantly affect the dynamics and krill biomass located in Subarea 48.1 during fishing seasons and years. Moreover, the krill biomass estimates from local acoustic surveys undertaken for short time (about one month) have been used for modelling the ability of krill in Subarea 48.1 to support different levels of catch over the entire subarea during different reference periods. She indicated the need to have acoustic surveys accompanied by net surveys more regularly within a year rather than a single survey in a year.

(iii) With respect to the recommendations provided by WG-FSA-15 (SC-CAMLR-XXXIV, Annex 7, paragraph 4.122) to refine the integrated krill assessment model for Subarea 48.1, she highlighted the necessity to clarify how these recommendations were implemented. In particular, she noted that there were no model diagnostics on the prior and posterior distribution of model estimates including boundary values (SC-CAMLR-XXXIV, Annex 7, paragraph 4.122ii).

2.4 The Working Group determined that the model should not presently be used to provide advice. It was agreed that additional work is required to systematically document how all past recommendations made by WG-SAM, WG-FSA and WG-EMM have been considered and either used to revise the model or suitably rebutted. It was noted that the model had been reviewed by two independent referees whose findings largely paralleled those previously made by the three working groups and which were summarised in WG-SAM-16/37. Thus, documenting how the model had been changed (or not) to address the recommendations of the working groups would also help to document how the recommendations of the independent referees had been addressed, and vice versa. It was further suggested that it would be useful to complement this documentation with how similar recommendations are accommodated within the current approach used to provide management advice for the krill fishery in Area 48.

2.5 The Working Group referred WG-SAM-16/36 Rev. 1 to WG-EMM noting that WG-EMM may usefully consider the reference points and alternative decision rules. It noted that the estimate of variability in recruitment was large and that this parameter may be a reflection of the uncertainty in the model rather than a true estimate of variability. This would need to be explored further. It further noted that changing the harvest control rule would require a full management strategy evaluation (MSE).

2.6 The Working Group thanked the authors for their continued work on an integrated assessment for krill in Subarea 48.1. It noted that WG-EMM may wish to consider application of the population model in the integrated assessment to explore hypotheses of stock structure for krill more generally.

2.7 Mr N. Okazoe (Japan) presented WG-SAM-16/38, which included information on the survey design of the dedicated cetacean-sighting vessel-based krill (CSVK) survey undertaken by Japan in the east Antarctic to enable commentary by WG-SAM on the survey design for future seasons, in particular the trade-offs between the primary goal of gathering information on cetaceans versus the secondary goal of gathering information on krill and the ocean. It also presented some results of the first CSVK survey in the east Antarctic (115°−130°E) conducted during the 2015/16 austral summer. The survey was designed for the main purpose of obtaining systematic sighting data for whale abundance estimates. Along the sighting track lines, krill survey (based on echosounder and net sampling) and oceanographic survey (based on conductivity temperature depth probe (CTD)), as well as some feasibility studies on biopsy sampling and telemetry in Antarctic minke whales (*Balaenoptera bonaerensis*), and routine photo-id and biopsy sampling on large whales, were also conducted. Mr Okazoe noted that the survey is undertaken annually over 12 years and another type of survey, CCAMLR-type dedicated krill survey, will be undertaken twice during the 12 years. The plan of the first dedicated krill survey is under development with the intention to submit the plan to the appropriate working group next year.

2.8 The Working Group noted that the sampling for krill was not likely to be adequate for validating the composition of acoustic marks obtained by the echosounders. It was noted that the size of the net is likely to be too small and is not being used to target the acoustic marks, but to identify species existing at the stations. Also, the use of a light on the net may lead to biased estimation of what organisms are being detected by the acoustics. This is because some organisms will avoid the light, while others will be attracted to it. A further concern is that insufficient krill are being obtained to estimate the length frequency of krill detected by the acoustics; the estimation of krill abundance is very sensitive to the assumed length composition.

2.9 The Working Group also noted that it was difficult to evaluate the requirements for krill and oceanographic sampling without a clear description of the questions being addressed. For example, the sampling is likely to be insufficient to determine the relationship of whales to the densities of krill or physical ocean habitat. It recommended random sampling across the area to better estimate conditions of the habitat and the characteristics of the krill populations. In this case, the number of sampling locations may need to be increased to ensure the results have high statistical power in testing hypotheses being posed. It noted that power analyses would be important to determine an appropriate number of stations.

2.10 The Working Group recalled that detailed discussions had been had in the Scientific Committee in the 1990s with respect to the design of surveys to estimate the abundance of krill. The preference from that work was for parallel transects in an area rather than a zig-zag design. It did note, however, that sea-ice may present difficulties in adhering to a design of parallel transects and that geostatistics may now be able to better estimate biomass from zig-zag designs. Simulation work based on ocean models would help identify whether that would be suitable. While the design of the whale sighting survey is a matter for the Scientific Committee of the International Whaling Commission (IWC), the Working Group also noted that many aerial sighting surveys for cetaceans used parallel transects by choice.

2.11 WG-SAM-16/39 assessed the effective sample size of different strategies for observing the catch of the krill fishery for assessing the length composition of the catch. Catch at length is an important input into any stock assessment. Consequently, collecting length data from the catch is a task undertaken by all at-sea observers in CCAMLR fisheries. Although analyses in the past have looked to the optimal design of the observer program, in terms of levels of coverage of vessels and hauls, less attention has been focused on how many krill should be measured by observers in any given haul. Catch and effort (C1 data) and observer data from Subarea 48.1, collected between 2010 and 2015, were used to characterise how many krill are measured by observers, and for how many hauls. The impact of different haul-wise sample sizes on the ability to estimate mean length in a sample per small-scale management unit (SSMU) × month combination (effective sample size) was assessed using resampling procedures and simulations. The median number of krill measured per haul was around 200 (range 0–652). However, haul-wise sample sizes of down to 50 measurements did not substantially reduce the effective sample size, whereas increasing the number of hauls sampled did substantially increase the effective sample size. The authors recommended that observers collect smaller samples (50 length measurements) at the haul level, over a greater number of hauls to allow better estimates of catch at length in the krill fishery.

2.12 The Working Group found the paper to be very informative about the current performance of the observer program and thanked the authors for bringing this paper forward. It agreed that reducing the number of krill measured in a haul while increasing the number of hauls from which krill are measured will be very important to achieve estimates of the mean size of krill in the catch in different areas and at different times.

2.13 The Working Group suggested that other metrics that may be useful for evaluating observer requirements for measuring the size of krill, such as the multinomial nature of the length-frequency distribution, should also be considered by WG-EMM in providing advice on the implementation of observations in the krill fishery.

2.14 The Working Group agreed that further analyses would be valuable in determining the spatial and temporal arrangements of observations from the krill fishery needed to assess the size of krill in different areas and times. This will be important for spreading the observations so that measurements are not concentrated where the fishery concentrates its activities in a given season. WG-SAM noted that the design of the observer program was different to the placement of hauls to obtain information on the krill population. In the case of the latter, consideration may need to be given on how to arrange some fishing operations in space and time for the purpose of addressing research questions on the characteristics of the krill stock.

2.15 WG-SAM-16/39 also presented an appendix on issues with the data extracted from the CCAMLR database.

2.16 Dr Ramm noted the data quality assurance (DQA) issues raised in the appendix and indicated that he would further discuss these issues with the authors and amend the data, where required, in the database. He also outlined the Secretariat’s current multi-year work plan to redevelop the CCAMLR database. This included the development of a data warehouse with improved data integration and DQA. The progression of the transactional database to a data warehouse will address many DQA issues that are currently being encountered.

2.17 The Working Group noted that various issues, such DQA issues, are being encountered by different researchers and there needed to be a mechanism for recording these issues and having them resolved in order that future research does not have to go through the same data cleaning and validation exercises. WG-SAM agreed that such a mechanism may be implemented through the use of standard data extracts and accompanying documentation which described each data extract and outlined DQA issues and updates.

2.18 Dr Ramm indicated that the historical data will be screened as it is transferred into the data warehouse. For new data, scripts are being developed to better automate and screen the data as it is uploaded into the transactional database. He noted that the documentation on the transactional database is limited and needs to be updated to support the use of the existing database, including the development of scripts for data extraction, prior to the implementation of the new systems associated with the data warehouse. Improved documentation is being developed for the data warehouse, along with the development of scripts for data extraction.

2.19 The Working Group encouraged all authors to provide appendices on data issues encountered during their research, as well as discuss DQA issues with the Data Manager. WG-SAM also suggested that the Secretariat develop an online archive of scripts for standard data extractions in order that these can be used to update extractions as the database evolves. It noted that, at present, there is no routine report to users of how the database has been changed from one year to another and how old records may have been modified or new records for past years been added.

2.20 The Working Group agreed that a data management group would be useful to provide a conduit between data users and the Secretariat in order to provide high-level input on the management and development of the CCAMLR database, standard data extracts and data tools.

Stock assessment methodologies

2.21 In 2013, WG-FSA produced a single table that included local biomass estimates and recommended research catch limits for exploratory fisheries for toothfish in Subareas 48.6 and 58.4 and in areas closed to fishing. This table also included relevant metrics used to assess the progress of such research fishing (see SC-CAMLR-XXXII, Annex 6, Table 13).

2.22 In response to the request from the Scientific Committee (SC-CAMLR-XXXIV, paragraph 3.232i), the Secretariat presented WG-SAM-16/18 Rev. 1 that provided an update to the summary table presented as SC-CAMLR-XXXII, Annex 6, Table 13, using the most recent data available and to detail the methods used for local biomass estimation.

2.23 The Working Group thanked the Secretariat for producing this important paper and noted that it had benefited from extensive intersessional discussion by Members via the WG-SAM e-group.

2.24 The Working Group recognised that changes in the criteria, metrics and application of methods used in setting research catch limits had resulted in some confusion in the application of methods in different research plans to WG-SAM-16.

2.25 Given the importance of this table to setting catch limits and research requirements in exploratory fisheries, there was a need to ensure clarity in the methods used to generate and update local biomass estimates. The Working Group agreed that following the confirmation of the detailed methods to be used to produce the biomass estimates (paragraph 2.28), the Secretariat be requested to produce the biomass estimates for all research blocks in Subareas 48.6 and 58.4 and to present these to WG-FSA-16.

2.26 The Working Group requested that estimates of the biomass for other proposed research blocks included in research proposals also be calculated by the Secretariat using the same methods. The Secretariat requested Members provide geographic coordinates for the extent of those research blocks in order to undertake this process.

2.27 The Working Group requested that, when producing these local biomass estimates for WG-FSA-16, the Secretariat provide the appropriate metadata on data extracted from the CCAMLR database, documentation of data cleaning processes, such as that provided in WG-FSA-13/56, and associated code for the analysis in order to ensure reproducibility of results. It was also noted that a summary of records removed or corrected due to data quality assurance processes in the database and as part of the analysis should be provided.

2.28 In reviewing the methods, the Working Group agreed the following methods for the estimation of local biomass using the catch-per-unit-effort (CPUE) by seabed area analogy and Chapman mark-recapture estimate:

CPUE by seabed area analogy method

$$B_x = \frac{I_x \times A_x \times B_r}{I_r \times A_r}$$

Where the subscripts *x* and *r* denote the parameter from the research block and reference area respectively and:

I is the median of the haul by haul CPUE where the total catch (kg) on a haul, including fish that are tagged and released (where the weight of released fish is estimated using the length–weight relationship for that area), divided by the length of line (km) reported for that set in the C2 data (paragraph 2.36).

A is seabed area (km^2) in the depth range 600–1 800 m using the GEBCO 2014 dataset (WG-SAM-15/01).

B_r is the current biomass (kg) from the most recent assessment in the reference area.

Chapman mark-recapture-based estimate of biomass

$$B_j = \frac{c_j\left(n_{j-1}+1\right)}{mx_j+1}$$

where n_{j-1} is the number of tagged fish available for recapture at the end of the season prior to season j, c_j is the catch in season j (as with CPUE the catch includes fish that are tagged and released, as these fish are scanned for tags upon capture) and mx_j is the number of tagged fish recaptured in season j (excluding within-season recaptures).

The number of tags available

$$n_j = \begin{cases} j=1, & r_j\left(1-t\right)e^{-(f+M)} - m_j \\ j>1, & n_{j-1}e^{-(f+M)} + r_j\left(1-t\right)e^{-(f+M)} - m_j \end{cases}$$

r_j is the total number of fish released in CCAMLR fishing season j

m_j is the total number of tagged fish recaptured in CCAMLR fishing season j

and n_{j-1} is the number of tagged fish available for recapture at the end of the season prior to season j

t is the post-tagging mortality rate of 0.1 (Agnew et al., 2006)

f is the annual tag loss rate which is 0.0084 (WG-SAM-11/18)

M is natural mortality where M = 0.13 for Antarctic toothfish (*Dissostichus mawsoni*) (WG-FSA-SAM-06/08) and 0.155 for Patagonian toothfish (*D. eleginoides*) (Candy et al., 2011).

2.29 The Working Group agreed that the CPUE should be estimated for *D. eleginoides* and *D. mawsoni* separately and that all hauls should be included and that the data used should not be limited to hauls with non-zero catches for that species.

2.30 The Working Group considered the choice of reference areas chosen for research blocks (WG-SAM-16/18 Rev. 1, Appendix 3, Table A3) and agreed that for *D. mawsoni* for research blocks in Subarea 48.6 and in Divisions 58.4.1 and 58.4.2, the Ross Sea region should be used as the reference area and that for research blocks in Divisions 58.4.3 and 58.4.4, the Heard Island and McDonald Islands (HIMI) region should be used as the reference area and for *D. eleginoides* in Subarea 48.6, the reference area would be Subarea 48.4 (N) (Table 1).

2.31 The Working Group requested that the Secretariat provide an analysis of effort (hooks set) and catch rate (number of fish and kg/hook) for the research blocks and reference areas, to evaluate the appropriateness of using the depth range of 600–1 800 m as the fishable area for these calculations.

2.32 In order to better understand the uncertainty in the estimate of local biomass in the research block, the Secretariat was requested to work with Members to present a bootstrap analysis to WG-FSA-16, drawing on distribution of CPUE data in the reference area and the research block and B_{current} in the reference area, to provide a mean and variance estimate of B_{r}. The methods and results from this analysis would be presented in a paper to WG-FSA-16.

2.33 The Working Group noted that a bias in the number of tags available could be introduced by the movement of fish out of a research block and that, while such a bias may vary between habitat types, it was likely to occur on research blocks that contain seamounts as well as those adjacent to the Antarctic coast.

2.34 The Working Group noted that, based on the analysis of data from small-scale research unit (SSRU) 882H, movement-related bias would increase with time and, therefore, the Working Group agreed that for research fishing where movement has yet to be assessed only tagged fish released in the last three years should be considered to be available for recapture. The Working Group noted that when there was sufficient data to address this bias for a particular research block, then this would be reviewed and applied as appropriate.

Future developments

CPUE standardisation

2.35 The Working Group recognised that differences in CPUE by gear type were potentially important, however, differences between the gear used in reference areas (Ross Sea region and HIMI) and in the research blocks mean that it is not always possible to use CPUE for the same gear in the CPUE by seabed area analogy approach.

2.36 The Working Group recalled previous work on standardising CPUE, including analyses presented in WG-FSA-11/35 and WG-FSA-13/63, and recommended building on those studies to review approaches to standardising CPUE data for use in the CPUE by seabed area analogy approach, including the suitability of using the number of hooks and/or line length as a measure of effort.

2.37 Dr Kasatkina noted that the local biomass estimation method used in WG-SAM-16/18 Rev. 1 was accompanied with significant uncertainty. She also noted that the Chapman biomass estimates were obtained disregarding any assumptions in relation to tag-release mortality, the degree of spatial overlap between tagged fish and fishing efforts, possibility of migration of tagged fish across the boundary of research blocks including migration out of the fishing ground.

2.38 Dr Kasatkina indicated that the CPUE by seabed analogy method was applied without standardisation of CPUE between types of longlines and the median CPUE (kg/km) was estimated from all vessels and all longline gears (trotlines, Spanish and autoline). She noted that the estimate of CPUE was obtained as kg of catch per 1 km of longline regardless of variability in the number of hooks per 1 km between vessels and gears. She further noted that the CPUE data normalised to thousand hooks would be more suitable for use in the CPUE analogy method.

2.39 Dr Kasatkina noted that analysis of the longline fishery in the Ross Sea (e.g. SSRUs 881B, C and G, WG-SAM-16/26 Rev. 1) highlighted significant variability of CPUE between longline types as well as differences in CPUE (kg km^{-1}) and CPUE (kg/thousand hooks) for each longline type (trotlines, Spanish and autoline). She indicated that this variability might arise from different selectivity and different spatial coverage of fishing effort using different gear types and that the latter issue would usually be taken into account in stock assessment methods.

2.40 The Working Group noted that commercial CPUE is not used in the Ross Sea stock assessment.

Selection of local biomass estimates for use in setting catch limits

2.41 The Working Group noted that in 2014 WG-FSA outlined a process for how catch limits for research are derived and agreed that where there were multiple estimates of biomass that the lower estimate should be used (SC-CAMLR-XXXIII, Annex 7, paragraph 5.123i). This was the method that was followed in WG-SAM-16/18 Rev. 1.

2.42 Dr Ichii noted that WG-FSA-13 agreed that where alternate methods yielded conflicting estimates of local biomass, comparing expected versus observed recaptures may inform selection of the more plausible biomass estimate (SC-CAMLR-XXXII, Annex 6, paragraph 6.25). He indicated that this selection procedure is indispensable and provides justification of the selection of a biomass estimate used in setting catch limit.

2.43 In addition, Dr K. Taki (Japan) and Mr Somhlaba pointed out the significant difference of meaning between SC-CAMLR-XXXII, Annex 6, paragraph 6.26 and SC-CAMLR-XXXIII, Annex 7, paragraph 5.123. They considered that SC-CAMLR-XXXII, Annex 6, paragraph 6.26, means the catch limits which expect the more than 10 recaptures of tagged fish are allowable when those do not exceed the exploitation rate of 4%, because the more sample sizes lead to the more reliable stock assessment, while SC-CAMLR-XXXIII, Annex 7, paragraph 5.123, considers the 10 recaptures of tagged fish as the precautionary index, which is not based on the original sense, and the precautionary index should be restricted to the exploitation rate of 4%. Dr Taki and Mr Somhlaba requested WG-FSA to clarify the situation.

2.44 The Working Group agreed that, while it may be considered precautionary to use the lower local biomass estimate, it was important to understand the variance. Where two biomass estimates are available, there are a range of factors that could be included in the choice of which estimate to use in determining a catch limit.

2.45 The Working Group agreed that, while it had not yet developed further advice on the process for the decision of which biomass estimate to use in setting catch limits for research, there is an expectation that the variance in those estimates is likely to be used in such a decision process. Therefore, the Working Group agreed that developing measures of the uncertainty in the estimates of local biomass and how such measures are used in the decision of selecting the most appropriate biomass estimate to use should be a priority area of work in the coming intersessional period.

2.46 The Working Group recalled that the local biomass estimates should not be considered as a biomass estimate upon which to set long-term catch limits for a sustainable fishery but they are designed to facilitate research and, therefore, it was important to define the period of that research.

2.47 The Secretariat had identified that differences in the numbers of fish available for recapture could arise as a result of the selection of the data source of the tagging location data such that when all data collected on a set are georeferenced to the location of the start of the set, there can be small differences in location relative to the tagging location data provided by observers. The Working Group noted that there are operational reasons why the location for the release of a tagged fish could be some distance from the actual set location and agreed that the location provided by observers was more appropriate and agreed that any tags released within 5 km of the research block boundary should be included in the estimation of tags available for recapture for that research block.

2.48 The Working Group noted that the estimated biomass based on tag data will be sensitive to the values of parameters for tag loss or mortality of tagged fish. If possible, these need to be estimated directly for different areas, to take account of factors that may differ between vessels or between areas such as the potential for thermal shock. In the absence of such direct estimates, it is highly desirable to investigate whether tag recaptures are consistent with those from areas where the parameters governing tag survivorship were estimated, including through an extension of the 'case-control' method used for the Ross Sea region assessment as described in WG-SAM-13/34.

2.49 WG-SAM-16/13 described the development of an index to assess the potential bias in the difference in the spatial distribution of the release of tagged fish and the subsequent spatial coverage of fishing effort to recapture tagged fish.

2.50 The Working Group welcomed WG-SAM-16/13 and noted that the issues of the spatial structuring of toothfish fisheries in the paper were directly relevant to important topics identified by the Scientific Committee (SC-CAMLR-XXXIV, paragraph 3.83) and encouraged further work on the indices developed in the paper and, in particular, how these indices might be used in an absolute (rather than relative) context and also work to evaluate the impact of the movement of fish on the overlap metrics.

2.51 In considering the description of the data cleaning steps undertaken in the preparation of WG-SAM-16/18 Rev. 1, the Working Group agreed that confidence in the data quality assurance in the CCAMLR database was fundamental to the work of CCAMLR scientists. It further agreed that there is a need to ensure that differences in analyses do not arise as a result of differences in the data provided in data extracts and recommended that all data extracts contain clear documentation on the code used to extract the data from the database and details of all data quality assurance and data cleaning that had been applied to the data used in any analysis.

2.52 The Data Manager updated the Working Group on the work outlined in WG-SAM-15/33 on the redevelopment of the CCAMLR database, including the implementation of a data warehouse, and described how the work underway in the Secretariat had expanded to cover all elements of CCAMLR data. Migrating all of the data simultaneously is a much larger undertaking than was originally planned, hence the timeline on the delivery has been impacted significantly and, as a consequence, it was not possible to provide a definitive date for the completion of this work.

2.53 The Working Group thanked the Secretariat for the ongoing work to improve the DQA associated with the CCAMLR databases and noted that this work should be applied to the transaction database as well as the data warehouse. The Working Group requested that changes to the data that arise as a result of applying data quality checks that occur in the current transaction database, and those that will occur in moving data from the transaction database to the data warehouse, be recorded in a systematic way that allows users to review the potential for such changes to introduce differences from the results of historical analyses.

2.54 The Working Group requested the Secretariat provide a paper to the Scientific Committee on the milestones and timeline for developing the new data system. It will be important for Members to know these timelines in order to better plan their work and what DQA tasks may be required in the interim of the data warehouse being completed.

Review of research plans in Subareas 48.6 and 58.4

Review of research plans in Divisions 58.4.1 and 58.4.2

3.1 WG-SAM-16/28 presented results of the second year of the Korean research program in Division 58.4.1. Research was conducted across the research blocks in Division 58.4.1. The Working Group noted that this program included the objective of characterising the food web in the region and that a paper on the stable isotope composition of *D. mawsoni* from the region had been submitted to WG-EMM-16 using samples collected during this program (WG-EMM-16/31).

3.2 WG-SAM-16/17 described the proposal to continue research in Divisions 58.4.1 and 58.4.2, continuing the design used to date, including sampling tissue and stomach contents of toothfish, otoliths, CTD casts and plankton sampling. The Working Group welcomed the collection of datasets which could provide additional context on the environment in Divisions 58.4.1 and 58.4.2. It also noted the recovery of a pop-up satellite archival tag (PSAT) released by the Republic of Korea in the previous year and welcomed a further analysis of the data to be submitted to WG-FSA-16.

3.3 WG-SAM-16/35 reported on the catch effort and biological data collected by Australia while undertaking its research plan in Division 58.4.1. Two research blocks in SSRU 5841E and the grid over the location of the Spanish depletion experiment in SSRU 5841G were fished. Catch was dominated by *D. mawsoni*, and by-catch by *Macrourus* spp. *Dissostichus eleginoides* were also encountered in small numbers in SSRU 5841E. By-catch was highest in sets conducted in depths shallower than 1 000 m and deeper than 1 800 m. Three tags were recaptured, however, two were within-season recaptures.

3.4 WG-SAM-16/34 reported on environmental and video data collected in Division 58.4.1. The Working Group noted that all video footage indicated the seafloor consisted of soft sediments or cobbles with low densities of vulnerable marine ecosystem (VME) indicator organisms in all 15 locations cameras were deployed. Motile fauna, including squids, fish and echinoderms were also recorded. CTD data was also collected from 33 locations. The Working Group welcomed this unique component of the Australian research, and encouraged other Members to consider adding cameras and other sensors to fishing gear to provide data to improve habitat and species distribution maps in the Convention Area.

3.5 WG-SAM-16/09 presented the plan for research fishing by Australia in Divisions 58.4.1 and 58.4.2 in 2016/17. The Working Group noted that the focus in the coming season would be returning to the research blocks fished in 2015/16, as well as targeting research block 5842_5 to attempt to discover younger *D. mawsoni* and assist with evaluating the current stock hypothesis for the region. Australian Antarctic Division scientists will also be developing an ageing program for *D. mawsoni* and methods for rapid analysis of video footage and CTD data.

3.6 WG-SAM-16/40 Rev. 1 presented a summary of results of the three years of depletion experiments conducted by Spain in Division 58.4.1. In two out of the three locations where depletion experiments had been initiated in 2015/16, depletion curves were not able to be consistently fitted, and tag recaptures were lower than expected. The Working Group recalled that there had also been mixed success with ad hoc depletion experiments in the past in the Convention Area, and that the Spanish results confirmed that planned depletion experiments were also difficult to interpret and convert into robust information on local biomass. It also noted that the data used for bootstrapping had outliers which appeared to be generating bias in the biomass distribution. It also noted that robust bootstrapping methods would be more appropriate to use with these datasets to reduce biases introduced by outliers.

3.7 WG-SAM-16/10 presented a proposal by Spain to conduct research fishing in Division 58.4.1 across existing research blocks as well as continuing to tag and recapture tagged fish in the three locations where depletion experiments have occurred over the last three seasons. The Working Group welcomed the information that Spain had initiated an ageing program using *D. mawsoni* otoliths collected from research catches. The Working Group requested that additional information be provided to WG-FSA-16 as to the rationale for establishing new research blocks around the three depletion experiment locations. It further noted that the Australian research in 2015/16 released tagged fish across a grid including the location of the depletion experiment in SSRU 5841G.

3.8 WG-SAM-16/04 and 16/05 presented proposals by Japan to conduct research fishing in Divisions 58.4.1 and 58.4.2 respectively. Japan was unable to conduct research fishing in this region in 2015/16, but proposed to undertake the same activities as outlined in its proposals last year (SC-CAMLR-XXXIV, Annex 5, paragraph 3.11).

3.9 WG-SAM-16/01 and 16/02 presented proposals by France to conduct research fishing in Divisions 58.4.1 and 58.4.2 respectively. France was unable to conduct research fishing in this region in 2015/16, and proposed to undertake the same activities as outlined in its proposals last year (SC-CAMLR-XXXIV, Annex 5, paragraph 3.16).

3.10 The Working Group noted that Japan had proposed to conduct research in this region for several years, but had not been able to commence research. It noted that the Scientific Committee had advised that Japan conduct research in Subarea 48.6 as a priority (SC-CAMLR-XXXIV, paragraph 3.233) and, therefore, the proposal should be modified to reflect what would be realistically possible in 2016/17 in Divisions 58.4.1 and 58.4.2.

3.11 The Working Group noted that during the previous three-year research plan, very little fishing effort in Division 58.4.2 had occurred due to the strong seasonal pattern of sea-ice and prioritisation of research and exploratory fishing in other areas during the summer when the research blocks were most likely to be open. However, it noted that the Republic of Korea had captured 11 tonnes of toothfish and released 82 tagged toothfish in research block 5842_1 during research in 2014/15.

General matters

3.12 The Working Group recalled the recommendation of the Scientific Committee (SC-CAMLR-XXXIV, paragraph 2.9) that there was a need to coordinate research across all of Subarea 58.4 to ensure that vessel effort was distributed to make the most effective use of the research and ensure rapid progress towards an assessment of the stock in these areas (SC-CAMLR-XXXIV, Annex 5, paragraph 3.17). It welcomed the undertaking that consolidated research plans be presented by the proponents of research in Divisions 58.4.1 and 58.4.2 to WG-FSA-16.

3.13 The Working Group requested the development of measurable research milestones that included both at-sea and onshore coordination of research activities, including analysis of samples and desktop studies to progress assessment of the toothfish stock in the area.

3.14 It was noted that activities in 2015/16 had been conducted using an initial research allocation as agreed between proponents in SC-CAMLR-XXXIV, Table 2, and that this mechanism had successfully avoided 'olympic research', as well as providing for circumstances where vessels were unable to participate. The Working Group noted that similar principles could be applied in other areas where multi-Member multi-vessel research plans were proposed or underway.

Review of research plans in Division 58.4.3a

3.15 WG-SAM-16/03 presented a research plan for the exploratory longline fishery for *Dissostichus* spp. in 2016/17 in Division 58.4.3a by France and Japan. The Working Group noted that research fishing has been conducted in the research block by two vessels using longlines. The proposal notified that France and Japan intend to continue their exploratory fisheries in Division 58.4.3a to contribute to the tagging program and to achieve a robust stock assessment.

3.16 A biomass of 398 tonnes was estimated during WG-FSA-15 using the geometric mean of Chapman biomass estimators. The Working Group noted that further developments of a CASAL integrated stock assessment model requires a stock biomass with reliable estimates of illegal, unreported and unregulated (IUU) removals, as well as a maturity key and parameters for the von Bertalanffy growth curve from age readings.

3.17 The Working Group noted that CPUE was described in different units (kg km^{-1} and kg/hooks) in different parts of WG-SAM-16/03 and recommended that it would be clearer to present these CPUEs in the same units throughout the paper. The Working Group further noted that only the size distribution of tagged fish was compared to the size distribution of the recaptures, and recommended that it would be useful to compare it with the length-frequency distribution of the entire catch.

3.18 The Working Group underscored the need to develop a procedure to estimate IUU removals in this division and to include this in the development of a robust stock assessment.

Review of research plans in Division 58.4.4b

3.19 WG-SAM-16/06 presented a research plan for the 2016/17 toothfish fishery in Division 58.4.4b (research blocks 5844b_1 and 5844b_2) by Japan and France using the updated CCAMLR C2 and observer data. The estimated median stock size in research blocks 5844b_1 and 5844b_2 was 380 and 483 tonnes respectively using the Chapman estimator, and 1 057 and 1 153 tonnes respectively using the CPUE analogy method (reference area: northern area of Subarea 48.4).

3.20 WG-SAM-16/06 suggested that predicted numbers of tag recaptures using a CPUE analogy method were generally closer to the observed ones for both blocks, and proposed to continue the current research operation for the next fishing season with the same survey design as recommend for 2015/16.

3.21 The Working Group noted that it would be useful to provide WG-FSA with a standardised CPUE series for this division (paragraph 2.36).

3.22 The Working Group recommended that it would be valuable to compare tag-recapture rates between the Japanese and French vessels in this division, and that a table of this comparison be provided to WG-FSA. It was further recommended that a figure of the location of planned and realised sets (mid-points) carried out in this division should be provided to WG-FSA-16.

Review of research plans in Subarea 48.6

3.23 The Working Group considered five papers relating to research plans and results of research conducted in Subarea 48.6, including a summary of results of four years of research fishing carried out by Japan and South Africa (WG-SAM-16/41 Rev. 1), an analysis of sea-ice concentration in the south of Subarea 48.6 (research blocks 486_4 and _5) (WG-SAM-16/42 Rev. 1), a proposal to extend the spatial extent of research block 486_2 (WG-SAM-16/08), an updated joint proposal to continue research fishing in Subarea 48.6 submitted by Japan and South Africa (WG-SAM-16/07) and a proposal for three years of planned research fishing by Uruguay (WG-SAM-16/12).

Review of Japanese and South African research plans

3.24 The Working Group welcomed the joint progress report on research fishing from South Africa and Japan (WG-SAM-16/41 Rev. 1) and noted that a preliminary integrated assessment for research block 486_2 had been attempted using data from 2009 onwards which included new estimates of growth parameters and age-at-maturity data derived from an otolith ageing program. The Working Group also welcomed the provision of research ‘milestones’ which included a summary of research progress to date and an overview of future research, including an indication of how various components of the research would be shared between the proponents (WG-SAM-16/41 Rev. 1, Table 11).

3.25 The report also contained an outline of a stock hypothesis for the region which suggests that the life history of *D. mawsoni* in Subarea 48.6 is similar to that seen in the Ross

Sea with juveniles inhabiting the continental shelf region with northward spawning and southward feeding movements. However, the Working Group noted that the stock area had not yet been resolved.

3.26 The Working Group noted that the research fishing was now into its fourth year and that over this period almost all fishing had taken place in research blocks 486_2–4. Research block 486_1 was fished in one year only and catches were dominated by *D. eleginoides*. Poor ice conditions meant that research block 486_5 was accessible in only one year in four. The Working Group noted that an inability of vessels to consistently return every year to a research block in order to deploy or catch tagged fish was a major constraint on the development of an assessment. Based on information from the Ross Sea, it is assumed that the change in availability of tagged fish resulting from movement of fish means that tagged fish are considered unavailable for recapture after three years at liberty. Therefore, if access to a region is restricted for more than two years in three, the recovery of tagged fish would not be predicted from that research block.

3.27 The Working Group noted that the lack of a robust stock hypothesis was impacting on the ability to develop an integrated stock assessment for Subarea 48.6. It noted that the further development of a stock hypothesis for *D. mawsoni* for Subarea 48.6 would benefit from data from the shelf region in research block 486_5 and this has been severely limited by access issues caused by sea-ice. The Working Group agreed that the current low levels of tag returns and only limited information on fish movement away from research blocks meant it was difficult to interpret the results obtained from different methods of estimating biomass and, therefore, evaluate which was likely to be the more reliable.

3.28 The Working Group agreed that the focus of research should be on efforts to resolve the movements of fish between research blocks and to improve the tag-recapture rate.

3.29 The Working Group agreed that the use of PSATs could provide a considerable amount of information on fish movement that could be used to further develop a stock hypothesis and noted that they could potentially be deployed in research block 486_5 (when ice conditions were good) without the need to return in subsequent years in order to obtain information on fish movement.

3.30 The Working Group noted that sea-ice could limit the utility of PSATs (as they must reach the surface to transmit data) but they could also provide useful and rapid information on movement of individuals if deployed in ice-free research blocks such as 486_2 and 486_3.

3.31 The Working Group welcomed the sea-ice analysis carried out by Japan (WG-SAM-16/42 Rev. 1) which examined accessibility of research blocks 486_4 and 486_5 in the southern region of Subarea 48.6 over the last four years using satellite-derived data.

3.32 The Working Group noted that such analyses are very useful in providing an indication of the inter- and intra-annual variability in the accessibility of research blocks to fishing vessels and could potentially be used to predict periods when access is most likely. However, it was noted that operational constraints on vessels mean there may not be a temporal overlap with optimum ice conditions and this may impact the ability to collect the necessary information. The Working Group encouraged Japan to continue these analyses using data spanning a greater number of years. This could be used to indicate regions of the continental shelf within fishable depths that may have more reliable and frequent access than research block 486_5.

3.33 The Working Group considered WG-SAM-16/08 by Japan which proposes an extension to the spatial extent of research block 486_2. The rationale for the extension to the research block is that it is adjacent to an area of higher *D. mawsoni* density within the existing research block which could increase the possibility of the catch limit for the research block being taken. There would be no increase in catch for this research block but it would come from the limit for the existing research block 486_2.

3.34 Dr Ichii noted that in the western part of research block 486_2 near Bouvet Island, both *D. mawsoni* and *D. eleginoides* will possibly be taken as by-catch, even though fishing tends to focus on *D. mawsoni*. He also considered that it is worthwhile shifting the block north-eastward where possibly only *D. mawsoni* are distributed, so that it can avoid by-catch of *D. eleginoides*. Japan will resubmit a proposal on this revision to WG-SAM-17.

3.35 The Working Group noted that such an approach was likely to dilute fishing effort across a larger area and, therefore, could reduce the ability of vessels to scan tagged fish and dilute tagging effort in the research block. It was suggested that moving the existing block whilst maintaining the same effort would have the same effect, but would result in the loss of some existing tagged fish that would then be outside the research block.

3.36 The Working Group considered the joint proposal by Japan and South Africa for continuing research in Subarea 48.6 for 2017 (WG-SAM-16/07). It noted that the proposal was largely unchanged from the existing plan, except for the proposal for extension of research block 486_2 (see paragraph 3.33).

Uruguayan proposal for research fishing in Subarea 48.6

3.37 The Working Group considered a three-year proposal by Uruguay to conduct a plan of research fishing in Subarea 48.6 (WG-SAM-16/12). The proposal is based on the joint Japanese/South African research with effort focussed on research blocks 486_1–4. The aims of the planned research fishing are to increase the number of fish tagged and scanned in the subarea. The vessel would use trotline fishing gear.

3.38 The Working Group noted that a greater number of Members involved in research in Subarea 48.6 may lead to an increased amount of work carried out and speed up the rate at which data are collected. However, the Working Group noted that the science objectives of the planned research were currently not clear and did not include a plan for analysis of collected samples, or for desktop analysis to contribute to the development of stock structure and other data inputs needed for stock assessment.

3.39 The Working Group also noted that Uruguay had not yet approached the proponents of the existing joint research plan in Subarea 48.6 (Japan and South Africa) in order to coordinate research activities. The Working Group recalled that this coordination should include both on-water activities and the subsequent analysis of samples and data and recommended that Uruguay collaborate with South Africa and Japan in any planned research fishing activities in Subarea 48.6.

Advice on research proposals in Subarea 48.6

3.40 The Working Group evaluated whether the current research plan was achieving its objective towards the development of an integrated stock assessment for Subarea 48.6. It noted that without data to test the stock hypothesis it was not clear how the transition from estimation of biomass within research blocks to an integrated assessment for the whole subarea would be achieved. In order to expedite the process of testing the stock hypothesis and increasing the likelihood of obtaining sufficient tags necessary for the development of an integrated stock assessment, the Working Group recommended that:

(i) research fishing in Subarea 48.6 should be targeted towards *D. mawsoni* as a greater amount of data derived from research fishing is available compared to *D. eleginoides*. Catches from research block 486_1 have been comprised solely of *D. eleginoides* and this block should be removed from research proposals

(ii) research blocks 486_2, _3 and _4 should be considered priority areas for research fishing as they are consistently free of sea-ice at the time of the research fishing and represent a diverse range of likely toothfish habitat

(iii) the use of PSATs is encouraged in the priority research blocks to provide data on fish movement within and outside these areas

(iv) the Working Group further recommended that the following analyses should be carried out and a report be submitted to WG-SAM-17:

   (a) further analyses of sea-ice dynamics should be carried out over the whole of the continental shelf region to identify other regions of suitable toothfish habitat that may be more reliably ice-free in a given year and would enable the detection of tags with an assumed tag availability period of three years

   (b) an analysis of all available tag data should be undertaken to better characterise fish movement within and between research blocks to assist with validation and development of the stock hypothesis.

3.41 The Working Group also agreed that a range of other research fishing and analytical activities analogous to those carried out in the Ross Sea should be considered in the longer term. This includes:

(i) winter surveys in ice-free northern areas to provide data on the spawning dynamics of *D. mawsoni* in the region

(ii) random stratified, effort-limited sub-adult surveys of the southern shelf region to provide data on recruitment

(iii) experimental work and desktop-based analyses of data from both fishery and other scientific fields to understand stock structure, life history, movement patterns and productivity.

Review of scientific research proposals for other areas (e.g. closed areas, areas with zero catch limits, Subareas 88.1 and 88.2)

Structurally changed or new research proposals intended to provide other advice

Research proposals in Subarea 88.1

4.1 WG-SAM-16/14 presented the results of the fifth CCAMLR-sponsored Ross Sea shelf survey to monitor abundance of sub-adult *D. mawsoni* in the southern Ross Sea. The survey included numerous objectives as outlined in WG-SAM-15/45, with two additional objectives relating to the deployment of PSATs to assess toothfish movements and baited cameras to observe fish and animals throughout the water column. The survey successfully completed 45 sets in the core survey strata and 10 sets in McMurdo Sound, detecting an increase in catch rates of sub-adult fish in the core strata consistent with a strong year class progressing through the surveyed population. The paper included the notification and survey station locations for the continuation of the survey in 2017. The Working Group recalled that continuing the survey in 2017 was recommended by the Scientific Committee and endorsed by the Commission (SC-CAMLR-XXXIV, paragraph 3.190; CCAMLR-XXXIV, paragraph 5.34).

4.2 The Working Group welcomed the paper, noting the new information presented on the prevalence of depredation by scavenging benthic amphipods (lice). It noted a high prevalence of lice in some areas, the potential for depredation to impact on CPUE and a weak correlation with soak time. It noted the recent Coalition of Legal Toothfish Operators (COLTO) symposium on depredation at which sperm whale and killer whale depredation were the key focus, but other forms of depredation (e.g. from lamprey, hagfish and squid) were also discussed. It noted a meta-analysis of lice prevalence would be useful, as would collection of lice prevalence data in other areas of the Ross Sea. It recalled the establishment of the depredation e-group and noted that it may be a useful forum for the discussion of all forms of depredation.

4.3 The Working Group noted that the survey estimates of CPUE were precise relative to other survey series. It noted that the precision of the estimates was a consequence of applying appropriate survey methodology (i.e. using standardised gear and applying a random stratified survey design) in an area with relatively stable catch rates. It noted the difference in size distribution between the catch in the survey strata and research fishing that was occurring through the sea-ice in McMurdo Sound, with predominantly larger older fish being found in the southern areas, highlighting the value of sampling in those areas.

4.4 Dr Parker provided an update on the CCAMLR-sponsored Ross Sea winter survey to investigate *D. mawsoni* spawning (WG-SAM-15/47) that is currently being conducted in the northern Ross Sea. The survey is being conducted with international collaboration from the Italian Antarctic Programme and ISMAR in Genoa. Five PSATs were deployed on the northern seamounts in collaboration with the USA. A report of the survey will be provided to WG-FSA.

Research proposals in Subarea 88.2 (north and south)

4.5 WG-SAM-16/26 Rev. 1 presented analysis of catch and fishing effort from *Dissostichus* spp., as proposed in SC-CAMLR-XXXIV, paragraphs 3.200 and 3.201 and

CCAMLR-XXXIV, paragraphs 5.38 to 5.41, in the exploratory fishery in the northern part of the Ross Sea (SSRUs 881B, C and G). Data from the autoline longline fishery for the period of 1997–2015 was used as example.

4.6 Dr Kasatkina recalled that in accordance with current practice used by WG-SAM and WG-FSA in the presence of questionable CPUE values (kg/thousand hooks or kg km^{-1}) it is recommended to analyse: (i) reconciliation of vessel monitoring system (VMS) data with reported catch location data; (ii) the relationship between hauling duration and CPUE; and (iii) the relationship between hauling speed and CPUE. She noted that it is necessary to clarify whether this approach to analyse longline fishery provides adequate information for decision-making.

4.7 Dr Kasatkina indicated that the analysis in WG-SAM-16/26 Rev. 1 shows the presence of a weak dependence between haul duration and CPUE and between haul speed and CPUE: the correlation coefficients were in the range 0.05–0.4. In some cases, a negative correlation or lack of dependence was observed. However, regardless of the relationship between CPUE and hauling duration (or speed), there is a possible presence of high CPUE, which are outside the upper limit of confidence interval of 95% CI as well as 99.7% CI. In her opinion, CPUE values outside the upper limit of 99.7% CI are statistically unreliable and questionably high with respect to the fishery data in the year under consideration.

4.8 Dr Kasatkina noted that it is obvious that the presence of high CPUE outside the 99.7% CI, as well as the lack of dependence between CPUE and hauling speed (hauling duration), may occur regardless of the reconciliation of VMS data with reported catch location data.

4.9 Dr Kasatkina highlighted that the current approach to analyse longline fishery data in the presence of questionable CPUE values does not allow revealing adequate information for decision-making. She proposed to add the following procedures into the above said analysis of longline fishery data:

(i) criteria for the assessment of CPUE variability from the duration and speed of hauling (for example, significance measure of the correlation values)

(ii) confidence interval (e.g. 99.7%) for the decision-making in relation to questionable CPUE values.

4.10 The Working Group thanked the authors for the analysis. It noted that the presentation included material that was not included in the paper and noted that the presentation was appended to the original paper and submitted as WG-SAM-16/26 Rev. 1. In reviewing the presented material, the Working Group noted that it is usual that some CPUE values will be above the confidence intervals. In the majority of CPUE analyses, the distribution of the CPUE values does not usually follow a normal distribution as was assumed in the analysis presented. The Working Group also noted that CPUE regression analysis could be improved by adding prediction intervals about the regression to highlight those data outside the specific interval. It noted, however, that the confidence intervals shown in the presentation reflected variation in only one dimension of one of the regressed parameters and, therefore, were not valid for the inferences made.

4.11 The Working Group noted that the survey data included in the analysis came from three Members' vessels and, therefore, represented independent CPUE samples with similar characteristics, exhibiting both high and low values of CPUE.

4.12 The Working Group acknowledged the offer of New Zealand and the UK to work with Russia to develop methods that could be used to assess the quality of fishery data and hoped that these methods could be presented to WG-FSA-16.

4.13 WG-SAM-16/16 Rev. 1 presented an analysis of catch and effort data in SSRUs 882A–B north from the 2015 fishing season, including comparisons with data from exploratory fisheries and closed areas (performed by New Zealand, Norway and the UK as indicated in SC-CAMLR-XXXIV, paragraphs 3.200 and 3.201). The authors concluded that the characteristics of the haul and catch metrics, and of the biological records taken from fish caught by the three independent vessels conducting the SSRUs 882A–B offshore survey, are consistent with those collected by other vessels fishing in comparable CCAMLR areas.

4.14 The Working Group thanked the authors for the analysis. It noted that it included all available data from exploratory fisheries and closed areas until 2015, but excluded quarantined data.

4.15 Dr Kasatkina noted that catch and effort data from the 18 longline sets undertaken during the 2015 survey in the northern region of SSRUs 882A–B were compared with those from a large number of longline sets conducted by exploratory fisheries in different areas of the Convention Area. She indicated that the results only showed that CPUE from the survey were within the range observed from all available data from exploratory fisheries and closed areas until 2015. She also emphasised that it has yet to be determined whether the high CPUE in the northern region of SSRUs 882A–B are the specific properties of this region or represent questionable data.

4.16 Dr Kasatkina also highlighted that the analysis does not provide methods for identifying any potentially questionable sources of the high CPUE observed in the northern region of SSRUs 882A–B. She noted that CPUE values of higher than 100 fish/thousand hooks constitute only a very small proportion of all available longline sets from exploratory fisheries and closed areas while they comprise 4 out of the 18 longline sets obtained during the 2015 survey in SSRUs 882A–B.

4.17 Dr Kasatkina emphasised the necessity to provide an analysis of the VMS data with reported haul locations and proposed to provide this to WG-FSA-16 that will accomplish the objectives stated in the Scientific Committee (SC-CAMLR-XXXIV, Annex 7, paragraph 4.104; SC-CAMLR-XXXIV, paragraph 3.200).

4.18 The Working Group noted that for any further analysis in this context, the objectives should be clearly stated, hypotheses identified, and that criteria to meet these objectives that are acceptable to all Members be stated.

4.19 The Working Group agreed on the importance of identifying a set of diagnostics and clear criteria to assess the likelihood that a vessel is operating as would be expected in normal research fishing activities, so that the Working Group could provide advice to the Scientific Committee. It noted that characterising research fishing activities and the operation of vessels would be helpful in developing diagnostics and criteria. The Working Group noted that those records identified as suspect should be flagged in the database.

4.20 The Working Group recommended that an e-group be established to develop objectives (paragraph 4.18) and to continue the analyses of CPUE identified above and to develop a common approach and outcomes. This would facilitate the participation of all Members to help continue the work and resolve any outstanding issues. All Members with an interest in these analyses and the results are encouraged to participate.

4.21 WG-SAM-16/15 presented the proposal for a second multi-Member longline survey of toothfish in the northern Ross Sea region (SSRUs 882A–B), to be conducted by Australia, New Zealand, Norway and the UK. The proponents noted the proposal had the same objectives as for the first year of the survey but that there had been minor modifications to the design, including: vessels recording depth and location every five minutes; vessels fishing in the same research blocks as in 2015; spreading samples spatially by applying a 25 tonne catch limit per research block while retaining a maximum of 17 250 hooks per cluster of five sets; adopting a data collection plan to ensure adequate data are collected and samples processed by Members; and agreeing that observers transmit summary data daily for scientific oversight by each Member conducting the research.

4.22 The Working Group noted the overall objective of the research was to provide the necessary information to enable the opening of closed SSRUs as part of the Ross Sea region toothfish fishery by identifying appropriate catch splits and obtaining movement data for a spatial population model (SPM) from tag recaptures. It noted that such research could be used as a template for CCAMLR-sponsored multi-Member, multi-sample surveys across the whole of the northern part of Subarea 88.1 and SSRUs 882A–B.

4.23 Dr Kasatkina recalled that analysis of the 2015 survey in the northern region of SSRUs 882A–B was uncompleted and this analysis does not meet the recommendation of the Scientific Committee (SC-CAMLR-XXXIV, Annex 7, paragraph 4.104; SC-CAMLR-XXXIV, paragraph 3.201). She cannot support the proposal for a second longline survey of toothfish in the northern Ross Sea region (SSRUs 882A–B).

4.24 Dr Kasatkina stated that the high CPUE from the 2015 survey in the northern region of SSRUs 882A–B should result in all of the data from this survey being placed into quarantine until a satisfactory analysis of the questionably high CPUE has been completed, as occurred when data from Subarea 48.5 showed questionable CPUE values and the data was subsequently placed under quarantine.

4.25 Some participants of the Working Group noted that the survey proponents had provided an analysis of the data in WG-SAM-16/16 Rev. 1, which contained both high and low catch rates. The initial analysis indicated that the data was consistent with fishing parameters estimated within other comparable areas, and the analysis will be continued and submitted to WG-FSA-16.

4.26 The Working Group noted that the data currently quarantined in Subarea 48.5 had been agreed to be quarantined by the Commission, including the Members submitting that data to CCAMLR (CCAMLR-XXXIII, paragraph 5.66; CCAMLR-XXXIV, paragraph 3.90), following analysis conducted at the Scientific Committee that showed it was inconsistent with what would be expected under normal research fishing activities (SC-CAMLR-XXXIII, paragraphs 3.230 to 3.234).

4.27 At the time of adoption, Dr Kasatkina stated that Russian data currently quarantined in Subarea 48.5 is the responsibility of the Standing Committee on Implementation and Compliance (SCIC) but not the responsibility of WG-SAM.

4.28 The Working Group recalled the discussion of the Scientific Committee (SC-CAMLR-XXXIV, paragraphs 3.200 and 3.201), noting that there were no Scientific Committee recommendations for further analysis, and the only outstanding analysis was that which Dr Kasatkina had indicated she would undertake. The Working Group agreed the analysis methods applied were appropriate and encouraged Members to work together to bring any further analysis to WG-FSA.

4.29 The Working Group requested the Secretariat provide an analysis to WG-FSA-16 comparing VMS data with reported catch location data for the most recent three years (as outlined in SC-CAMLR-XXXIV, Annex 7, paragraphs 3.30 to 3.32), consistent with the proposal of Dr Kasatkina (SC-CAMLR-XXXIV, paragraph 3.200), to verify if catch records correspond to VMS locations for all exploratory fisheries and closed areas within the CCAMLR area.

4.30 Dr Kasatkina presented WG-SAM-16/27 describing the Russian research program on resource potential and life cycle of *Dissostichus* species in SSRU 882A from 2016 to 2019. She noted that the proposed survey by Russia in the southern region of SSRU 882A includes sampling requirements that exceed the observer sampling requirements specified in Conservation Measure (CM) 41-01, Annex 41-01/A. Moreover, the Russian program sampling is consistent with the Ross Sea region fisheries data collection plan proposed by WG-FSA-15/40. She noted that the Russian program requirements include tagging (5 toothfish per tonne of catch), toothfish biological sampling (length, weight, sex, stomach weight and stomach contents, gonad state and gonad weight, muscle tissue and otoliths), as well as sampling for more detailed analysis (gonad histology, muscle tissue for stable isotope analysis, genetic analysis and parasitological analysis). She noted that the majority of these sampling requirements would also be undertaken for by-catch species.

4.31 Dr Kasatkina recalled the recommendation of the Scientific Committee that if the survey in the southern part of SSRU 882A was undertaken within the catch limit for the Ross Sea region, then to achieve the objectives of the research a catch limit of 100 tonnes would be appropriate (SC-CAMLR-XXXIII, paragraph 3.226). She noted that this catch limit would be used by the Russian research program.

4.32 Dr Kasatkina highlighted that a Ukrainian observer is planned to be on board the Russian vessel. A vessel from Member countries is invited to take part in the research program in the southern region of SSRU 882A.

4.33 The Working Group asked how the catch limit was derived. Dr Kasatkina informed the Working Group that the proposed catch limit was based on the original proposal for research undertaken by Russia in 2010–2012. The Working Group recalled that the Secretariat will compute biomass estimates for research blocks and research fisheries, including the proposal presented in WG-SAM-16/27 (paragraph 2.26), which will allow WG-FSA-16 to evaluate the proposed catch limit.

4.34 The Working Group requested more information regarding the partner vessel that is proposed to undertake research in the adjacent research block along with a table of proposed milestones for the research. Dr Kasatkina informed the Working Group that a Member had been approached to provide a partner vessel to participate in this research proposal and that, should the Member accept this proposal, a joint-research proposal would be submitted to WG-FSA-16.

4.35 The Working Group noted that this research plan had the opportunity to collect information relevant for toothfish predators such as Weddell seals and encouraged the proponents to consider incorporating these objectives into the research proposal.

Research proposals in Subarea 88.3

Korean survey

4.36 WG-SAM-16/29 reported research fishing by the Republic of Korea in Subarea 88.3 from 8 February to 25 March 2016 with 41 of 47 days on the fishing grounds. Four of the five research blocks were visited. The total catch of *D. mawsoni* was 106 tonnes, comprising 5 227 individuals with an average CPUE of 0.19 kg/hook; 566 individuals of *D. mawsoni* were tagged. Length frequency of *D. mawsoni* showed peaks with both small and large individuals within the subarea, with a high proportion of individuals at maturity stages 1 and 2. Biological information was collected comprising otoliths, stomach contents, gonad and muscle samples. Temperature and salinity data were collected at nine CTD stations.

4.37 WG-SAM reviewed the results from the survey and the proposal for continuation of the research (WG-SAM-16/11). No issues were identified with the proposal that would require changes before submission to WG-FSA. The Working Group thanked Korea for the information provided.

Research proposals in Subarea 48.2

Ukrainian survey

4.38 WG-SAM-16/22 reported on the second year of research fishing and observations on *Dissostichus* spp. in Subarea 48.2. The design had been amended following discussions within WG-SAM, WG-FSA and SC-CCAMLR. After adjustment for the catch taken by Chile during the previous month (7 tonnes), the remaining catch limit available for the survey did not allow all planned stations to be completed, only those in the southern area. Biological information on age, length and maturity were presented. Catch rates were used to provide estimates of the local biomass which differed between the 2015 and 2016 surveys due to the relative contribution of the CPUE collected in the areas surveyed; only three of 18 planned stations were conducted in the northern area due to the catch limit restrictions.

4.39 The survey noted fragments of IUU gillnets at three stations in the southern area and a longline at a fourth. COMM CIRC 16/24 had been issued to inform Members of the details. Samples of the nets and marked hooks were retained and the hooks passed to Chile to establish whether they belonged to the vessel which conducted the survey before Ukraine. Depredation by giant squid had also occurred.

4.40 WG-SAM thanked Ukraine for the report and welcomed the progress to obtain information from this closed area.

4.41 WG-SAM recalled the request for the development of forms to record observations of interactions with IUU gear by station, including measurements of gillnet mesh and longline gear details (SC-CAMLR-XXXIV, Annex 7, paragraph 3.47). This would allow mapping of the distribution of IUU fishing at a finer scale and allow selection of the gillnets used to be estimated. Furthermore, evidence of gillnet activity, such as abrasion or scarring from gillnet interactions, should be reported through such a mechanism.

4.42 WG-SAM-16/23 presented the research plan for the third year of research fishing, which would visit the same research grid. Ukraine noted that tagging larger fish of lengths more than 160 cm, the quantity of which did not exceed 20% of the catch, presented difficulties in hauling that were likely to result in the fish having poor survivorship as a result of the hauling process and requested consideration of omitting these from the tagging program.

4.43 WG-SAM noted that omitting large fish from the tagging program would result in bias in the assessment process. Other Members had developed methods for handling large fish, and noted that they could provide Ukraine with the details before or during WG-FSA. Previous advice provided in the CCAMLR tagging protocol and CCAMLR tag training module, including working with large fish, was available from the Secretariat (www.ccamlr.org/node/76310).

4.44 The Working Group requested Ukraine to provide a paper for review to WG-FSA-16 outlining their concerns if they wish to progress this consideration.

4.45 The Working Group noted that this research is still within the prospecting phase of the CCAMLR research plan flowchart (SC-CAMLR-XXXII, Annex 6, Figure 10) and, as such, the blocks defined within the research plan in this closed area were defined by the survey proponents for the purposes of defining areas with similar species composition and catch rates. The nomenclature used for describing research blocks, survey blocks and other bounded areas is required to be clarified to enable transparency in the ongoing development of the data-poor assessments.

Chilean survey

4.46 WG-SAM-16/20 reported on the first year of research fishing and observations on *Dissostichus* spp. in Subarea 48.2 by Chile. The vessel had arrived late to the fishing grounds at the end of the time period agreed for the Chilean fishing and had, therefore, only fished for 11 days before leaving the area. Due to the short time available, only 11 of the 30 research sets were completed. Seven tonnes of toothfish were caught (183 fish) but only four fish were considered by the observer to be in a condition that was suitable for tagging. Biological data (length and maturity) were collected and reported along with by-catch composition and *Dissostichus* spp. spatial catch rates.

4.47 The survey recaptured one tagged fish that had been released in Subarea 48.6, research block 486_5 in 2011, a new record for the longest movement by a toothfish. The Working Group discussed the implications of this information and noted that to date the majority of tagged toothfish movements had been of very restricted range but that occasional long-distance movements had also been noted. Consequently, the majority of toothfish distances travelled recorded so far were relatively short.

4.48 The Working Group highlighted the need for further genetic studies to help in the differentiation of the population structure of the toothfish within Area 48 (southern Atlantic). It also requested that the Secretariat update its previous meta-analysis of the long-distance movement of tagged fish throughout the CCAMLR area.

4.49 The Working Group noted that the time available for the survey had restricted the amount of data that could be collected. However, it was presented with no information to indicate why the condition of caught toothfish was considered too poor for tagging and requested that further information be provided to WG-FSA-16 to allow evaluation of the likelihood that the vessel would be able to provide toothfish in a condition suitable for tagging if the research were to proceed and to fulfil its research commitments successfully. The Working Group also considered that this inability to provide fish in a condition for tagging should be brought to the attention of the Scientific Committee.

4.50 Chile noted that the vessel conducting the research would be replaced in 2016/17.

4.51 The Working Group questioned whether the replacement vessel would be able to conduct tagging successfully, as without it, WG-FSA may be in a situation whereby it could not recommend that the current research program continues.

4.52 The Working Group also noted that the vessel had a substantial catch of grenadiers, considerably higher than the target species catch. This contrasted with the by-catch recorded by the Ukrainian research which had a very low grenadier by-catch. It requested that the spatial distribution of grenadier by-catch be presented to WG-FSA along with any information on species composition.

UK survey

4.53 WG-SAM-16/33 presented a proposal by the UK for a longline survey connecting the currently undertaken surveys in Subarea 48.2 with the established fishery in Subarea 48.4. The research objectives included determining population connectivity between these subareas, improving understanding of *Dissostichus* spp. population structures in this region, and improving available data on bathymetry and associated distributions of benthic by-catch species. The proposal included a three-year data collection and two-year data analysis plan towards the development of a stock hypothesis for the northern regions of Subarea 48.2 and southern regions of Subarea 48.4.

4.54 Dr Kasatkina noted that the UK survey is aimed at providing data on *Dissostichus* spp. population structure in Subarea 48.2 and UK survey data will be combined with those from surveys conducted by Chile and Ukraine. She also noted that to obtain accuracy in the survey data, all vessels should operate with the same type of longline; and so the UK should also use trotline, rather than autoline, gear in this survey.

4.55 The Working Group noted that the gear used was consistent with the gear type used in Subarea 48.4. Whilst different longline gear may have different CPUE for *Dissostichus* spp., CPUE differences are not an issue when collecting biological data and conducting tagging to provide information on population structure and, therefore, this was not an issue for this survey. The Working Group also requested that Dr Kasatkina provide a reference to papers which indicated that selectivity, rather than catchability, differed between gear types.

4.56 Dr Kasatkina noted that the UK survey area in Subarea 48.2 is adjacent to the Ukrainian survey area. However, the catch limit for research fishing in the neighbouring areas was estimated using different analogies: a reference area from Subarea 88.2 (Ukrainian survey) and a reference area from Subarea 48.4 (UK survey). She noted that above said requests additional consideration.

4.57 Dr Kasatkina also noted that the catch limit estimated for the UK survey in Subarea 48.2 was based first on the reference area of Subarea 48.4S exploratory fishery and then on the southern part of the Subarea 48.4S fishery, and using the stock size for *D. mawsoni* in Subarea 48.4. However, the UK survey in Subarea 48.2 will be undertaken for research fishing of two species of toothfish. This issue has to be clarified.

4.58 Dr Kasatkina noted it was necessary to indicate the source of the research catch limit in Subarea 48.4. She asked if the research catch limit should be part of the total catch limit established for the fishery in Subarea 48.4.

4.59 The Working Group noted that the proposed catch limits were provided on the basis of two comparative areas and information for both species in those areas. The catch limits were considered as indicative and would be reviewed at WG-FSA-16 in light of the standardised methodology estimates being prepared by the Secretariat (paragraph 2.26).

4.60 The Working Group recalled its advice that there was a need to coordinate research across all of Subarea 48.2 to ensure the most effective use of the research and ensure rapid progress towards an assessment of the stock in the area (SC-CAMLR-XXXIV, Annex 5, paragraph 3.17).

4.61 The UK noted that it was collaborating with Ukraine in the analysis of ageing information and the genetic analysis of tissue samples. This had been occurring since the first survey was conducted in 2014/15.

Chilean finfish survey

4.62 WG-SAM-16/19 reported on the first year of research fishing for finfish around the South Orkney Islands and Elephant Island (Subareas 48.2 and 48.1 respectively). Fishing had been conducted in a circuit around the two islands using a midwater and a bottom trawl. Observations on the finfish species caught, seabird and cetacean encounters and also acoustic data were collected on icefish and krill. A second year of research with an increase in the number of days, shorter haul times and, therefore, an increased number of hauls was envisaged for the second year.

4.63 The Working Group questioned why the survey objectives in the research report differed substantially from those agreed by WG-SAM-15, WG-FSA-15 and SC-CAMLR-XXXIV. The cruise track did not follow the original transect lines but appeared to have the characteristics of a fishing exercise. In addition, a bottom trawl (two hauls) had been used in addition to a midwater trawl (30 hauls), whereas the research proposal, agreed in 2015, only specified the use of a midwater trawl.

4.64 The Working Group noted that the survey spent less time (10 days) than had been planned (1 month), but the abandonment of a clearly specified and agreed survey design for all of the survey area, rather than completing a partial survey incorporating the original objectives, was disappointing; the original over-arching objectives had not been adhered to or met.

4.65 The lack of a clearly designed random stratified survey trawl protocol in the revised program was noted by the Working Group. As such, acoustic and trawl data collected by the survey was directed and considered biased. It could, therefore, not be used as a basis for determining any structure within the resource – an overriding aim of the survey.

4.66 Combined bottom and midwater trawling methods had been investigated by the UK and Russia in the early 2000s (SC-CAMLR-XXI, Annex 5, paragraphs 5.103 to 5.105) and trawling and acoustic work on icefish had been conducted more recently (WG-EMM-16/23). The Working Group noted that the survey design used in Subareas 48.1 and 48.2 in 2016 was extremely unlikely to produce results that will meet the requirements of the revised objectives. Consequently, the revised survey objectives, presented in the research report WG-SAM-16/19, would, most likely, not have been supported by WG-SAM and WG-FSA without substantial revision.

4.67 The Working Group agreed that the departure of the survey from its agreed objectives and the introduction of new objectives should be raised at the Scientific Committee before the survey is considered for further exemption under CM 24-01.

Research proposals in Subarea 48.5

4.68 Dr Kasatkina presented WG-SAM-16/25 in which she indicated that in 2016/17 Russia is proposing to continue investigations in Subarea 48.5 according to the research program adopted by the Commission (WG-FSA-12/12; SC-CAMLR-XXXI, paragraphs 9.5 to 9.15; CCAMLR-XXXI, paragraphs 5.37 to 5.43). She presented the Russian research program in Subarea 48.5 (Weddell Sea) from 2016 to 2019 (WG-SAM-16/25).

4.69 Dr Kasatkina noted that the Russian survey in the eastern part of the Weddell Sea includes sampling requirements that exceed the observer sampling requirements specified in CM 41-01, Annex 41-01/A. She noted that the Russian program requirements include tagging (5 toothfish per tonne of catch), toothfish biological sampling (length, weight, sex, stomach weight and stomach contents, gonad state and gonad weight, muscle tissue and otoliths), as well as sampling for more detailed analysis (gonad histology, muscle tissue for stable isotope analysis, genetic analysis and parasitological analysis). She noted that the majority of these sampling requirements would also be undertaken for by-catch species.

4.70 Dr Kasatkina noted that the catch limit was calculated based on the CPUE analogy method using SSRU 882H as the analogy (CPUE – 0.202 tonnes km^{-1} – SC-CAMLR-XXX, Annex 5, Table 2). The catch limit of 60 tonnes for option 1 and 50 tonnes for option 2 would be taken under the Russian research program (SC-CAMLR-XXXI, paragraphs 9.5 to 9.15;

CCAMLR-XXXI, paragraphs 5.37 to 5.43). Dr Kasatkina highlighted that a Ukrainian observer is planned to be on board the Russian vessel. One or two vessels from Member countries are invited to take part in the research program in the Weddell Sea.

4.71 The Working Group noted that Russia had not, to date, provided an update on the analyses requested by the Scientific Committee on the catch rates in Subarea 48.5 to which WG-SAM-16/25 referred (SC-CAMLR-XXXIII, paragraph 3.232; SC-CAMLR-XXXIV, paragraphs 3.271 and 3.272), and which were due to be provided to WG-SAM-16 and SCIC in 2016. The Working Group requested a timeline of when the results of these analyses would be available. Dr Kasatkina confirmed that these results will be available before SC-CAMLR-XXXV.

4.72 At the time of adoption, Dr Kasatkina stated that the situation with the quarantined Russian data is the responsibility of SCIC, but not of WG-SAM.

4.73 The Working Group recalled that the situation with this survey proposal in Subarea 48.5 has not changed since 2014 (SC-CAMLR-XXXIII, paragraphs 3.230 to 3.233), and WG-SAM is thus still unable to evaluate the research proposal in its current or previous formats. The Working Group referred to the discussions at WG-SAM-15 (SC-CAMLR-XXXIV, Annex 5, paragraph 4.10) recommending that the data concerned remain quarantined until such time that a complete analysis has been undertaken and submitted for consideration by WG-SAM, WG-FSA and SC-CAMLR.

4.74 The Working Group recalled that, as in previous years, the submitted proposal was based on assumptions and results of previous work carried out by Russia in Subarea 48.5 in 2012–2014, and that data from these activities have been quarantined by CCAMLR since 2014 (SC-CAMLR-XXXIII, paragraph 3.232). Without further clarification of these data as requested from Russia (SC-CAMLR-XXXIII, paragraph 3.232; SC-CAMLR-XXXIV, paragraphs 3.271 and 3.272), the Working Group was not able to evaluate the approach and proposed research in WG-SAM-16/25.

4.75 The Working Group further noted that the ice maps contained in WG-SAM-16/25 showed varied and difficult sea-ice conditions in the proposed working areas and their access routes, questioning whether the research area can be revisited sufficiently regularly to conduct the proposed research program. The Working Group referred to similar observations made regarding research block 486_5, where it had encouraged sea-ice analyses using data over a longer temporal range (>4 years) to indicate ice conditions along the continental slope more suited to regular access (paragraph 3.26).

General matters

4.76 In view of the discussions concerning all research plans presented during WG-SAM-16, the Working Group encouraged all multi-Member, multi-vessel research plan proposals to identify a coordination manager or group for a given research area to facilitate coordination of research proposals, operations at sea and data analyses.

4.77 The Working Group requested that such multi-Member, multi-vessel research proposals include a coordination paper outlining milestones, operational contingency plans and progress made.

Other business

5.1 WG-SAM-16/24 presented proposals by Russia to standardise reporting of by-catch. The paper reported that there were discrepancies between the methods employed by different Members.

5.2 The Working Group agreed that by-catch estimation was important and noted that under CM 23-07 the responsibility for reporting by-catch rested with the Flag State. The Working Group noted that the *CCAMLR Scientific Observers Manual* does not include comprehensive details of the methods of by-catch recording to be employed. Further detail is provided in the electronic logbooks, which should be the method of reporting used by all Members. Some Members are currently using electronic monitoring to supplement observer coverage in fisheries outside the CCAMLR area, and the Working Group considered that this approach could be useful to help develop accurate and efficient mechanisms to monitor and quantify by-catch in longline fisheries.

5.3 The Working Group noted that the differences in approach referred to in the paper were not specified precisely and may relate to confusion between the protocols for by-catch accounting and for monitoring interactions with VME indicator taxa. The Working Group further noted that it would be helpful if the Russian observer manual referred to in the paper were provided to the Secretariat to better understand the processes used on Russian vessels.

5.4 The Working Group noted that the recommendation in the paper to develop species identification resources is already underway and a draft identification guide is currently being reviewed by the Scheme of Scientific Observation e-group (SC-CAMLR-XXXIV, Annex 7, paragraph 7.3).

5.5 WG-SAM-16/30 reported estimates of conversion factors used to estimate green weight from processed weight in the Korean longline fishery during 2015/16. There was generally a good overlap between estimates and measured samples. Conversion factors slightly decreased with weight of fish. The conversion factors reported by observers were higher than those reported by the vessel, which could lead to an underestimate of the actual catch green weight reported by the vessel.

5.6 The Working Group welcomed the response to previous recommendations (SC-CAMLR-XXXIV, paragraphs 3.93 and 3.94) to do further work on green weight conversion factors and noted the importance of these factors to accurately estimate catch. The Working Group noted that the difference in conversion factors between vessels and observers has the potential to introduce a bias into catch data used in assessments and management.

5.7 The Secretariat reported that trials are currently underway to investigate the differences in conversion factors using data collected by observers from South Africa. The Secretariat noted that this work will inform development of routine processes for reconciliation of catch and Catch Documentation Scheme for *Dissostichus* spp. (CDS) data that will be made available through the data warehouse which is currently under development (paragraph 6.8).

5.8 WG-SAM-16/31 presented details of 10 CCAMLR tags recaptured by Korean vessels from 2011 to 2013 within the southern Indian Ocean (Area 51).

5.9 The Working Group welcomed the reports of tagging data from outside the CAMLR Convention Area. The Working Group noted the collaboration with adjacent Regional Fishery Management Organisations (RFMOs), and agreed the importance of continuing these relationships; in particular, ensuring that CCAMLR's expertise in tagging programs is available to inform the design of such programs beyond the CAMLR Convention Area. Such collaboration is important for ensuring optimal data collection for stocks straddling the boundary of the CAMLR Convention Area.

5.10 WG-SAM-16/32 compared the depredation estimation method of Gasco (WG-FSA-14/10) with the method using CPUE difference currently used within the assessment for toothfish in Subarea 48.3. The analysis showed that the methods were comparable and consistent with each other. A verbal report on the recent depredation symposium organised by COLTO was also included in the presentation of this work (paragraph 4.2).

5.11 The Working Group welcomed the paper and noted that such work crosses the remit of several fora, including the Scientific Committee Symposium to be convened this year, and the Depredation e-group. The Working Group recommended that the Scientific Committee consider whether such work may need its own work program in future years.

5.12 The Working Group noted the variability in depredation rates between regions, and emphasised the importance of the continued monitoring of these rates, even in areas where they are low, to avoid missing potentially substantial mortality effects from the fishery.

5.13 The Working Group noted the importance of gaining understanding of the scale of depredation by scavenging benthic amphipods (sea lice) and the effect on catch estimation as part of the work on depredation.

Data

5.14 Although no paper was submitted on the subject, the Working Group considered the ongoing issue of quarantined data. The Working Group noted that originally it had been assumed that quarantine would be a temporary stage until issues with the data had been addressed, but it has become apparent that this is not the case. The Working Group noted that careful consideration will need to be given by the Secretariat to the inclusion of these data in extracts available from the data warehouse as these are developed, and to inclusion in the *CCAMLR Statistical Bulletin*.

5.15 The Working Group noted the importance of accurate and complete metadata to guide users during selection of data for analysis. This is being actively developed by the Secretariat as part of the development of the data warehouse and metadata has been made publicly available. The Secretariat also reported on efforts to make the *CCAMLR Statistical Bulletin* more easily available via a web interface and non-proprietary file types. The Working Group welcomed these efforts to make the work of CCAMLR more transparent to the public.

Future work

6.1 The Working Group agreed that its future work should be driven by the outcomes of the forthcoming Scientific Committee Symposium. The Symposium will develop priorities for future work from, inter alia, a table that lists the various issues currently considered, or planned for consideration, by all of its working groups. This table was circulated to Members as Appendix 2 of SC CIRC 16/36.

6.2 Due to an editorial error, SC CIRC 16/36 does not correctly reflect the Working Group's efforts to address depredation and assess risks to by-catch species. A correct version of the entries in Appendix 2 of SC CIRC 16/36 would be provided by the Convener of WG-SAM for consideration at the forthcoming Scientific Committee Symposium (SC CIRC 16/06 and SC CIRC 16/36).

6.3 The Working Group advised the Scientific Committee that, during its last few meetings, most of its work has focused on reviewing research plans of Members who notify to fish in data-poor exploratory fisheries or closed areas. This point is relevant to discussions about future work for at least three reasons:

(i) if business continues as usual, WG-SAM will likely be unable to address all the issues identified in SC CIRC 16/36 and paragraph 6.2

(ii) although WG-SAM's efforts to review Members' research plans have proven invaluable, the work of WG-SAM has largely evolved away from detailed consideration of quantitative methods and now overlaps substantially with that of WG-FSA

(iii) many research plans and their accompanying progress reports are Member-specific and uncoordinated but apply to the same statistical subarea or division; this lack of coordination has increased the complexity of the review process and caused discussion by WG-SAM to be repetitive.

6.4 The Working Group identified issues arising from the lack of coordination and communication among proponents of research plans. These issues include the additional time required to review multiple proposals and results, confusion generated by applying different analytical procedures to the same data describing the same area, and the lack of accountability for analysing samples and data collected by all proponents, and Members proposing to fish in a given area but ultimately not conducting the planned research.

6.5 The Working Group encouraged the development of performance milestones for all research plans, including proposals made under CM 24-01, and noted that project management and reviews of research would be enhanced if Gantt charts were used to identify specific measurable objectives of the research; the expected outputs associated with those objectives; the dates those outputs would be provided; and, in the case of multi-Member proposals, the Member(s) responsible for conducting the work.

6.6 It was suggested that all the issues facing WG-SAM, including review of research plans, might be most efficiently and thoroughly addressed as a series of focus topics that are sequentially considered over a scheduled period of years rather than annually considered as standing agenda items. The schedule might be established on the basis of statistical area, for example with all research plans in Area 88 being reviewed one year and then progressing to Areas 48 and 58 in two subsequent years. It was noted that the detailed review of Members' plans to fish in Subarea 48.6 (paragraphs 3.23 to 3.41) had demonstrated the utility of such focused area-based discussion. It was suggested that if a rotation of detailed reviews by WG-SAM were to continue, then a coordinated review of research plans in Divisions 58.4.1 and 58.4.2 would be useful.

6.7 There would be several advantages to minimising the number of standing agenda items considered at future meetings and focusing future discussions on area-based issues. These include:

(i) providing Members with advance notice of what science will be needed and considered at any given meeting

(ii) reducing the number of papers which receive only cursory review

(iii) providing opportunity for more in-depth discussion on any given issue

(iv) increasing coordination among Members.

6.8 The Working Group recommended that the Scientific Committee consider establishing a data management group for the reasons outlined in paragraph 2.20. It drew the attention of the Scientific Committee to a number of database issues currently needing to be resolved or worked on (paragraphs 2.15 to 2.20, 2.51 to 2.54, 5.7, 5.14 and 5.15).

Advice to the Scientific Committee

7.1 The Working Group's advice to the Scientific Committee and its working groups is summarised below; the body of the report leading to these paragraphs should also be considered:

(i) Development of the CCAMLR database and data quality assurance –

(a) data management group (paragraph 2.20)
(b) milestones and timeline (paragraph 2.54).

(ii) Development of assessment methods in data-poor areas –

(a) estimation of local biomass (paragraphs 2.28 to 2.30, 2.34 and 2.46).

(iii) Review of research plans in Subareas 48.6 and 58.4 –

(a) Subarea 48.6 (paragraph 3.40)
(b) Division 58.4.3a (paragraph 3.18).

(iv) Review of scientific research proposals for other areas –

(a) interactions with IUU fishing gear (paragraph 4.41)
(b) Chilean surveys in Subareas 48.1 and 48.2 (paragraphs 4.49 and 4.67).

(v) Other business –

(a) depredation work program (paragraph 5.11).

(vi) Future work –

(a) WG-SAM work program (paragraph 6.3)
(b) data management (paragraph 6.8).

Adoption of the report and close of the meeting

8.1 The report of the meeting of WG-SAM was adopted.

8.2 In closing the meeting, Dr Parker thanked CNR for hosting the meeting, and Dr Vacchi and the local organising team and Berio Library staff for their kind hospitality and use of the library facilities and the Sala Lignea. He also thanked participants for their contributions to the work of WG-SAM and engaging in the discussions and preparation of the report.

8.3 Dr Reid, on behalf of WG-SAM, thanked Dr Parker for his leadership of WG-SAM and successful completion of the meeting.

References

Agnew, D.J., J. Moir Clark, P.A. McCarthy, M. Unwin, M. Ward, L. Jones, G. Breedt, S. Du Plessis, J. Van Heerdon and G. Moreno. 2006. A study of Patagonian toothfish (*Dissostichus eleginoides*) post-tagging survivorship in Subarea 48.3. *CCAMLR Science*, 13: 279–289.

Candy, S.G., D.C. Welsford, T. Lamb, J.J. Verdouw and J.J. Hutchins. 2011. Estimation of natural mortality for the Patagonian toothfish at Heard and McDonald Islands using catch-at-age and aged mark-recapture data from the main trawl ground. *CCAMLR Science*, 18: 29–45.

Table 1: Agreed reference areas for species and research blocks in Subareas 48.6 and 58.4. TOP – *Dissostichus eleginoides*; TOA – *D. mawsoni*; 48.4 N – Subarea 48.4 north; RSR – Ross Sea region; HIMI – Heard Island and McDonald Islands.

Research block	Species	Reference region for CPUE analogy method
486_1	TOP	48.4 N
486_2	TOP	48.4 N
486_2	TOA	RSR
486_3	TOA	RSR
486_4	TOA	RSR
486_5	TOA	RSR
5841_1	TOA	RSR
5841_2	TOA	RSR
5841_3	TOA	RSR
5841_4	TOA	RSR
5841_5	TOA	RSR
5842_1	TOA	RSR
5844b_1	TOP	HIMI
5844b_2	TOP	HIMI
5843a_1	TOP	HIMI

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(Genoa, Italy, 27 June to 1 July 2016)

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Appendix B

Agenda

Working Group on Statistics, Assessments and Modelling
(Genoa, Italy, 27 June to 1 July 2016)

1. Introduction

   1.1 Opening of the meeting
   1.2 Adoption of the agenda and organisation of the meeting

2. Methods for assessing stocks in established fisheries

   2.1 Review of progress towards updated integrated assessments
   2.2 Stock assessment methodologies

3. Review of research plans in Subareas 48.6 and 58.4

   3.1 Review of research plans in Subarea 58.4
      3.1.1 Review of research plans in Divisions 58.4.1 and 58.4.2
      3.1.2 Review of research plans in Division 58.4.3a
      3.1.3 Review of research plans in Division 58.4.4b

   3.2 Subarea 48.6 review

4. Review of scientific research proposals for other areas (e.g. closed areas, areas with zero catch limits, Subareas 88.1 and 88.2)

   4.1 Structurally changed or new research proposals intended to provide other advice
      4.1.1 Research proposals in Subarea 88.1
      4.1.2 Research proposals in Subarea 88.2 (north and south)
      4.1.3 Research proposals in Subarea 88.3
      4.1.4 Research proposals in Subareas 48.1, 48.2 and 48.4
      4.1.5 Research proposals in Subarea 48.5

5. Other business

6. Future work

7. Advice to the Scientific Committee

8. Adoption of report and close of meeting.

Appendix C

List of Documents

Working Group on Statistics, Assessments and Modelling
(Genoa, Italy, 27 June to 1 July 2016)

WG-SAM-16/01	Research plan for exploratory fishing for toothfish (*Dissostichus* spp.) in 2016/17 in Division 58.4.1 Delegation of France
WG-SAM-16/02	Research plan for exploratory fishing for toothfish (*Dissostichus* spp.) in 2016/17 in Division 58.4.2 Delegation of France
WG-SAM-16/03	Research plan for the exploratory longline fishery for *Dissostichus* spp. in 2016/17 in Division 58.4.3a Delegations of France and Japan
WG-SAM-16/04	Research plan for the 2016/17 exploratory longline fishery of *Dissostichus* spp. in Division 58.4.1 Delegation of Japan
WG-SAM-16/05	Research plan for the 2016/17 exploratory longline fishery of *Dissostichus* spp. in Division 58.4.2 Delegation of Japan
WG-SAM-16/06	Research plan for the 2016/17 toothfish fishery in Division 58.4.4b by Japan and France Delegations of Japan and France
WG-SAM-16/07	Research plan for the 2016/17 exploratory longline fishery of *Dissostichus* spp. in Subarea 48.6 by South Africa and Japan Delegations of Japan and South Africa
WG-SAM-16/08	Proposal of extension of research block 48.6_2 to complete planned research and examine the habitat model and the stock structure T. Namba, T. Ichii and K. Taki
WG-SAM-16/09	Proposal for continuation of Australia's research plan for exploratory fishing for toothfish (*Dissostichus* spp.) in East Antarctica (Divisions 58.4.1 and 58.4.2) Delegation of Australia
WG-SAM-16/10	Spanish research proposal for the 2016/17 season in Division 58.4.1 Delegation of Spain

WG-SAM-16/11	Korean research plan in Subarea 88.3 in 2016/17 Delegation of the Republic of Korea
WG-SAM-16/12	Proposal for research fishing in CCAMLR Subarea 48.6 during the three-year period 2016/17–2018/19 Delegation of Uruguay
WG-SAM-16/13	Performance metrics to index the spatial coverage of mark-recapture data C. Marsh, A. Dunn and S. Mormede
WG-SAM-16/14	Results of the fifth Ross Sea shelf survey to monitor abundance of sub-adult Antarctic toothfish in the southern Ross Sea, February 2016, and notification for continuation in 2017 A. Dunn, C. Jones, S. Mormede and S. Parker
WG-SAM-16/15	Proposal for a second longline survey of toothfish in the northern Ross Sea region (SSRUs 882A and B) S.J. Parker, R.J.C. Currey, M. Söffker, C. Darby, D. Welsford and O.R. Godø
WG-SAM-16/16 Rev. 1	Analysis of catch and effort data in SSRUs 882A–B North from the 2015 fishing season including comparisons with data from exploratory fisheries and closed areas K. Large, A. Dunn, S.J. Parker, T. Earl, C. Darby, M. Söffker and O.R. Godø
WG-SAM-16/17	Korean research plan in Divisions 58.4.1 and 58.4.2 in 2016/17 Delegation of the Republic of Korea
WG-SAM-16/18 Rev. 1	A description of current metrics and methods used in providing advice to the Scientific Committee on setting catch limits and assessing research plans in research blocks in exploratory fisheries and closed areas Secretariat
WG-SAM-16/19	Finfish distribution and abundance in Subareas 48.1 and 48.2, years 2016–2018 P.M. Arana, G. Plaza, J. Arata, N. Alegría and S. Viquerat
WG-SAM-16/20	Preliminary report on the survey for *Dissostichus* spp. in Subarea 48.2 (Phase one 2016) A. Zuleta, S. Hopf and P. Ruiz
WG-SAM-16/21	Research longline fishing proposal for *Dissostichus* spp. in Subarea 48.2 (Second season) Delegation of Chile

WG-SAM-16/22	The preliminary report on the survey in Subarea 48.2 in 2016 (the second year of the planned 3-year-old investigations) L. Pshenichnov, S. Ajiumerov and D. Marichev
WG-SAM-16/23	Plan of research program of the Ukraine in Subarea 48.2 in 2017 (third season) L. Pshenichnov, S. Ajiumerov and D. Marichev
WG-SAM-16/24	Proposals of the Russian Federation on by-catch reporting in the longline toothfish fishery in the CCAMLR Convention Area Delegation of the Russian Federation
WG-SAM-16/25	Plan of research program of the Russian Federation in Subarea 48.5 (Weddell Sea) in season 2016/17 Delegation of the Russian Federation
WG-SAM-16/26 Rev. 1	Analysis of the data at the international exploratory toothfish fishery in the northern part of the Ross Sea (SSRUs 881 B, C and G) Delegation of the Russian Federation
WG-SAM-16/27	Research program on resource potential and life cycle of *Dissostichus* species from the Subarea 88.2 A in 2016–2019 Delegation of the Russian Federation
WG-SAM-16/28	Progress report on the Korean exploratory longline fishery for *Dissostichus* spp. in Division 58.4.1 in 2015/16 Delegation of the Republic of Korea
WG-SAM-16/29	Progress report on the Korean research fishing by longline fishery for *Dissostichus* spp. in Subarea 88.3 in 2015/16 Delegation of the Republic of Korea
WG-SAM-16/30	Report on conversion factor of the Antarctic toothfish, *Dissostichus mawsoni*, by Korean longline vessels in 2015/16 Delegation of the Republic of Korea
WG-SAM-16/31	Recapture information by Korean longline fishery in Southern Indian Ocean Delegation of the Republic of Korea
WG-SAM-16/32	Validating the Gasco-method for depredation estimation in Subarea 48.3 M. Söffker and T. Earl
WG-SAM-16/33	Proposal for a longline survey to determine toothfish population connectivity between Subareas 48.2 and 48.4 Delegation of the United Kingdom

WG-SAM-16/34	Report on the collection of environmental data during exploratory fishing by Australia in Division 58.4.1 during the 2015/16 fishing season D. Maschette, T. Lamb, D. Welsford, P. Yates and P. Ziegler
WG-SAM-16/35	Report on exploratory fishing by Australia in Division 58.4.1 during the 2015/16 fishing season P. Yates, D. Welsford, P. Ziegler, D. Maschette and T. Lamb
WG-SAM-16/36 Rev. 1	The integrated krill assessment model for Subarea 48.1 with future catches meeting alternative decision rules D. Kinzey, G.M. Watters and C.S. Reiss
WG-SAM-16/37	Independent peer review of an integrated stock assessment model for Antarctic krill (*Euphausia superba*) conducted by the Center for Independent Experts J. Rusin, D. Kinzey and G. Watters
WG-SAM-16/38	Preliminary results of a dedicated cetacean sighting vessel-based krill survey in East Antarctica (115°–130°E) during the 2015/16 austral summer season K. Matsuoka, A. Wada, T. Isoda, T. Mogoe and L.A. Pastene
WG-SAM-16/39	Using effective sample sizes to evaluate the efficiency of length samples collected by at-sea observers in the krill fishery in Subarea 48.1 N. Kelly, S. Kawaguchi, P. Ziegler and D. Welsford
WG-SAM-16/40 Rev. 1	Preliminary results of the three season research surveys of the Spanish FV *Tronio* in Division 58.4.1 R. Sarralde, L.J. López-Abellán and S. Barreiro
WG-SAM-16/41 Rev. 1	Progress report for the fourth year of the research fishery for *Dissostichus* spp. in Subarea 48.6 being jointly undertaken by Japan and South Africa in the years 2013–2016 S. Somhlaba, R. Leslie, K. Taki, T. Ichii and T. Namba
WG-SAM-16/42 Rev. 1	Analysis of sea-ice concentration of 48.6_4 and _5 with remote sensing data during the latest four seasons T. Namba, K. Taki and T. Ichii

Report of the Working Group on Ecosystem Monitoring and Management
(Bologna, Italy, 4 to 15 July 2016)

Contents

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Opening of the meeting

1.1 The 2016 meeting of WG-EMM was held at the National Research Council (CNR), Bologna, Italy, from 4 to 15 July. The meeting was opened by the Convener, Dr S. Kawaguchi (Australia), who welcomed participants (Appendix A) including Dr J. Zuzunaga from Peru (Acceding State; see also SC CIRC 16/39). Dr Kawaguchi thanked CNR for hosting the meeting. The Working Group was warmly welcomed by Dr A.M. Fioretti (Institute of Geosciences and Earth Resources, CNR).

1.2 Dr Kawaguchi reviewed the current work of WG-EMM and recalled that in 2015 the Scientific Committee indicated that the development of feedback management (FBM) of the krill fishery and the evaluation of candidate decision rules could be advanced by holding a workshop in 2016, perhaps associated with WG-EMM (SC-CAMLR-XXXIV, paragraph 3.44). Dr Kawaguchi advised that it had not been possible to hold such a workshop during WG-EMM-16. The Working Group's work remained focused on the krill-centric ecosystem and issues related to the development of FBM.

Adoption of the agenda and organisation of the meeting

1.3 The Working Group discussed the provisional agenda and agreed to add an item on general issues for spatial management (Subitem 3.3). The agenda was adopted (Appendix B), and subgroups were formed to address detailed aspects of the agenda. A one-day symposium on the Ross Sea ecosystem was held during the meeting (Item 4).

1.4 Documents submitted to the meeting are listed in Appendix C. While the report has few references to the contributions of individuals and co-authors, the Working Group thanked all authors of papers for their valuable contributions to the work presented to the meeting.

1.5 In this report, paragraphs that provide advice to the Scientific Committee and its other working groups have been highlighted; these paragraphs are listed in Item 5.

1.6 The report was prepared by M. Belchier (UK), T. Brey (Germany), R. Cavanagh (UK), A. Constable (Australia), R. Currey (New Zealand), C. Darby (UK), K. Demianenko (Ukraine), S. Fielding (UK), L. Ghigliotti (Italy), O.R. Godø (Norway), M. Goebel (USA), S. Grant (UK), E. Grilly (Secretariat), S. Hill (UK), J. Hinke and E. Klein (USA), P. Koubbi (France), B. Krafft (Norway), S. Olmastroni (Italy), P. Penhale (USA), D. Ramm (Secretariat), N. Ratcliffe (UK), K. Reid (Secretariat), C. Reiss (USA), L. Robinson (Secretariat), M. Santos (Argentina), M. Söffker and P. Trathan (UK), M. Vacchi (Italy) and G. Watters (USA).

The krill-centric ecosystem and issues related to management of the krill fishery

Fishing activities

2.1 The Working Group reviewed the content of the draft Krill Fishery Report (WG-EMM-16/07) which provided a consolidated summary of information related to the krill fishery prepared in a similar format to the fishery reports completed for finfish fisheries (www.ccamlr.org/node/75667). Recommendations from WG-EMM-14 (SC-CAMLR-XXXIII, Annex 6, paragraphs 2.2 to 2.7) and WG-EMM-15 (SC-CAMLR-XXXIV, Annex 6, paragraphs 2.4 to 2.11) on the report were included along with information provided in previous reports (i.e. an introduction on the background of the fishery, an inventory of catch and Scheme of International Scientific Observation (SISO) data, including incidental mortality of marine mammals and seabirds as well as CCAMLR's approach to the management of the krill fishery), decadal catch maps at 1° latitude by 2° longitude grid cell resolution, and a comparison of by-catch occurrence in C1 and SISO data. Gridded monthly catch maps at 1° latitude by 2° longitude grid cell resolution for 2014/15 and 2015/16 (to 8 June 2016) were included as an appendix for use by working groups only, and will not be included in the published version of the fishery report (CCAMLR-XXXIV, paragraph 5.3).

2.2 The Working Group reviewed the fishing activity information for 2014/15 and 2015/16, provided in the Krill Fishery Report, and noted that:

(i) in 2014/15 (1 December 2014 to 30 November 2015), 12 vessels fished in Subareas 48.1, 48.2 and 48.3 and the total catch of krill reported was 225 466 tonnes of which 154 177 tonnes (68%) was taken from Subarea 48.1; Subarea 48.1 was closed on 28 May 2015

(ii) in 2015/16 (to 8 June 2016), 11 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 189 609 tonnes of which 154 460 tonnes was taken from Subarea 48.1; Subarea 48.1 was closed on 28 May 2016

(iii) in both 2014/15 and 2015/16, fishing occurred in Subarea 48.1 in December and January, particularly in the southern part of Bransfield Strait (Gerlache Strait). The spatial distribution of the fishery during February and March was also similar in both seasons with a focus towards the central part of Bransfield Strait in April and May prior to the closure of Subarea 48.1.

2.3 The Working Group noted that historically fishing in Subarea 48.1 had been primarily in the summer, but for the past few seasons fishing in this area had been occurring throughout the austral summer and winter. The Working Group also noted that the fishery was regularly operating in areas in the southern part of Subarea 48.1 where no regular krill surveys are conducted.

2.4 The Working Group agreed that a spatial measure of fishing concentration, including a measure of the number of vessels operating in a given area, could be a useful way to describe the operation of the fishery that could potentially be included in future Krill Fishery Reports.

2.5 Dr Godø offered to investigate how such indices were used in other fisheries and report back to the Working Group next year.

2.6 The Working Group discussed the change in the distribution of fishing in Subarea 48.1 from Drake Passage to the Bransfield Strait over recent seasons and the potential for such a change to influence the size of krill selected by the fishery. The Working Group noted that these changes were likely due to a combination of factors that included management restrictions (i.e. fishery closures), abundance of krill, weather conditions and proximity to the market.

2.7 The Working Group noted that more information from the fishing industry on what drives its behaviour and decisions to fish in an area at a particular point in time would be useful in assisting with those studies that aim to determine whether there are predictable attributes that give rise to fishing in some areas.

2.8 The Working Group agreed that the data on krill catches by month and small-scale management unit (SSMU) (WG-EMM-16/07, Table A2.1) should be included in the *Statistical Bulletin*.

Krill fishery notifications

2.9 The Working Group reviewed the notifications for krill fisheries in 2016/17 which had been received by the submission deadline (1 June 2016) and summarised in the Krill Fishery Report, noting that additional information on vessel details and subsequent withdrawals of notifications are provided on the CCAMLR website (www.ccamlr.org/en/fishery-notifications/notified). Six Members had notified a total of 18 vessels for krill fisheries in Subareas 48.1 (17 vessels), 48.2 (16 vessels), 48.3 (15 vessels) and 48.4 (10 vessels), and Divisions 58.4.1 (3 vessels) and 58.4.2 (3 vessels), and there were no notifications submitted for exploratory fisheries for krill in 2016/17. The Secretariat advised during the meeting that Poland had withdrawn the notifications for its vessels *Alina* and *Saga*.

2.10 The Working Group also reviewed WG-EMM-16/72 Rev. 1 which summarised the information notified for krill fishing operations and gears in 2016/17. The data presented in that paper was extracted directly from the new online submission system for fishery notifications (SC-CAMLR-XXXIV, Annex 6, paragraphs 2.22 to 2.27).

2.11 The Working Group noted that the daily processing capacity for notified vessels ranged from 120 to 700 tonnes green weight per day (Table 1), and that two Norwegian- and one Chinese-flagged vessels had notified use of the continuous fishing system (Table 2).

2.12 The Working Group sought further information about the intentions of the three Chinese-flagged vessels notified in Divisions 58.4.1 and 58.4.2. Dr G. Zhu (China) advised that the decision to send the notified vessels to these divisions in 2016/17 would rest with the vessels' operator.

2.13 The Working Group agreed that the new online system for submitting fishery notifications had greatly facilitated its work in reviewing the krill fishery notifications and thanked the Secretariat for successfully introducing this system. The Secretariat thanked Members that had submitted online notifications for providing feedback and assistance in developing appropriate data checks and constraints used in the online system.

2.14 The Working Group agreed that the information provided in the notifications for krill fisheries in 2016/17 was consistent with the requirements of Conservation Measure (CM) 21-03.

Escape mortality

2.15 WG-EMM-16/04 reported on further developments in the estimation of krill mortality which escape from trawl nets. WG-EMM-13/34 (see also Krag et al., 2014) had demonstrated that most of the length classes of krill can escape through commonly used commercial trawl mesh sizes. Further, a method to estimate escape mortality for krill was developed and presented in WG-EMM-14/14 (see also Krafft and Krag, 2015). WG-EMM-16/04 reported that haul duration, hydrological conditions, maximum fishing depth and catch-size had no significant effect on mortality of krill escaping the trawl, nor was there any further mortality associated with the holding tank conditions. The mortality of krill escaping the trawl nets in the study was 4.4 ± 4.4%, which indicated that krill are fairly robust to the capture-and-escape process in trawls.

2.16 The Working Group noted that the results from WG-EMM-16/04, in combination with the modelling work on proportions of krill with different morphology classes escaping trawl meshes ranging from 5 to 40 mm and mesh opening angles ranging from 10° to 90° (WG-EMM-13/34 and Krag et al., 2014), enabled the calculation of escapement from the entire trawl body (including side panels and codend). The total escape mortality for the fishery may be estimated when parameters from the trawl nets used and size/demography of the krill in the geographical area, in addition to the landed catch, are known.

2.17 The Working Group agreed that quantifying escape mortality is an essential element of estimating the total removals by the fishery. The Working Group agreed that it would be useful for the Secretariat to compile results on escape mortality into a single document once the work is completed.

Reporting interval for the continuous fishing system

2.18 WG-EMM-16/05 evaluated the reporting of 'haul-by-haul' catch and effort data (C1 data) for the continuous fishing system and proposed a change in the current two-hour reporting period to produce more robust and appropriate catch statistics. The authors summarised issues related to the choice of the current two-hour reporting interval for the continuous fishing system which had led to apparent anomalies in the reported catches. According to the vessels' owners and captains, this variability in catches is a consequence of the two-hour reporting period not coinciding with the vessel's daily production routine. The authors suggested that a six-hour reporting period more closely matches the processing schedule and, as a result, would improve the accuracy of the reported catch.

2.19 The Working Group discussed the data required for scientific analysis of the spatial pattern of catch rates from continuous trawls and noted that the catch data are required to be reported for each net in a two-hour period. It had been previously assumed that the catch reported for a two-hour period had actually been caught during that period. However, information from the krill fishing vessels has revealed that this is not the case and the catch reported in a two-hour period is, in fact, the amount of krill passing from the holding tanks to the factory in that period.

2.20 The Working Group agreed that the objective of developing technology and methods that would ensure that the catch reported for a particular two-hour period is the catch that is actually caught during that period would be most effectively addressed by discussion with vessel owners and captains. The Working Group provided the following suggestions for the fishing companies to consider:

(i) using trawl-mounted sensors that could aid to quantify the amount of krill entering the trawl mouth per time unit

(ii) recording the amount of krill entering the holding tank

(iii) recording the time to fill a holding tank and final quantity of krill it contained after it has been emptied

(iv) addition of pump capacity to the vessel details included in the notification such that periods of saturation (i.e. the pump is operating at full capacity) can be identified

(v) clarification of the potential time lag between the fishing time reported for the catch and the time at which the catch was taken in order to evaluate how existing data from continuous fishing operations might be analysed.

2.21 The Working Group agreed that paragraphs 2.20(i) and (ii) above would provide close to real-time spatial distribution of krill catch and would also allow the actual catch in a two-hour period to be reported. Paragraph 2.20(iii) would most likely result in reporting every six hours, which is currently considered less optimal and would also imply a time lag in catch reporting similar to the time lags noted for the current two-hour reporting period and which need to be corrected for. The Working Group recommended that, during the development of a revised process for catch reporting, the two-hour reporting is continued in order to provide continuity and comparative analyses. Any new method developed should be trialled alongside the two-hour reporting procedure and the result presented to WG-EMM for evaluation.

2.22 The Working Group noted that any vessel that uses the continuous fishing system should consider the issues highlighted here in order to implement accurate catch reporting methods.

Use of net monitoring cables

2.23 WG-EMM-16/06 reviewed the current regulation of net monitoring cables in CCAMLR fisheries and proposed a revision which would enable krill fishing vessels to collect larger quantities and quality of monitoring and research data. The prohibition on the use of net monitoring cables was introduced in 1994 to minimise the risk of seabirds striking the cable and resultant incidental mortality of seabirds in trawl fisheries. As a result, vessels that use net sensors are required to transmit trawl net data using underwater wireless communication which has limited bandwidth and requires the use of a submerged receiver. The authors proposed a revision to CM 25-03 to allow the use of net monitoring cables which are deployed using purpose-built rigging which guide the cable into the water within 2 m from the vessel’s stern and thereby minimise the risk of seabirds striking the cable.

2.24 The Working Group recognised the advantages of using data transfer cables connected to trawls for monitoring net performance and catches, as well as collecting research and environmental data of interest to WG-EMM's work.

2.25 The Working Group requested that Dr Godø liaise with the Secretariat to distribute this proposal by Scientific Committee Circular for consideration by relevant specialists on seabird by-catch mitigation in trawl fisheries in order that advice can be formulated for submission to WG-FSA-16. The Working Group noted that the formulation of that advice should also include a review of the tasks for scientific observers related to seabird by-catch mitigation.

CPUE and fishery performance

2.26 WG-EMM-16/10 reviewed catch and effort data from the krill fishery from 2000/01 to 2015/16 in Subareas 48.1 to 48.3 to determine whether catch-per-unit-effort (CPUE) might be used to produce a fishery-scale performance index. The vessels-specific mean CPUE (log catch (kg) per minute fishing) was estimated using all data for each vessel, and an annual index was calculated as the difference between this overall mean and the mean for each year in which the vessel fished. An overall fishery performance index (FPI) was derived from the sum of the vessel-specific indices for each season. The annual FPI for each of the three subareas showed no synchronous relationship with each other and showed a differing relationship with the total catch in the same subarea. Comparison of the annual FPI with the krill biomass (from research surveys) and the combined standardised indices (CSIs) from CCAMLR Ecosystem Monitoring Program (CEMP) data suggests (at least qualitatively) some concordance between the performance of the fishery and krill abundance.

2.27 The Working Group thanked the authors for this analysis and encouraged further work on addressing data quality issues (including catch reporting precision), alternative approaches (including generalised linear models (GLMs)) to estimate the FPI, the impact of sea-ice and the spatial and temporal scales at which the FPI is compared with other indicators of krill abundance.

2.28 The Working Group noted WG-EMM-16/40, which reported on an integrated analysis of the krill fishery in Subareas 48.1 to 48.3 from 2005/06 to 2014/15. The authors found a significant spatial–temporal trend in CPUE which was influenced by krill distribution patterns as well as the fishing technique used. In general, fishing using conventional trawls was characterised by higher CPUE and higher interannual variability in each SSMU compared with data from the continuous fishing system. The authors found significant variability of the CPUE indices between fishing vessels operating with conventional trawl in the same fishing grounds. One of the reasons for this CPUE variability was vessels using different designs of fishing gear and producing a range of krill products. The latter is clearly illustrated in the Bransfield Strait.

2.29 Dr S. Kasatkina (Russia) proposed to investigate the effect of the on-board krill processing on CPUE dynamics for understanding the dynamics and strategies in the krill fishery. She noted that the corresponding information should be included in the CCAMLR database.

2.30 The Working Group agreed that CPUE data are an important element of fisheries data and encouraged further investigation of the influence of fishery strategy on CPUE dynamics. The Working Group noted that the analysis of catch data and acoustic data collected during fishing operations could provide a means to develop standardised CPUEs from the krill fishery.

Fishing season

2.31 The Working Group discussed WG-EMM-16/16, which considered whether the CCAMLR season for the krill fishery should start at a time of year that is based on ecological events, rather than on a date that is convenient for management. The authors of WG-EMM-16/16 used data on the breeding period of predators and catch data to explore whether there are times of year that would reduce the potential for competition between land-based krill-eating predators and the fishery.

2.32 Dr Kasatkina noted that WG-EMM-16/16 only reported evidence of temporal overlap between the krill fishery and breeding predators. However, in considering the start date of the krill fishing season, Dr Kasatkina indicated that the Working Group should have evidence on spatial and functional overlap between fishery and predators and to take into account the sea-ice conditions being the important factor for fishing vessel allocations. Dr Kasatkina noted that moving the start of the fishing season would have an impact on fishery efficiency and safety of navigation for fishing vessels.

2.33 The Working Group advised that the start date of the fishery and the period when fishing might actually take place each year must be balanced with overall requirements for land-based predators during both the summer breeding period and other times of year, including the requirements for predators which overwinter in the areas in which the fishery operates. The Working Group agreed that such requirements may vary between subareas and this may require different management approaches.

2.34 The Working Group discussed the spatio–temporal overlap between krill-eating predators and the fishery, as well as the potential for fishing to disrupt the structure of krill swarms (i.e. functional overlap) and agreed to give this matter further consideration while developing FBM.

SG-ASAM report

2.35 The Working Group noted the report from the 2016 meeting of SG-ASAM (Annex 4). The Subgroup has been developing methods to use fishing-vessel-based acoustic data to provide qualitative and quantifiable information on the distribution and relative abundance of krill, and the 2016 meeting focused on: analysis to generate validated acoustic data suitable for further analyses; and analysis to produce specific products from those validated acoustic data. The Working Group thanked Dr Reiss for convening that meeting.

2.36 The Working Group’s discussion of the SG-ASAM report (Annex 4) focused on the development of methods for the evaluation of uncertainty in acoustic estimates of krill biomass which include the development of metrics of acoustic data quality, and processes to estimate the proportion of bad and missing data and the signal-to-noise ratio.

2.37 The Working Group encouraged SG-ASAM to develop a single processing approach for use with acoustic data collected by all fishing vessels (paragraph 2.271) and to continue work on statistical techniques that adequately represent uncertainty in data processing decisions.

2.38 The Working Group noted that analyses using the three-frequency method for differentiating krill usually integrated data to a depth of 250 m because the acoustic data from frequencies above 120 kHz did not have sufficient signal-to-noise ratio below 250 m. The increasing use of 70 KHz for collecting acoustic data may allow integration to depths greater than 250 m in the future.

2.39 The Working Group supported SG-ASAM's advice to explore incentives to achieve the broad-scale participation in the collection of acoustic data in the krill fishery, for example, by allowing extra catch to be available to those vessels that voluntarily undertake surveys or repeated transects.

2.40 The Working Group noted that, as requested by SG-ASAM, the Secretariat has included information for fishing vessels on how to collect acoustic data along nominated transects in its routine communications with Members and vessels participating in the krill fishery.

Scientific observation

Observer coverage

2.41 Two papers resulted from the discussions at WG-EMM-15 and SC-CAMLR-XXXIV on observer coverage and the associated metrics. WG-EMM-16/63 highlighted that uncertainties in stock status for Antarctic krill do not allow for the development of a comprehensive FBM at present, and these uncertainties would best be addressed through better, more frequent observations in the fishery. In order to monitor rapid changes in the Antarctic ecosystem in the context of climatic change, the authors suggested 100% mandatory observer coverage.

2.42 WG-EMM-16/11 by the Secretariat followed the request of WG-EMM-15 (SC-CAMLR-XXXIV, Annex 6, paragraph 2.34) and SC-CAMLR-XXXIV (paragraph 7.5) to develop a metric to describe actual levels of observer coverage in the krill fishery. The metric evaluated in this paper was the number of days observed during a trip, consistent with the practice in the finfish fishery, where 100% coverage means having a SISO observer on board for the entire fishing activity of a given vessel. The authors first evaluated the level of observation (in days) for the past five years in the krill fishery, concluding that during that time period, 90% of fishing days were observed (WG-EMM-16/11, Table 1). Furthermore, within the krill fishing fleet, 92% of vessels had 100% observer coverage. Previous work had shown that observers on krill vessels exceed sampling requirements under SISO, and thus the authors concluded that data collection on krill vessels is methodical and systematic.

2.43 The Working Group noted that both papers have independently defined observer coverage the same way.

2.44 Some participants noted that, at present, there is no need to rewrite the level of observer coverage required in CM 51-06, because (i) current coverage of 50% as required under CM 51-06 is suitable for understanding spatial and temporal variation in krill lengths, and increase to the observer coverage should be based on scientific analysis; (ii) observer data is currently not used for krill fishery management; and (iii) quality of observer data with regard to finfish larvae is not equivalent between vessels, and suggested that effort should focus on increasing the quality of observer data, not the quantity of coverage. Furthermore, the implementation of observer coverage would be a matter for the Scientific Committee, not WG-EMM.

2.45 Other participants pointed out that it is the common responsibility of CCAMLR to conserve its living resources and, as such, there is a need to collect all data, as scientific information will allow better management and development of the krill fishery. Furthermore, although scientific observation data is not used to set catch limits, it is used for fishery management, for example through the development of seal by-catch mitigation which was an issue first identified using observer data.

2.46 The Working Group recalled that the discussion on the level of observer coverage has taken place several times in the past (WG-EMM-14/58, Annex 1; SC-CAMLR-XXXIV, Annex 6, paragraph 2.41; SC-CAMLR-XXXIV, paragraphs 7.4 to 7.22; CCAMLR-XXXIV, paragraphs 3.70 to 3.73 and 6.2 to 6.4) and reiterated its previous general acknowledgement that 100% observer coverage on krill vessels is scientifically desirable.

2.47 In order to reach the scientifically desirable state of 100% observer coverage (SC-CAMLR-XXXIV, paragraph 7.4), the Working Group noted the importance of understanding the circumstances preventing the remaining vessels from reaching this target.

2.48 The Working Group advised the Scientific Committee that an analysis of the observer coverage in the last five years (defined as the number of days when an observer was on a krill fishing vessel as a percentage of the days fished) showed that 90% of fishing days had been observed and 92% of vessels had achieved 100% observer coverage.

2.49 The Working Group considered the request by WG-SAM-16 (Annex 5, paragraphs 2.13 and 2.14) to consider metrics relevant to krill sizes and distribution as part of the observer requirements, as presented in WG-SAM-16/39.

2.50 WG-SAM-16/39 examined the efficiency of the sizes of krill length samples taken by observers by looking at effective sample sizes. All SISO observers on krill fishing vessels collect krill length data which is a basic component in stock assessments, but to date the actual sample size necessary to provide sufficient information has not been examined. This study simulated the effect of reducing the sample size for krill length measurements per haul on the estimate of effective sample size for overall lengths per SSMU/month, randomly subsampling without replacement. At the same time, the effect of spreading out sampling effort over a larger number of hauls at the same temporal–spatial scale was tested. The authors concluded that the sample sizes per haul could be reduced to 50 measurements without reducing the effective sample size, but increasing the number of hauls increased effective sample size, and therefore recommended to reduce sampling of length per haul to 50 but increase sampling effort on haul numbers.

2.51 The Working Group discussed the effects of reducing sample size but spreading sampling effort, noting this will efficiently increase the effective sample size without increasing the number of krill individuals to be processed. It suggested that an evaluation on effective sample sizes looking at the complete length-frequency distributions may be needed in addition to looking at the mean for each haul.

2.52 The Working Group further reflected if there are other questions that are asked of the data collected by observers, and concluded that it is not the samples or sample sizes that need to be primarily considered, but the sampling design. To achieve maximum use from the collected data, sampling could be stratified to include different locations, times and sample sizes.

2.53 The Working Group recommended to examine whether the current sampling design is appropriate to the overall questions raised, and to consider sample sizes after the sampling design is confirmed.

2.54 The Working Group recognised the large amount of data that is provided by observers on krill fishing vessels and thanked all observers for their good work at sea and the high level of coverage, supporting CCAMLR and krill fishery management.

2.55 The Working Group noted that there needs to be commitment to continue collecting data for contribution to FBM and krill management, and that national commitment and the ability of observers to collect krill data need to be considered when designing FBM procedures.

Krill biology, ecology and ecosystem interactions

Krill

2.56 WG-EMM-16/39 examined the interannual variability of krill transport in the Scotia Sea using data from available mesoscale surveys during three seasons (January–March 1984, October–December 1984, January–March 1988). The water circulation patterns were calculated using the geostrophic approximation from hydrographic data while data from the Russian trawl surveys were used to estimate krill abundance. Krill transport was considered as a passive transport with the water flow, and the total flux of krill was calculated assuming a constant supply of krill along sections between adjacent conductivity temperature depth probe (CTD) stations where flux was calculated. The authors analysed variability of water mass and krill biomass transported across different meridional transects in each survey. The authors noted that significant seasonal and interannual variability in water circulation can be clearly observed by SSMU.

2.57 Dr Kasatkina noted that krill coming to the Scotia Sea across the Antarctic Peninsula area can be transported in different ways along the Scotia Arc depending on the current speed and direction. She also noted that estimates of water mass and krill biomass transported across the Scotia Sea have high spatial–temporal variability along and between transects. Dr Kasatkina noted that these calculations of krill biomass transported out of the Bransfield Strait and the Drake Passage might constitute 3.19 million tonnes for the fishing season, and the total krill biomass transported into the Scotia Sea might constitute up to 10.6 million tonnes and 16.2 million tonnes for the fishing season. These estimates of krill flux exceed the trigger level and the precautionary catch limit in Area 48. Dr Kasatkina highlighted that the presence or absence of krill in a subarea/SSMU is in a greater degree a reflection of the dynamics of krill flux, and is not determined by the local stock state or the influence of the krill fishery. Developing the FBM for the krill fishery in Area 48 requires studying krill flux in different spatial–temporal scales.

2.58 The Working Group thanked Dr Kasatkina for her contribution and noted that this presentation built on previous studies (Sushin and Shulgovsky, 1999).

2.59 Dr Kasatkina noted that data from AtlantNIRO’s mesoscale surveys during three seasons (January–March 1984, October–December 1984, January–March 1988) was used for the first time to estimate krill flux and compare its indices with those obtained by the authors of WG-EMM-16/39 from the CCAMLR 2000 Krill Synoptic Survey of Area 48.

2.60 The Working Group noted that the assumptions regarding the estimate of the total flux of krill using this approach were dependent on the assumption of time-invariant flow and constant source concentrations of krill as measured at one instant in time. The Working Group noted that an estimate of the variability of flux could be useful.

2.61 The Working Group noted that there were a number of different approaches to the calculation of currents that could be used to estimate the flux of krill (WG-EMM-16/45 and 16/15). Dr Reiss presented a general overview of these methods that included derivation of currents from surface drifters or hydrographic data to generate static surface flow fields and the development of fine-scale four-dimensional numerical circulation models that could better represent the temporal variability and total flux of krill. The Working Group noted that:

(i) the circulation models could be used to examine the sensitivity of the flux estimates by conducting simulations that could be used to determine where to place, and how often to sample, transects

(ii) simulations from numerical models could be used to examine the aggregation and concentration of krill under conditions of both passive and active vertical migration or directed movements for feeding and that these simulations could help to understand the local depletion or recovery of krill in different areas as well as connectivity between areas

(iii) the aggregation of krill in hotspots or in areas of low current flow could generate patterns of krill harvest in those areas that would be hyper stable, and that such attributes could complicate the use of CPUE as indices of abundance.

2.62 The Working Group recalled the previous work (SC-CAMLR-XIII, Annex 5) to understand the flux of krill through the ecosystem, given the importance of this variable to developing FBM and to allocation of catch amongst areas. The Working Group recommended that the Scientific Committee consider how to progress the development of methods to quantify flux, and to better understand the role of both behaviour of krill and oceanographic processes that can aggregate krill and transport krill to downstream areas. This may need the involvement of experts from WG-EMM, SG-ASAM and oceanographers.

2.63 WG-EMM-16/51 presented an analysis of the abundance of larval stages of krill species in the Weddell–Scotia Confluence during the 2011 austral summer. The authors compared abundance estimates with previously published work from the early 1980s and early 1990s and showed that larval abundance for Antarctic krill (*Euphausia superba*) was lower than over the last 25 to 35 years. The authors also show that since the earlier period, considerable freshening of waters may have occurred in this region, suggesting that environmental conditions have changed coincident with the lower krill larval abundance.

2.64 The Working Group noted the importance of these kinds of studies, given the changes occurring at the Antarctic Peninsula owing to climate change. The Working Group also noted that the apparent changes in larval krill were associated with changes in the oceanographic properties of the water column, but that, given the variability associated with krill population dynamics and production, detecting a systematic change using existing data was difficult.

2.65 WG-EMM-16/53 presented the results of a modelling analysis of the potential future effects of changing temperature based on a best-case and worst-case scenario of climate change on individual weight and population biomass of krill through changing gross growth potential (GGP). It examined these potential changes on predator populations using an ecosystem model (the FOOSA or KPFM models) to drive the predator populations and the GGP. The authors first assessed outcomes of climate change for individual krill weight, and then compared the effects of (i) climate change alone, (ii) fishing at the precautionary catch limit (with the spatial distribution of catch following the historical pattern) alone, and (iii) GGP and fishing together relative to a base simulation with no fishing and a constant GGP. The results of this analysis show that changing ocean temperatures are likely to decrease individual krill weights and decrease krill population biomass with concomitant effects on a krill-dependent species. In the model, average krill weight declined by 22%. The authors compared these direct effects of climate-driven changes in temperature on krill biomass and predator performance to models with the addition of fishing where both biomass and penguin abundance showing greater declines when both climate change and fishing occurs. The authors argue that these data provide some evidence that long-term climate change predictions must be considered as part of the strategy to manage krill.

2.66 The Working Group noted that there could be evolutionary or adaptive responses by krill to the changing environmental conditions that are unrecognised at present and that these changes may give rise to an absence of a response of krill to climate change. However, the model also assessed only one impact of climate change and one pathway for impact, whereas climate change will likely impact environmental conditions beyond temperature, and have more complex consequences for krill and krill-dependent predators than are represented in the paper.

2.67 The Working Group had a number of questions regarding the dynamics of the model under different conditions. The dynamics in long-term simulations might change if changes were stabilised half way through the simulation. Such an investigation could indicate whether there are substantial lags in the response of the populations to changing climate forcing, or if the system would be resilient to moderate impacts. In addition, the long time scale of the model currently, while necessary to include output from climate change models, is less informative for making management decisions.

2.68 The Working Group noted that management strategies based on this approach would need to be robust to these kinds of unforeseen responses and protect against the worst effects. The Working Group indicated that some further work to develop evaluation strategies for the potential effects could help mitigate against differences between model projections and suggested management decisions that might be developed using this model.

2.69 WG-EMM-16/P02 reported on progress to further develop a direct ageing technique for Antarctic krill based on counting of what is believed to be growth zones in cross sections of eyestalks. The authors were able to find up to six growth bands isolated from krill. The authors found a number of interesting size-, sex- and maturity-based relationships. In particular, the authors showed that females tended to have narrower growth zones from the third zone and onwards compared with males. The data showed that sub-adult male krill (MIIA1, MIIA2 and MIIA3) had 2.2 ± 0.8 (average ± SD) zones and adult male krill had 3.8 ± 0.8 zones. Female juvenile krill (FIIB) had 1.7 ± 0.5 zones and adult female krill (FIIIA-E) had 3.7 ± 1.0 zones. The authors noted that there were positive relationships between the number of zones and the maturity stage, and between the number of zones and body length.

2.70 The Working Group welcomed the progress being made towards the development of a direct ageing method for krill. The Working Group recalled WG-EMM-15/45 that also worked towards validating krill ages, and noted that validating the methodology was critical and encouraged the continued development of the technique, including calibration of the technique between laboratories. It agreed that further development of the approach to age krill will be useful to the development of age-based assessments and comparative studies of krill biology and ecology.

2.71 WG-EMM-16/P04 reported on an analysis that examined seasonal changes in the size of male and female krill in Scotia Sea (South Georgia and the Antarctic Peninsula). By using a combination of fishery-dependent and fishery-independent data on the length of krill, the authors demonstrated that female krill in the Scotia Sea shrink approximately 3 mm during winter when modal size classes were tracked over seasons and sex ratio changes were accounted for. The authors tested for other explanatory factors, like differential mortality, immigration and emigration and argued these could not explain the observed patterns. The authors fitted seasonally modulated von Bertalanffy growth functions for males and females and showed a pattern of overwintering shrinkage in all body-length classes of females, but only stagnation in growth in males. This shrinkage most likely reflects morphometric changes resulting from the contraction of the ovaries and is not necessarily an outcome of winter hardship. The authors argue that the sex-dependent changes that were observed should be incorporated into life-cycle and population dynamic models of this species, particularly those used in managing the fishery.

2.72 The Working Group noted that this paper highlights the utility of fishery data to fill in gaps in our understanding of krill biology.

2.73 WG-EMM-16/76 presented results of two acoustic surveys conducted by Peru during the austral summers of 2013 and 2014. The Working Group thanked Peru for presenting its data to the Working Group and Peru indicated a willingness to continue to collaborate with Members. The Working Group also noted that such collaborations can help to meet broader CCAMLR goals.

2.74 The Working Group received presentations by two early career scientists. Ms Fokje Schaafsma from the EU (mentor Jan van Franeker) had been selected for the CCAMLR Scientific Scholarship. Dr Aleksandr Sytov from Russia (mentor Svetlana Kasatkina) was a candidate for a scholarship in 2014 but was unable to participate in the scheme for technical reasons.

2.75 Ms Schaafsma provided an update on her research to examine patterns of krill and zooplankton distributions in the water column and under sea-ice during a number of cruises to the Antarctic (WG-EMM-16/P16). Using data collected by the surface and under-ice trawl (SUIT) she outlined how krill (larvae and adults) are distributed within the pack ice. Ms Schaafsma highlighted that, given the importance of sea-ice to the life history of krill and the potential impact of climate change on sea-ice dynamics, the study is very timely.

2.76 The Working Group thanked Ms Schaafsma for her work and encouraged her to present the findings to WG-EMM in the future. The Working Group expressed interest in details of the gear regarding the size of nets within the gear, deployment details and the kinds of animals (whales, penguins and fish) that were observed by the camera attached to the net system. Dr Vacchi was interested in whether platelet ice, an important habitat for silverfish, was observed with the camera in any of the sampled areas. Others expressed interest in details of the distribution of krill and zooplankton within and outside the ice, and in relation to hypotheses regarding concentrations of krill across the open water and pack-ice habitat.

2.77 Dr Sytov presented results from his research (WG-EMM-16/41) on analyses of historical catch and acoustic data from the Russian krill fishery between 1988 and 2002 in the Atlantic sector (Subareas 48.1, 48.2 and 48.3) of the Southern Ocean. In particular, Dr Sytov's research focussed on questions of the spatial distribution of krill in terms of swarms and patch structure. Additionally, the research focussed on some aspects of the changes in maturity stages and feeding rates over the fishing seasons. Investigation was focused on the following aspects: What are the characteristics of krill spatial distribution, apart from biomass density, that are important for the fishery? In what way does the variability of these characteristics during the fishing season affect the indices of fishing vessels?

2.78 Dr Sytov indicated that variability of the fishing indices of commercial vessels (catch per hour, catch per trawling, daily catch, trawl efficiency) during the fishing season is in a great degree a reflection of changing swarm spatial distributions (i.e. parameters swarm distribution in two-dimensional and three-dimensional space) and not determined by swarm size. Moreover, the catch per hour trawling is mostly sensitive to the changing krill spatial distribution. The daily catch is limited by the vessel's technological equipment capacity and it may be attained by application of different fishing effort. Dr Sytov noted that the impact of variability of krill biological state (length composition, maturity stages, feeding rate) on krill distribution in the fishing ground was not revealed. Dr Sytov noted the importance to investigate the characteristics of krill spatial distribution in fishing grounds by using acoustic observation on board commercial vessels.

2.79 Dr Kasatkina, as Dr Sytov's mentor, underlined that the investigation fulfilled by Dr Sytov (SC-CAMLR-XXXIII, paragraph 13.12) would be important for: developing FBM; providing approaches for acoustic data processing to analyse the krill fishing performance; and studying functional overlap between krill fishery and dependent predators.

2.80 The Working Group welcomed this research especially because the use of acoustic data to examine the structure of krill distributions during the early part of the time series could be compared to the structure of the spatial distribution of krill during operation of the current fishery. The Working Group noted how far offshore the fishery operated in the past (well into the pelagic SSMUs in each subarea). The Working Group indicated that previous analyses of both the Japanese and former Soviet fishery data showed that the fleet-based searching that the Soviet fleet used allowed that fishery to operate farther offshore compared to the individual ship effort that was used by the Japanese fishery, and that advances in technology could change the effort required to search these areas in the current fishery.

2.81 The Working Group noted that analysing historical acoustic fishing data was as important as analysing the current fishery data as the data could be used to compare a variety of biological characteristics of krill at a variety of spatio–temporal scales.

Ecosystem monitoring and observation

2.82 WG-EMM-16/29 presented phyto- and zoo-plankton density distribution in relation to the environment from continuous plankton recorder (CPR) data collected on repeated transects in the Scotia Sea over the period from 2005 to 2015. The analysis used satellite information on sea-surface height (SSH) to identify fronts and eddies, which were overlaid plankton distributions, demonstrating clear physical–biological relationships that can be used to inform predictions about potential impacts of global climate change on biological production.

2.83 WG-EMM-16/70 provided an update on the Southern Ocean Observing System (SOOS) which was established by SCAR and SCOR and has direct relevance for CCAMLR. It is motivated by data scarcity and the difficulties in collecting information due to high costs and difficult logistics, which call for cooperation and coordination. Its four objectives include to: (i) facilitate multidisciplinary data collection, (ii) optimise observation effort, (iii) establish long-term time series and (iv) provide services that make data accessible to users. The aim of assessing the state of the Southern Ocean is ambitious, as is the aim of circumpolar benchmarking in 2022. SOOS has a technology focus and invited CCAMLR to join, as CCAMLR infrastructure represents a resource for SOOS, for example due to the potential of using fishing vessels as platforms for data collection.

2.84 The Working Group agreed that there is a need for cooperation with SOOS and that this should be brought up when discussing collaboration between other organisations and CCAMLR (paragraphs 6.22 to 6.26).

2.85 WG-EMM-16/75 presented the results of abundance studies of *Salpa thompsoni* over a time series from 1975 to 2001 as a follow-up to the information presented in WG-EMM-15/P08. Scientific questions addressed in the study included: (i) which environmental factors determine presence or absence of salps? and (ii) which of these factors influence their abundance?

2.86 The presence–absence of salps was correlated with presence or absence of sea-ice; temperature and depth and the abundance was inversely related to sea-ice concentration and the highest concentration was found in water around 1°C. The authors suggested further study of the issue in relation to climate change.

2.87 The Working Group recalled that salps were discussed more broadly in CCAMLR in earlier years but have received less attention in recent years. Dr T. Ichii (Japan) recalled that salps impacted fishing 20 years ago as krill swarms occasionally contained large quantities of salps. This situation, as reported from the current fishery, is not the same and the Working Group suggested that the more inshore operation of the fleet might be an important explanatory factor.

2.88 The Working Group suggested that available data and information about salps could be used to establish models that enable CCAMLR to understand the potential impact of climate change on the relationship between krill and salps. Such data exist from routine surveys and Members were advised to analyse this information and make it available to WG-EMM and SOOS.

2.89 The Working Group noted that information on the acoustic identification and target strength of salps have been published (Wiebe et al., 2010) and this provides an opportunity for using acoustics to distinguish salps from krill as well as estimating their biomass.

2.90 The Working Group recommended that the SISO fish by-catch data reporting form be modified to collect data on salps by requesting observers to record whether salps were present or absent in the 25 kg sample collected for the analysis of fish by-catch.

2.91 WG-EMM-16/P03 reported the update of the annual Norwegian standard acoustic trawl survey (WG-EMM-15/54). The report documents survey methods and the krill abundance estimates for this year. Antarctic krill demography is reported as well as occurrence of other zooplankton from the trawl catches. Sighting data of cetaceans, pinnipeds and seabirds were collected along the survey transects. Additional experiments were also conducted on board to collect data for the verification of a method to determine the age of krill and to model trawl net mesh penetration behaviour of krill.

2.92 Dr Krafft informed the Working Group that pack-ice concentration was low this season and that the zooplankton distribution was different compared to previous years. Salps were found distributed more or less throughout the entire study area, which was in contrast to previous seasons when they were more abundant in the northern part. Also, there were more fish in the krill catch, a situation that was underlined by Dr Trathan who reported more fish in the diet of penguins in the South Orkney Islands.

2.93 WG-EMM-16/P11 reported on developing priority variables (ecosystem Essential Ocean Variables – eEOVs) for observing dynamics and change in Southern Ocean ecosystems. The paper organised a framework for prioritising eEOVs to be collected within the SOOS monitoring program. These variables address questions regarding ecosystem status, trends, attribution and scenarios for marine ecosystems. The authors underlined that efficiency in data collection is enhanced by first agreeing on eEOVs. The paper raised several issues of direct relevance to CCAMLR.

2.94 The Working Group agreed that interaction with SOOS, and particularly regarding the development of eEOVs, is needed. It was recommended that this issue be discussed by the Scientific Committee.

Ecosystem interactions

2.95 WG-EMM-16/14 reported on the second meeting of the workshop on the Retrospective Analysis of Antarctic Tracking Data (RAATD), sponsored by the Expert Group on Birds and Marine Mammals (SCAR-EGBAMM), held in Delmenhorst, Germany, in 2016. The first workshop, held in Brussels, Belgium, in 2015, established a database of Antarctic animal tracking data that now holds 3 447 tracks from 15 species (10 species of seabirds and five species of marine mammals). The data were provided by more than 37 data holders from 23 institutions in 11 countries. The workshop reviewed interim progress on:

(i) developing habitat utilisation models for each species

(ii) using those models to make global species-specific predictions of important habitat based on colony locations

(iii) identifying areas of ecological significance (AES).

2.96 The specific goals of the meeting were outlined for two areas: data management and data modelling. The goals included identifying and sourcing missing datasets and developing specific guidelines for quality control of datasets. For the data modelling group, the objectives included running state–space movement models for each species, extracting environmental datasets and developing statistical habitat use models for each species. The report also provided an extensive list of candidate environmental variables that will be used in developing predictive models of habitat use for each species.

2.97 Significant progress was made on all the stated objectives and post-sessional work was identified for providing habitat use models for all tracked species and identifying AES.

2.98 The Working Group recognised that, given the scale at which predators are distributed and the inability to monitor all colonies, habitat modelling is an important approach to identifying ecologically important habitat and identifying where potential overlap with fisheries occurs.

2.99 The Working Group noted that the work of SCAR on animal tracking and habitat use models will be important for developing predator consumption models and will potentially have implications for managing the krill fisheries at finer scales.

2.100 The Working Group further recognised the importance of the SCAR-EGBAMM RAATD for a variety of CCAMLR analyses, including work on the development of a variety of FBM approaches for the krill fishery and work on the spatial planning processes needed for identifying candidate CCAMLR marine protected areas (MPAs).

2.101 WG-EMM-16/20 reported on a first attempt at using a methodology established by BirdLife International over 35 years ago to identify important bird and biodiversity areas (IBAs) for penguins in Subareas 48.1 and 48.2. The authors used all available tracking data for four species of penguin and identified candidate IBAs based on BirdLife International's internationally established criteria: (i) the species is a globally threatened species, (ii) the site is known, or thought, to hold on a regular basis >1% of the global population of the species, and (iii) the site holds on a regular basis >20 000 waterbirds or >10 000 seabird pairs. The analysis identified candidate IBAs for Subareas 48.1 and 48.2 (Hope Bay; Powell Island; Gourlay Penisula, Signy Island; North Point, Signy Island; and Admiralty Bay, King George Island). The authors outlined future intersessional work for developing a more complete Antarctic IBA network.

2.102 The Working Group noted that the criteria used by BirdLife International may exclude some important smaller datasets. The Working Group encouraged the authors of WG-EMM-16/20 to work closely with other CCAMLR-led habitat modelling initiatives and to submit a paper to WG-SAM for evaluation of methods and provide an update on their progress for WG-EMM-17.

2.103 The Working Group noted that multiple approaches to the analysis of animal tracking data with the aim of identifying important predator habitat can be useful in a comparative approach to identifying habitat important to predators.

2.104 WG-EMM-16/15 described preliminary progress on high-resolution hydrodynamic modelling using a modelling framework developed by the Nucleus for European Modelling of the Ocean (NEMO) for Subareas 48.2 and 48.3 continental shelves and adjacent areas. Past ocean models have been instrumental in describing and studying large-scale transport of water and biota. However, much less is known about movement and transport over finer scales (<10 km) that are relevant to understanding distribution and movement of krill, fish, predators and fishing. The working scale for these models is ~3 km.

2.105 The results provided are simulations for one year, however, it is the intention of the authors to provide model results for a historical 20-year period. The South Georgia model has already undergone validation with favourable results using an extensive CTD dataset and satellite-derived sea-surface temperature (SST) data collected in 1995. The South Orkney Islands model is currently undergoing validation using in situ data collected from 1997 to 1998. Dr Trathan noted that sea-ice dynamics will be included in future developments of the models.

2.106 The Working Group agreed that such models will improve our fundamental understanding of hydrodynamic impacts over the scales that predator–prey relationships take place and will provide the basis for examining the local controls on prey availability and distribution of predators. Once completed, such models offer hindcast capabilities for numerous past studies of both prey and predators, including during the CCAMLR-2000 Survey and the recent international cruise at the South Orkney Islands in 2016 (WG-EMM-16/19). Such analyses will help inform future management and conservation measures within CCAMLR.

2.107 WG-EMM-16/19 reported on a recent multinational effort led by the UK and Norway and included participants from the US AMLR Program, University of Washington and the University of Coimbra. The survey was conducted in January and February 2016 around the South Orkney Islands in an area important to the krill fishery. It was coordinated with an annual five-day survey of an important fishing area northwest of the South Orkney Islands conducted by Norway. It included extensive net and CTD sampling. The acoustic survey was also supplemented with data collected from two newly designed stationary moorings and a third mooring deployed by the *Saga Sea*. At-sea predator distribution data was collected concurrently.

2.108 The Working Group noted the importance of this multinational effort as the data collected will be important in understanding krill and mesopelagic fish distributions in relation to oceanography and predators.

2.109 WG-EMM-16/P06 analysed several climate indices and krill densities at South Georgia to show significant correlations with annual calf production of southern right whales (*Eubalaena australis*) in southern Brazil over a 17 year period. The results are noteworthy because most CEMP indices are necessarily collected using land-based predators and this study provides evidence of a significant correlation between krill abundance at South Georgia and reproductive success for a recovering cetacean species.

2.110 The Working Group welcomed this paper and noted that southern right whales are known to be important krill consumers which are present near South Georgia in the summer. The Working Group recognised that, while the krill density data were from a local-scale survey, these data may well reflect changes in the variability in krill abundance over the feeding area of the population of southern right whales that calve in Brazil.

2.111 The Working Group encouraged further work on data from long-term monitoring of the reproductive success of baleen whales and variability in krill abundance in their summer feeding areas.

2.112 WG-EMM-16/P15 reported on the at-sea distribution and prey selection of Antarctic petrels (*Thalassoica antarctica*) and commercial fisheries. Past working groups and the Subgroup on Status and Trend Assessment for Predator Populations (WG-EMM-STAPP) have often identified the need for more information on flying seabirds. This paper provided new information on the degree of overlap in krill fisheries and Antarctic petrels during the breeding and non-breeding phases. The study occurred over three consecutive years beginning in 2011 using global positioning system (GPS) data loggers providing 133 tracks of 124 individuals during the breeding phase. An additional 51 loggers provided data during the non-breeding phase. The authors found that the degree of overlap with the fishery varied greatly within and between years and was higher during the non-breeding phase. They compared krill length frequencies in the diet of Antarctic petrels and found that they did not differ from the fishery. Their results indicate that competition, although limited, may exist between Antarctic petrels and krill fisheries and may increase with increased fishing.

2.113 WG-EMM-16/28 reported on the present status of the marine ecosystem at South Georgia using long-term datasets of predator performance indices coupled with data collected concurrently on krill density offshore. The paper found: (i) some predator performance indices at large scales broadly correlated across two sites separated by ~65 km; (ii) at smaller scales, however, some variables reflected local ecological conditions; (iii) previously documented predator–prey relationships were not apparent and this may reflect the fact that the analyses used a different subset of data covering different years during which fewer years of extreme low krill density were apparent; (iv) variability in krill was evident at different spatial and temporal scales and, at low densities, spatial variability and patchiness may become important as determinants of predator performance. The authors noted that mean krill density alone may not be adequate to explain variability in predator performance.

2.114 The Working Group noted that the recent work on developing mesoscale models (WG-EMM-16/15 and 16/45) to describe flux and prey movement at scales relevant to predator foraging may help provide better metrics for explaining variability in predator success.

2.115 Dr Kasatkina noted that the proposed analysis of spatial variability and patchiness of krill distribution would provide important information for understanding relationships between predators and krill, as well as competition between fishing and krill-dependent predators. She also noted that knowing the critical density thresholds of krill for foraging predators would also provide management information for understanding reproductive success for different predators in relation to annual estimates of variability in krill biomass.

2.116 WG-EMM-16/26 examined temporal changes in historical distribution and sighting density of baleen whales in Subareas 48.1 and 48.2 in response to the request of

WG-EMM-15 that an analysis of historical cetacean surveys could provide a context for at-sea observations of cetaceans (SC-CAMLR-XXXIV, Annex 6, Table 3). Whale sighting data were obtained during a series of Antarctic sighting cruises organised by the International Whaling Commission Scientific Committee (IWC SC) in three circumpolar surveys (CPI, II and III) that took place in Subareas 48.1 and 48.2 between 1982 and 2000. The density indices in both subareas reflect variation in sighting density for blue (*Balaenoptera musculus*), fin (*B. physalus*), humpback (*Megaptera novaeangliae*) and Antarctic minke (*B. bonaerensis*) whales, with some evidence to suggest an increase in fin and humpback whale sightings, and a decrease in Antarctic minke whale sightings across one or both areas over time. The authors noted that due to differences in survey design from CPI, comparison of density across CPII and CPIII is more appropriate. The authors concluded that stock abundance estimates of baleen whales, and concentration of whales in fishing and other predator foraging areas, are of importance for managing krill under FBM.

2.117 The Working Group noted the differences in transect design between CPI and both CPII and CPIII. It recalled previous discussion of survey design for the concurrent krill and cetacean sightings survey (SC-CAMLR-XXXIV, Annex 6, paragraphs 2.239 to 2.241; Annex 5, paragraphs 2.7 to 2.10). The Working Group noted that inferring a trend in whale populations in Subareas 48.1 or 48.2 on the basis of three periods of data collected using inconsistent survey design, in a region that we know to be characterised by high interannual variability, may be problematic. Furthermore, it noted the importance of consistent survey timing to reduce the risk of conflating inter- and intra-annual variability. On this point, it was clarified that International Decade of Cetacean Research/Southern Ocean Whale Ecology Research (IDCR/SOWER) surveys in each year were carried out at similar times. The Working Group noted that the dedicated cetacean surveys reported in WG-EMM-15/26 had not been conducted since 2000. The Working Group encouraged further cetacean sighting surveys in Subareas 48.1 and 48.2 and encouraged analysis of other sources of cetacean sighting data that are available for these subareas.

2.118 The Working Group agreed the importance of considering krill consumption by baleen whales in the development of an effective FBM regime. It highlighted the increasing numbers of humpback and fin whales in Bransfield Strait as one area where consideration of cetaceans in FBM may be important. It noted that with a staged approach to FBM, effects on cetaceans could be incorporated in the future but that temporal lags due to cetacean life-history characteristics would need to be considered. It noted that cetaceans may be good candidates for monitoring the ecosystem as a whole.

2.119 The Working Group agreed that it is valuable to receive regular updates from IWC on the status of whale populations and noted the reciprocal interest from IWC with regard to CCAMLR data. It noted that the Joint CCAMLR–IWC Workshop next year could provide a basis for data sharing related to the krill-based ecosystem (paragraphs 6.3 to 6.7).

2.120 WG-EMM-16/64 reviewed information that could be indicative of changes in the east Antarctic ecosystem in the context of two hypotheses, the ‘krill surplus’ hypothesis in the middle of the past century and the recovery of baleen whales since the 1980s. The authors suggested that increased krill availability in the middle of the past century may have translated into better nutritional conditions for some krill predators like Antarctic minke whales, resulting in a decreasing trend in the age at sexual maturity of this species between approximately 1940 and 1970. A low age at sexual maturity could help explain an increase in the recruitment rate and total population size over a similar period. The authors noted that the evidence available since the 1980s showed a sharp increase in the abundance of some species in East Antarctica such as the humpback and fin whales. In contrast, the authors described a stable trend of age at sexual maturity and recruitment for Antarctic minke whales after the 1970s. They noted this was consistent with the total abundance of Antarctic minke whales estimated by sighting surveys, which has been broadly stable since the 1980s. The authors suggested the availability of krill for Antarctic minke whales could have decreased in recent years, possibly as a result of competition with recovering whale species. The authors noted the concurrent recovery of baleen whales and an increasing trend in Adélie penguin (*Pygoscelis adeliae*) numbers in East Antarctica. While this appears inconsistent with conditions of resource limitation, the authors supported one of the explanations provided by Southwell et al. (2015) that environmental factors such as decreasing sea-ice extent may explain this. The authors explained that the motivations to prepare this document were: (i) to start discussions on possible differences in the kind of ecosystem changes observed in the eastern and western Antarctic; (ii) highlight the importance of the long-term monitoring of sea-based krill predators like baleen whales.

2.121 The Working Group noted that aspects of the paper were still being considered by IWC SC and focused its comments on aspects related to interactions with the krill-based ecosystem. It noted the Joint CCAMLR–IWC Workshop would provide an opportunity to discuss areas of mutual interest. It noted the focus of the workshop was the Antarctic Peninsula, and that approaches developed there may be able to be applied in other areas like East Antarctica.

2.122 The Working Group noted the evidence of spatial overlap of humpback and Antarctic minke whale distribution at the sea-ice edge in East Antarctica and agreed that krill biomass data in this area would be valuable to examine the authors' hypotheses, or alternative hypotheses, for ecosystem interactions in East Antarctica. In considering alternative hypotheses, the Working Group noted the large increase in Adélie penguin numbers in the region and in the adjacent Ross Sea region over the past two decades that occurred despite variable and increasing sea-ice extent and recovering whale populations. It encouraged the exploration of alternative hypotheses to resource limitation in East Antarctica, including shifts in Antarctic minke whale distribution with respect to sea-ice and polynyas as noted in the paper, positive feedback loops associated with recovering whale populations (Lavery et al., 2014) that may explain simultaneous increases in whale and penguin numbers, and the impacts of climate change.

2.123 WG-EMM-16/P01 provided an example of the use of passive ocean acoustic waveguide remote sensing techniques to study the foraging behaviour of an assemblage of more than eight species of cetaceans preying on herring shoals in their spawning areas in the Gulf of Maine in the North Atlantic (Wang et al., 2016). The vocal cetacean species detected include blue, fin, humpback, sei (*B. borealis*), minke, sperm (*Physeter macrocephalus*), pilot (*Globicephala* spp.) and killer (*Orcinus orca*) whales along with other delphinids. All these species spatially converge on fish spawning areas containing massive densely populated herring shoals at night-time and diffuse herring distributions during daytime. Vocalisation rates for baleen whales are highly correlated with trends in fish shoaling density and with each other over the diel cycle but some species-related spatial preferences occurred. The results reveal the dynamics of combined multi-species foraging activities in the vicinity of an extensive prey field that forms a massive ecological hotspot.

2.124 The Working Group noted that the study revealed spatial and temporal complexity of predator–prey interactions, coupled with potential niche partitioning, at the mesoscale (30–100 km) consistent with findings from fine-scale studies of baleen whales in Antarctic waters (Santora et al., 2010; Friedlaender et al., 2014). It noted the potential application of passive ocean acoustic waveguide remote sensing techniques to study the foraging behaviour of baleen whales and the krill-based ecosystem. It noted that for krill, it would be necessary to increase the active acoustic frequency to 12 kHz, which would reduce the detection range, but that passive acoustic arrays could be deployed from vessels at up to 8 knots. It noted the need for bathymetric data and the potential environmental impact of using low-frequency active acoustics. However, it noted that this system used only the same energy levels as the whales themselves, and multiple sub-sources to minimise impacts.

2.125 The Working Group noted the value of passive acoustics for localising cetaceans in the Southern Ocean and recalled the SORP initiative 'the Southern Ocean Hydrophone Network' (van Opzeeland et al., 2013). It noted that such gear may be able to be deployed opportunistically from fishing vessels if the post-processing requirements can be addressed. It noted that candidate sites and systems for trials (e.g. baleen whales and krill in Bransfield Strait, or sperm whale depredation of toothfish fisheries) could be considered by the steering group for potential discussion at the Joint CCAMLR–IWC Workshop next year.

CEMP and WG-EMM STAPP

CEMP data

2.126 As of 1 June 2016, nine Members working at 15 sites in Areas 48, 58 and 88 contributed data for 12 CEMP parameters on six species of krill-dependent predators for the 2015/16 breeding season. Additional data have since been submitted by Ukraine and entered into the CEMP database.

2.127 At the request of WG-EMM, an analysis of data in the CEMP database was undertaken by the Secretariat to support use of CEMP data in FBM development. The analysis in WG-EMM-16/08 noted several potential issues with data submissions. A subgroup was convened to discuss these issues and the Working Group agreed that Members would continue discussions intersessionally on the e-group to resolve outstanding issues. Issues to be resolved are:

(i) Parameter A3: Efforts were ongoing to identify appropriate units of breeding unit aggregation for reporting A3 data. Thus far, the subgroup recommended that CEMP data providers submit updated maps of nest census areas that clearly define the spatial scale of their A3 data.

(ii) Parameter A6: There is uncertainty in the estimation method for reproductive success. That is, should aggregate totals of nest and chick census data for the entire colony be used or should an average of reproductive success across multiple sites within a colony be used to estimate colony success.

(iii) Parameter A7: It was noted that submission of ancillary data for estimating mean fledging weights was often incomplete, particularly the estimates of the percent of the population fledging over time. Additionally, different interpretations of the standard methods, driven in part by differences in colony sizes and the degree of synchrony in the colony, result in different data collection methods. While some Members report data collected every fifth day, others report daily data aggregated on five-day intervals.

(iv) Parameter A8: Diet data suggest methodological changes in the field may compromise the ability to estimate diet mass. There has been a general decline in the collection of diet data across the CEMP network. The subgroup recognised the loss of potentially valuable diet composition and diet mass data, but noted that isotopic and genetic analyses may be useful tools to recover diet composition data. Additionally, it was suggested that krill length-frequency distributions for predator diets may be valuable additions to CEMP, as similar data are increasingly used in assessment models and complement fishery observer and research survey data.

(v) Parameter A9: Inconsistencies in proper formatting of A9 data are evident and an example of proper formatting was provided. The Working Group recommended intersessional work to advance camera-specific methods for parameter A9.

(vi) Parameter C1: Foraging trip durations for fur seal cows are only reported for the first six trips to sea. The Working Group noted that this method was based on historical considerations of occupancy of field camps by researchers. Additional data may be available; however, no specific reason to amend this CEMP method was determined.

(vii) Parameter C2: Estimates of fur seal pup mass resulted in differences in the relative trends in growth rates for males and females between sites. The Working Group noted that such differences in pup growth rates may be related to latitudinal differences in energetics.

2.128 On the whole, it was noted that despite potentially small differences in the implementation of the CEMP standard methods between sites, consistency of the method used within a site is critical. Such consistency ensures that standardisation of the data, for example as standard normal deviates or as a CSI for a particular site, enables direct comparisons across sites.

2.129 As a follow-on to the description of the CEMP inventory, the Secretariat reported on the spatial scales over which CSIs from existing CEMP sites are correlated. Correlations between CSIs of summer CEMP parameters were generally positive across all sites considered in Subareas 48.1, 48.2 and 48.3. Sites in Subareas 48.1 and 48.3 showed concordant interannual variation and the patterns of interannual variability in sites in the Bransfield Strait (Subarea 48.1) showed an increased level of concordance in the period since 2008.

2.130 The Secretariat also presented a comparison of summer CSIs from the three longest-running monitoring programs in each of Subarea 48.1 (Admiralty Bay), 48.2 (Signy Island) and 48.3 (Bird Island) and the Working Group noted that a three-year running average of CSIs from these sites exhibited a strong concordance suggesting region-scale concordance in predator responses.

2.131 The Working Group agreed that, while there was evidence of concordant responses in CSIs from sites, there was also evidence of site-specific signals that underlined the importance of understanding local-scale effects for some parameters. Reconciling these local impacts within the broader regional concordance remains an important task for understanding the spatial scales reflected by CEMP monitoring data.

2.132 The Working Group noted that the importance of local effects on monitoring data was provided by an analysis of an acute mortality event of penguins in WG-EMM-16/59. In the austral summer of 2011/12, the abnormal presence of summer sea-ice may have limited feeding opportunities for gentoo penguins (*P. papua*) at the southern limit of their range. Abandonment of nests by adults resulted in high chick mortality rates, estimated at >84%. Dr G. Milinevskyi (Ukraine) noted that research dives (through holes in the ice) at the time near the colony recorded the presence of krill, suggesting that breeding failure was linked to blocked access to foraging grounds.

2.133 A mortality event of gentoo penguin chicks, potentially restricted to the southwestern Bransfield Strait and West Antarctic Peninsula in 2015/16, was reported to the Working Group. The initial observations were reported by the international association of Antarctica tour operators (IAATO) members and later confirmed by researchers at the Palmer long-term ecological research (LTER) study area. Autopsies of available chicks suggested starvation, rather than disease, as the mechanism of death.

2.134 The Working Group noted the importance of addressing health issues to determine not only mortality events but also the performance of seabirds and marine mammals. The Working Group recalled the existence of a SCAR Working Group on Health Monitoring of Birds and Marine Mammals included in the SCAR EGBAMM that could provide help and advice on these issues.

2.135 The Working Group recalled that the *CEMP Standard Methods*, Part 4, Section 6, contain a protocol for collection of samples for pathological analysis in the event that disease is suspected in mortality events.

2.136 The Working Group agreed that ancillary data that describe Members' research activities and document the general conditions encountered during monitoring activities would be a useful contribution to CEMP. Such metadata would improve interpretation of submitted data. The Working Group encouraged Members to provide such metadata when submitting CEMP data and requested that the Secretariat include a request for this information in its annual request for CEMP data.

2.137 In addition to the ongoing data submissions, the Working Group welcomed submission of new CEMP data from the Republic of Korea. Since 2006/07, Korea has maintained a monitoring program on gentoo and chinstrap penguin (*P. antarctica*) abundance and breeding success in Antarctic Specially Protected Area (ASPA) No. 171 on the Barton Peninsula of King George Island. Korea also indicated plans to monitor Adélie penguins at Cape Hallett in the Ross Sea beginning in 2016/17. Dr J.-H. Kim (Republic of Korea) thanked the Secretariat for its assistance in completing the CEMP data submission forms and he noted that this had made the process much easier.

2.138 The Working Group welcomed the commitment of Korea to initiate a long-term monitoring program in the Ross Sea, including data from Adélie penguins at Cape Hallett that would be submitted to CEMP. The Working Group noted that such data may be useful to support the MPA process being considered there.

2.139 The Working Group welcomed the proposed submission of CEMP data from Korea and noted that discussions underway with France, Spain and the USA may also lead to new CEMP data submissions from existing long-term monitoring programs.

2.140 The Working Group considered three papers that contain analyses based on CEMP data that support development of an FBM procedure based on an existing monitoring program in Subarea 48.1. WG-EMM-16/45 (vignette 6) reported that Antarctic fur seal (*Arctocephalus gazella*) foraging trip duration and within-individual variance in trip durations are correlated with krill size and biomass estimates on the west shelf of the South Shetland Islands. The analysis demonstrates sensitivity of the CEMP foraging trip duration parameter (C1) to variation in krill populations.

2.141 WG-EMM-16/45 (vignette 7) reported on a meta-analysis to quantify predator performance based on multiple CEMP indices and to relate that index of performance to krill biomass and local harvest rates. The analysis suggested that there is sufficient signal in existing CEMP indices to detect reduced predator performance when krill biomass is low or when local harvest rates are of similar magnitude as local biomass.

2.142 WG-EMM-16/47 (vignette 1) built on the meta-analysis to demonstrate a method for evaluating predator performance in a binary 'red light'/'green light' classification and how using such an evaluation could lead to adjustment in catch allocations in an FBM.

2.143 The Working Group agreed that, together, these analyses draw attention to the value of existing CEMP data for understanding predator performance and their utility for developing FBM strategies.

2.144 The Working Group noted that the analysis of WG-EMM-16/45 (vignette 7) presented plausible evidence for impacts of fishing on krill-dependent predator performance in Subarea 48.1. While interannual variability in krill and predator data had seemed too large to allow such an assessment previously, the analysis showed that assumptions about a lack of impact may not be supported. Given such plausible impacts, it was recommended that CM 51-07 be retained in its current form as a precautionary management strategy while alternative allocation options and proposed FBM strategies are evaluated further.

2.145 The Working Group noted that the length of time series and methods necessary to differentiate fishing and climate effects in monitoring data remain a critical issue. In particular, the Working Group recalled the importance of identifying the spatial scale over which monitoring data integrate. Understanding the spatial scale of such variability and its major drivers will be useful for providing robust advice to the Commission.

2.146 The Working Group agreed that identifying reference areas may help identify major drivers of variation in monitoring data. Ideally, multi-site and multi-scale concordance of monitoring data would facilitate the use of reference areas. The Working Group noted the temporal concordance of CSIs of CEMP data across Area 48 presented by the Secretariat in WG-EMM-16/09 and suggested that such concordance may allow identification of reference monitoring areas.

2.147 The Working Group considered three papers related to the development of a camera network in Subarea 48.1 for monitoring predators. WG-EMM-16/55 and 16/58 described implementation and progress of a CEMP Fund project to establish an extended camera network in Subarea 48.1. In total, 53 cameras have been deployed at sites on King George Island, Livingston Island, Deception Island and along the Antarctic Peninsula from Cierva Cove south toward the Argentine Islands. Species coverage includes the three Pygoscelid penguin species (Adélie, gentoo and chinstrap).

2.148 The Working Group noted the successful collaboration of multiple Members in establishing the network and invigorating data collection efforts to support CEMP and FBM efforts. While the original intent of the camera network was to provide data on reproductive success and breeding phenology, the Working Group noted that camera techniques provide an opportunity for monitoring numerous other parameters. In particular, time-lapse imagery could be used to examine nest survival, predation events, the impacts of storms, or foraging trip durations, among others. In addition, automated weather stations installed in parallel with cameras might provide additional data streams for interpreting data derived from photographs.

2.149 WG-EMM-16/46 (vignette 3) presented a method to estimate breeding parameters from photo-derived observations of adult attendance at focal nests. The method was validated for chinstrap penguins, following advice of WG-EMM (SC-CAMLR-XXXIV, Annex 5, paragraph 2.185). The results suggest equivalency of ground and photo-derived observations and demonstrate the potential for cameras to provide CEMP data. Consequently, breeding success and breeding chronology data derived from some deployments of time-lapse cameras have already been submitted to the CEMP database. The CEMP camera project expects data from all cameras to be available following the 2016/17 field season.

Predator consumption

2.150 WG-EMM-16/37 estimated macaroni penguin (*Eudyptes chrysolophus*) prey consumption in terms of krill and fish mass in Subarea 48.3. A bioenergetics model developed in WG-EMM-16/P10 for Adélie penguins was applied to monitored colonies on Bird Island and extrapolated across the estimated South Georgia population. The resulting estimates of krill consumption per capita were comparable to estimates from other published studies. The authors proposed that the modelling framework for predator consumption developed in WG-EMM-16/P10 could provide a common basis for understanding prey consumption by penguins across CEMP sites and species. The authors noted that the results represented preliminary estimates, and that these would continue to be revised.

2.151 WG-EMM-16/65 presented a bioenergetics-derived estimate of krill consumption by Adélie penguins in Divisions 58.4.1 and 58.4.2. The authors estimated contemporary population sizes from older survey data and forward-projecting estimated regional rates of change. Contemporary population estimates across the divisions were approximately 5.8 million and included estimates of pre-breeding and intermittent breeding penguins. The estimated breeding population of 2.9 million individuals consumed approximately 195 000 tonnes of krill in a breeding season. Acknowledging the difficulties in estimating consumption of non-breeders, the authors finished by highlighting this study as the first Adélie penguin krill consumption estimate at CCAMLR-relevant spatial scales.

2.152 The Working Group noted that the paper provided a good example of methods to estimate population sizes of non-breeding, as well as breeding, penguins and concomitant levels of krill consumption by these demographics.

2.153 WG-EMM-16/66 presented crabeater seal (*Lobodon carcinophagus*) krill consumption rates for 1999/2000 in Divisions 58.4.1 and 58.4.2. Population estimates are based on the Antarctic pack-ice seal (APIS) survey conducted over the 1999/2000 season, and the authors utilised the estimated per capita consumption rates provided by Forcada et al., 2009 and 2012. During the period of the study, crabeater seals were estimated to consume approximately 3.8 million tonnes of krill, approximately 20% of the estimated stock in the region.

2.154 The Working Group noted that surveys of krill during the winter in the Bransfield Strait yielded estimated stocks in the range of 4 to 5 million tonnes, and that, given that crabeater seals were the dominant seal species observed in the region during this time, estimating consumption rates at different spatial scales of this species will be of considerable importance.

2.155 WG-EMM-16/67 provided a synopsis of work currently underway aiming to estimate spatio–temporal foraging effort of flying seabirds in Divisions 58.4.1 and 58.4.2. The focus is on four species, southern fulmar (*Fulmarus glacialoides*), Antarctic petrel, Cape petrel (*Daption capense*) and snow petrel (*Pagodroma nivea*). The paper outlined plans to generate a database of population demographic data from historical and unpublished data sources, and to conduct a large-scale survey of snow petrels in the future. Further work is to be conducted on the bioenergetics model in WG-EMM-16/P10 to make it appropriate for application to flying seabirds. The authors outlined the methodology involved in telemetry tracking these four species during the 2014/15 seasons and in the winter. Preliminary results show that Cape petrels forage at distances of up to 970 km from their breeding sites.

2.156 The Working Group highlighted the general absence of data on flying seabirds in the considerations of the Working Group and noted that this paper represented a good start to bringing the data into this group.

2.157 WG-EMM-16/68 summarised WG-EMM-16/37, 16/65, 16/66 and 16/67. The authors highlighted that estimates of consumption of krill by whales, squid and fish are currently not addressed within the WG-EMM-STAPP framework. Furthermore, the authors highlighted that estimation of consumption is currently restricted to the breeding period for each taxa.

2.158 The Working Group welcomed the substantial progress made by WG-EMM-STAPP, given the magnitude of effort required for data collation and analysis. The Working Group further commented on the need to link these efforts with groups focusing on krill predator tracking data, such as SCAR RAATD and the penguin habitat modelling project, funded by the CEMP Fund, in order to more fully resolve areas of high predation pressure or foraging intensity.

2.159 WG-EMM-16/P10 outlined the derivation of the bioenergetics model for Adélie penguins that is referred to in WG-EMM-16/37, 16/65, 16/67 and 16/68. The paper is primarily methodological, and the model is parameterised by data from long-term monitoring of Adélie penguin colonies at Béchervaise Island in East Antarctica. The modelling results identify clear peaks in periods of krill consumption throughout the penguin breeding cycle, particularly during incubation and the pre-moult periods.

Predator trends and dynamics

2.160 WG-EMM-16/P07 described the population trends and breeding performance of Adélie and gentoo penguins on Petermann Island; a site that is the focus of frequent tourist visits. The Working Group recognised that the study presents an analytical and experimental framework for disentangling drivers of breeding success that could be replicated across sites to examine drivers of change at regional scales. The finding that breeding success was reduced by precipitation was also discussed, with the Working Group noting that climatic change is likely to exacerbate variation in breeding success.

2.161 WG-EMM-16/P08 described an online tool for accessing penguin count data known as Mapping Application for Penguin Populations and Projected Dynamics (MAPPPD). This comprises a database populated with penguin count data, presence–absence data for 16 species of Antarctic seabird, and a model that predicts habitat distribution across the region based on previous occurrence and habitat variables. For Adélie penguins, missing values are imputed using a hierarchical Bayesian model which can also be used to generate forecasted counts, with uncertainty. There are plans to develop these models for other penguin species.

2.162 The Working Group noted that this useful tool was the result of considerable effort by the authors and the wider penguin research community. The Working Group noted that the online application is intuitive and looked forward to continued development and improvement. Finally, the Working Group noted that raw data can be extracted from the database to allow scientists to fit population models specific to their own requirements.

2.163 The Working Group also noted that it would be useful to establish mechanisms to access the results of those analyses and any datasets that would be helpful to CCAMLR (paragraph 6.14). This would best be achieved through links with the Secretariat data management facilities. The Working Group recommended that such links to datasets be made using metadata records, which would include commentaries from working groups on those datasets so that Members understand how they may best be used for CCAMLR work, including any reviews and validation analyses.

2.164 If the model is to be used for management advice, then the Working Group recommended that the model and analyses presented in WG-EMM-16/P08 be reviewed by WG-SAM.

2.165 WG-EMM-16/P09 described the population trends and diets of Antarctic shags (*Phalacrocorax bransfieldensis*) at two sites in the South Shetland Islands from 1988 to 2010 and at two sites along the Danco Coast during the 1997/98 austral summer. The authors concluded that declines in marbled rockcod (*Notothenia rossii*) and humped rockcod (*Gobionotothen gibberifrons*) due to fisheries are responsible for the declines in shag numbers at the South Shetland Islands colonies.

2.166 The Working Group welcomed this analysis of piscivorous species, noting that WG-EMM has historically considered primarily krill-dependent predators.

2.167 WG-EMM-16/P13 described the effects of snow storms on the stage-dependent nest survival and productivity of Antarctic petrels in Dronning Maud Land. The Working Group recognised that this is a valuable study of storm effects on a little-studied species. The Working Group noted that analyses of CEMP data may benefit from inclusion of weather effects (paragraph 2.136) as explanatory variables, since these may obscure effects of variation in food availability. Dr A. Lowther (Norway) noted that the monitoring project has now ended and there are no plans at present to continue the study.

2.168 WG-EMM-16/P14 assessed the effects of large-scale climate variables on the demography of Antarctic petrels in Dronning Maud Land from 1992 to 2012. The Working Group noted that this is an interesting paper that provides valuable and robust information on the demography of a krill-eating petrel species in relation to climatic processes.

Krill integrated assessment model

2.169 WG-SAM-16/36 Rev. 1 described recent developments towards an integrated stock assessment for krill in Subarea 48.1. The model was fitted to time series of survey biomass indices and length-composition data from research surveys as well as to catches and length compositions from the krill fishery. A simulated population with parameters estimated from these data was projected 20 years into the future under various candidate levels of catch.

2.170 WG-SAM-16 (Annex 5, paragraphs 2.1 to 2.6) noted that, in its present implementation, too many parameters are being estimated. The parameter estimates are confounded and are likely to be unstable, particularly as new data are added. It was recommended that retrospective analyses and fits to simulated data be conducted to explore the properties of the estimated parameters. Plotting the marginal likelihoods of parameters that are likely to be confounded would also help identify which parameters are estimable from the available data and clarify model performance. The Working Group further noted that model stability might be enhanced by treating fishery catches as known, rather than estimated, quantities.

2.171 The model had been reviewed by two independent referees whose findings largely paralleled those previously made by the three working groups and which were summarised in WG-SAM-16/37. WG-SAM therefore noted that additional work is required to systematically document how all past recommendations made by WG-SAM, WG-FSA, WG-EMM and the independent review have been considered and either used to revise the model or suitably rebutted. The model should not presently be used to provide management advice on setting krill catch limits.

Acoustic surveys

2.172 WG-EMM-16/23 presented the use of the random forest statistical method to classify mackerel icefish (*Champsocephalus gunnari*) and Antarctic krill echoes from 38 and 120 kHz acoustic data collected during fish and krill surveys. It identified that for commonly used frequencies, the acoustic signal from krill and from co-occurring fish without swim bladders may be similar. The random forest analysis classified krill, icefish and mixed aggregations with an estimated accuracy of 95%. In addition to the difference between the dual frequency acoustic data ($S_{v120\text{-}38kHz}$), min S_v, mean aggregation depth, mean distance from seabed and geographic position were important classifiers.

2.173 The Working Group noted that CCAMLR is currently using a three-frequency (38/120/200 kHz) method to identify krill as outlined in SG-ASAM-16 (Annex 4). The Working Group noted that for vessels having only two frequencies (38/120 kHz), using the supplementary information such as described in WG-EMM-16/23 may enable them to better identify krill from other scatterers. The Working Group further noted such approaches may provide estimates of relative biomass, but the method still needed further validation before it can be used in absolute abundance estimation.

2.174 The Working Group agreed that it was important to identify an approach for better identifying and estimating krill from acoustic data, highlighting that technological development in both hardware platforms and software analysis methods means that there are now several tools available for better identification of Antarctic krill.

2.175 The Working Group recommended this paper be forwarded to SG-ASAM, and that SG-ASAM discuss different ways of improving the identification of Antarctic krill in acoustic data in light of the current and future technology available on krill fishing vessels.

2.176 The Working Group noted that the current method for estimating stocks of mackerel icefish at South Georgia uses a groundfish survey (Annex 5, paragraph 4.66). It also noted that methods for identifying icefish within acoustic data are important for addressing the currently unsampled component of juvenile icefish that reside in the pelagic realm, as well as for investigating the known but unobserved predator–prey interactions between icefish and krill (SC-CAMLR-XX, Annex 5, Appendix D).

2.177 Dr Kasatkina noted that the possibility for classification of krill and icefish echoes could facilitate the acoustic estimation of the pelagic component of icefish biomass unavailable to fishing with a bottom trawl survey. Combining acoustic and trawl survey data should improve estimates of the standing stock for *C. gunnari*. She recalled that the Russian trawl acoustic survey in 2002 revealed that a bottom trawl survey significantly underestimates *C. gunnari* biomass (WG-FSA-02/44; WG-FSA-SAM-04/10).

2.178 WG-EMM-16/36 presented an overview of the Southern Ocean Network of Acoustics (SONA) 'Acoustic processing and methods' workshop that was attended by six international (Australia, France, New Zealand, Norway, UK and USA) partners. SONA identified a number of national programs that aim to appropriately steward and facilitate access to bioacoustic datasets, using standardised internationally recognised metadata standards. The SONA workshop aimed to assess how comparable these datasets and their processing were, and identified that these types of regional datasets are likely to provide a framework for global coverage. A comparison of Australian, New Zealand and UK data showed that, where processing was undertaken using the same program and similar templates, resultant acoustic data were comparable (in both intensity and variability), but there were still subtle differences based on user decisions.

2.179 The Working Group identified that SONA had provided a good vehicle for coordinated analysis, pertinent to using acoustic data from multiple fishing vessels, and taken the first steps towards where acoustic data and processing protocols should develop to. It thanked Dr Fielding and the SONA participants for starting the process and sharing this with CCAMLR.

2.180 The Working Group noted that reinforcing the benefit of the work of the group and identifying opportunities to further collect data were important, particularly in identifying rapid processing and improved design of observations with a view to improving types of data for feedback. The Working Group was made aware of a new emerging EU Horizon 2020 project 'Mesopelagic Southern Ocean Prey and Predators' (MESOPP, www.MESOPP.eu), a collaboration between Australia, France, Norway and the UK, which aims to fuse acoustic data with models. MESOPP will encourage wider participation, and SONA will be an important data provider to this project.

2.181 The Working Group recognised that SONA was an active outward-facing network that was open to discussion with new collaborators.

2.182 WG-EMM-16/38 summarised the acoustic data collection and processing methods used to calculate the 2010 B_0 estimate, and identified where changes were made compared with previous estimates. In particular, Table 1 in the paper detailed the original method implemented in 2000, and the changes made in order to make the 2010 estimate. It highlighted that the main changes made were in the areas of the target strength model used to convert acoustic backscatter to krill biomass and target identification.

2.183 The Working Group noted that the method used to estimate krill biomass using the CCAMLR method had been the subject of confusion last year (SC-CAMLR-XXXIV, Annex 6) and commended the efforts of Dr Fielding and her co-authors in collating documentation to resolve this issue. The Working Group identified that this paper should enable all Members to analyse acoustic data for krill density estimates in a consistent manner in order to get comparable numbers across current and future surveys.

2.184 The Working Group requested CCAMLR Members to review the document to confirm that it adequately describes the method used in 2010, and identify or clarify any ambiguities. The Working Group recommended this document be reviewed by SG-ASAM at its next meeting, and its corrected form be included in the meeting report and made available on the CCAMLR website.

2.185 The Working Group noted that WG-EMM-16/38 provided important information to improve acoustic surveys for estimating krill density and biomass, and this document will be useful when deriving krill density estimates from acoustic observations made on board commercial vessels.

2.186 The Working Group noted that there would continue to be developments to the methods used to estimate krill density in acoustic data and recommended that, in order to allow for these, a living document of the most up-to-date method should be hosted by the Secretariat following agreement at SG-ASAM.

2.187 WG-EMM-16/60 presented an estimate of krill biomass from the South Shetland Islands in April 2016 conducted by the Korean fishing vessel *Kwangja-Ho*. Two-frequency (38 and 120 kHz) acoustic data were collected along transects using an EK60 echosounder and net samples were collected using a midwater trawl (15 mm codend mesh size of inner net). Antarctic krill were identified using a two-frequency identification ($S_{v120\text{-}38kHz}$) estimated from a distribution of dB differences and converted to krill biomass using an empirically derived log-linear relationship.

2.188 The Working Group noted that the inclusion of flow diagrams of the method used to estimate krill (WG-EMM-16/60, Figure 2) was advantageous in highlighting the methodology used to estimate krill and potential areas for processing variability. It encouraged other Members to include such diagrams in presenting their analyses.

2.189 The Working Group noted that these were preliminary results and identified that the method used to estimate krill in WG-EMM-16/60 and the CCAMLR 2010 method were different, and how they varied should be examined. Dr J. Lee (Republic of Korea) identified Korea's intention to submit survey results using the CCAMLR 2010 protocol for discussion at the next SG-ASAM meeting.

2.190 WG-EMM welcomed the submission of krill survey information derived from an industry vessel in support of management, and highlighted that it was a significant event to be discussing fishery-collected acoustic data from several fishing nations at WG-EMM.

2.191 WG-EMM recommended that the geographic distribution of net samples within a survey area, what type of net samples (targeted or oblique) and how many net samples are required to provide a relevant krill length-frequency distribution to parameterise the krill density estimates from acoustic surveys, should be discussed at the next SG-ASAM meeting.

2.192 The Working Group noted the concordance in krill length-frequency distribution described from the midwater trawls in WG-EMM-16/60 and predator diet data that AMLR had collected during 2015/16, and highlighted the benefit of receiving additional data from the South Shetland Islands region during an alternative season to the US AMLR survey.

2.193 WG-EMM-16/61 presented the use of seabed data to calibrate an ES70 fisheries echosounder and addressed a request by SG-ASAM to investigate alternative methods to calibrate fishery echosounders. The *Kwangja-Ho* was used to collect both ES70 and calibrated EK60 acoustic data along two transects. Data from the seabed at water depths shallower than 300 m were used to apply a correction to the ES70 data. After correction, the ES70 identified more targets as krill using the dual-frequency identification method.

2.194 The Working Group agreed that comparison of EK60 and ES70 data from a single vessel over a common transect presented in WG-EMM-16/61 is an exemplar method to estimate the errors associated with utilising seabed acoustic returns for system calibration. It recommended SG-ASAM discuss this paper at its next meeting.

2.195 WG-EMM-16/P12 described a geostatistical approach to estimate the distribution, density and relative abundance of krill using acoustic data collected during commercial fishing operations. The approach was selected to account for the lack of sampling design and likely correlation in time and space, and generated estimates of the probability of presence, conditional density and relative abundance estimates on a monthly, weekly and daily basis. Monthly and weekly estimates were robust, but lower and more variable estimates were obtained from daily datasets. The authors were not able to evaluate potential bias due to preferential sampling of high-density krill aggregations and limited area coverage, and identified that this method would be enhanced by implementing a minimum quota of mandatory design-based coverage of fishing grounds and the ability to combine acoustic data from all vessels operating in a single area.

2.196 WG-EMM-16/74 identified that whilst pre-determined survey design supports stock abundance information, a geostatistical analysis of fishing acoustic data might inform about patterns in the ecosystem of importance to FBM. WG-EMM-16/74 proposed combining these approaches and presented a feeding opportunity index (FOI) that includes the relative abundance of krill, concentration of krill (patchiness) and flux of krill that could be expressed in a multiple linear regression. This FOI is assumed to be positively linked to the relative abundance of krill, flux of krill and concentration of krill.

2.197 The Working Group noted that the geostatistical method (WG-EMM-16/P12) could enable an estimate of relative krill abundance to be calculated for areas that are fished but not surveyed and, combined with a pre-determined survey for absolute krill biomass, these estimates of relative krill abundance could be placed in a wider context pertinent to FBM. It noted the following with respect to further development of the method:

(i) this technique may also enable temporal or spatial changes in patchiness characteristics and relative krill abundance to be detected as the fishery progressed. The Working Group commended the approach of endeavouring to simplify the complexity of fishing operations into informed metrics

(ii) in some cases, the fishing vessel appeared to be fishing on low abundances and identified that caution was required in interpreting krill density values at the boundaries of the geospatial analysis. Dr Godø reminded the group that vessels target krill swarms and this behaviour would influence the relative krill abundance derived from the data

(iii) this approach, when combined with CPUE, may add value to the interpretation of the data and also identify that an adaptive survey design, for example over regions of gradients in krill density, would further constrain the relative index

(iv) sensitivity analyses may be useful to help determine the optimal strategy for the commercial vessel to map swarm characteristics using this method.

2.198 WG-SAM-16/38 presented information on survey design and results of the dedicated cetacean sighting vessel-based krill (CSVK) survey by Japan in East Antarctica (115°−130°E) conducted during the 2015/16 austral summer season. Acoustic data were collected along a zig-zag stratified survey, designed for obtaining systematic sighting data for whale abundance. A small vertically hauled net (1 m mouth diameter) was used to collect qualitative information on species occurring in the echograms. The authors aim to estimate relative krill abundance from the annual CSVK surveys (carried out for 12 years) and undertake additional surveys with a design compatible with CCAMLR survey protocols to obtain an index of absolute krill abundance at a lower frequency.

2.199 The Working Group noted that WG-SAM-16/38 had been discussed at WG-SAM (Annex 5, paragraphs 2.7 to 2.10) and that the design of the survey in relation to estimating abundance of whales is a matter for the IWC SC. In relation to krill, it also noted that the zig-zag survey design was not the recommended random stratified design utilised to estimate absolute krill density, but acknowledged that the CSVK survey's primary aim was obtaining abundance estimates of cetaceans under the IWC standard zig-zag track line with the secondary objective of obtaining relative krill abundance.

2.200 The Working Group agreed that the statistical properties of krill acoustic data collected using a survey designed for another purpose (e.g. the IWC standard zig-zag track line) should be examined prior to their use so that their suitability for application to other studies can be assessed. The Working Group also noted that autocorrelation would be an important issue to resolve during analysis of krill acoustic data using a zig-zag survey design.

Feedback management

Stage 1

Background material considered by the Working Group

2.201 The Working Group recalled its obligation to review and advise on CM 51-07, which is due to lapse at the end of the 2015/16 fishing season. Members submitted several papers on topics of relevance to the review of CM 51-07. These are summarised here, in an order that is intended to facilitate review of CM 51-07:

(i) paragraphs 2.202 to 2.214 summarise the Working Group's work to assess whether exploitation rates of krill are precautionary at the subarea scale

(ii) paragraphs 2.215 to 2.221 summarise discussions on recent spatial concentration of krill fishing effort

(iii) paragraphs 2.222 to 2.227 summarise work to describe the physical and ecological conditions in areas where krill fishing effort has concentrated

(iv) paragraphs 2.228 to 2.244 summarise consideration of methods that can be used to evaluate the risks associated with changing the spatial distribution of krill fishing effort and catches in the future.

Subarea-scale exploitation rates

2.202 Dr Hill presented results from WG-EMM-16/21, which provides estimates of potential, annual, subarea-scale krill exploitation rates (estimated as catch/biomass ratios). The calculations use conservative estimates of subarea biomass calculated as annual biomass estimates from local area acoustic surveys, scaled by the relevant estimate of subarea biomass from the CCAMLR-2000 Survey. Exploitation rates of 9.3% and 12.4% are used as the basis for the precautionary evaluation. The former rate was estimated from application of the GYM and decision rules for krill using the total biomass estimate from the CCAMLR-2000 Survey (SC-CAMLR-XXIX, Annex 6). The latter exploitation rate would be expected if the precautionary catch limit for krill (5.61 million tonnes) is divided by 75% of the total biomass estimate from the CCAMLR-2000 Survey (60.3 million tonnes). Catching the entire trigger level in a single subarea was estimated to cause subarea exploitation rates to exceed the range of precautionary reference levels 47% of the time. The subarea catch limits defined in CM 51-07 reduce this probability to 0.09. Improved comparisons of krill biomass at the local survey and subarea scales would further improve the accuracy of exploitation rate estimates.

2.203 The Working Group agreed to review and repeat the calculations described in WG-EMM-16/21 during the meeting for the purposes of reviewing CM 51-07. It noted that the calculations in WG-EMM-16/21 can provide an initial risk analysis that indicates how often, and to what degree, the subarea catch limits in CM 51-07 might cause reference exploitation rates such as 9.3% and 12.4% to be exceeded due to natural variations in krill biomass recorded by the local area acoustic surveys. The calculations can also be easily extended to consider alternative proposals for subarea catch limits, such as might be proposed in a revision to CM 51-07.

2.204 Results from repeating the calculations in WG-EMM-16/21 are illustrated in Figures 1 and 2. These results indicate that if the fishery continues to achieve the catch limits established in CM 51-07 and the trigger limit in CM 51-01 continues to be fixed, the precautionary exploitation rate of 9.3% agreed by CCAMLR might be exceeded in one out of every five years within Subarea 48.1 (Figure 1). The precautionary exploitation rate of 9.3% might be exceeded less frequently in Subareas 48.2 and 48.3. Figure 2 shows how the exploitation rate in Subarea 48.1 may exceed the precautionary rate of 9.3%.

2.205 The results illustrated in Figures 1 and 2 also indicate that both the frequency of exceeding the precautionary exploitation rate and the average catch that exceeds 9.3% of the estimated biomass will increase if the proportional allocation of the trigger limit to Subarea 48.1 is increased in any proposed future revisions to CM 51-07.

2.206 Dr Kasatkina noted that exploitation rates estimated for krill in Subareas 48.1, 48.2, and 48.3 were estimated inappropriately. Catch and acoustically based estimates of krill biomass were obtained over different temporal scales. In each subarea, the surveys are carried out only during a brief period and not throughout the fishing season, but krill biomass in the survey area would be significantly changed by flux over the fishing season.

2.207 Dr Kasatkina underlined that considering the question 'whether current management of the Antarctic krill fishery in the Atlantic sector is precautionary' requires an understanding of krill consumption by overall predators and status of overlapping between predators and fishery. She recalled, as an example, in the South Georgia area it is evident that the mean krill consumption by predators, is an estimated 900 000 tonnes per month (11.2 million tonnes per year) (Boyd, 2002). This consumption is extremely large in comparison with the maximum monthly krill catch.

2.208 Although participants agreed that it is important to understand overall krill consumption by predators, it was noted that the reference exploitation rates of 9.3% and 12.4% considered in WG-EMM-16/21 and used to recalculate the results presented in Figures 1 and 2 already take account of predator demand.

2.209 The authors of WG-EMM-16/21 also emphasised that the assumptions made to estimate potential, annual, subarea-scale krill exploitation rates were precautionary. The analysis used available data as far as possible and can be refined as new information becomes available.

2.210 Dr Milinevskyi summarised WG-EMM-16/56, which is a proposal to revise CM 51-07. Specifically, Ukraine proposed that the percentage of the trigger limit allocated to Subarea 48.1 should be increased from 25% to 45% and accompanied with a prohibition of krill fishing within 3 n miles of the coast from 1 November to 1 March every fishing season.

The former revision is intended to allow for further development of the krill fishery, and the latter is intended to protect land-based predators during the breeding season. Dr Milinevskyi indicated that increasing the percentage allocation to Subarea 48.1, while prohibiting krill fishing in a coastal buffer zone, should be viewed as a trade-off.

2.211 The Working Group noted that no scientific evidence had been provided to support the proposal in WG-EMM-16/56, including whether an increase in the catch in Subarea 48.1 would impact on predators, and resolving trade-offs such as that suggested in the paper is the remit of the Commission.

2.212 Many participants noted that increasing the percentage of the trigger limit allocated to Subarea 48.1 would increase the risk that a precautionary exploitation rate would be exceeded in Subarea 48.1 (Figure 2).

2.213 Other participants noted that increasing the percentage of the trigger limit distribution for Subarea 48.1 can be implemented because, in recent years, the total krill catch has not exceeded 50% of the trigger limit. These participants also noted that the krill stock has not been impacted by historical fishing, and that there are no clear negative impacts to krill predators or other components of the Antarctic marine ecosystem.

2.214 The Working Group did not attempt to evaluate the potential consequences of prohibiting krill fishing within 3 n miles of the coast, but some participants noted that such a buffer zone might negatively impact on the performance of the fishery. The Working Group referred the proposal to the Commission, noting it has already been submitted for consideration by the Scientific Committee.

Concentration of fishing effort

2.215 Dr Trathan summarised WG-EMM-16/17, which explored krill catches and fishing effort for the period 1999/2000 to 2014/15. The paper documented how, since 2013, both the levels of catch as well as the associated numbers of hauls have increased in Subarea 48.1 during the penguin breeding season. WG-EMM-16/17 also explored the detailed fishing patterns in Subarea 48.1 during 2014/15, showing that concentrated fishing took place in two areas, one in the Bransfield Strait and one in Hughes Bay on the Danco coast. The latter concentration took place over 153 days from 27 December until 28 May. Four vessels operated over this period, collectively taking over 42 000 tonnes of krill from an area less than 30 km in diameter; this equates to approximately 27% of the catch limit established in CM 51-07. The fishing concentration comprised three periods of harvesting; catch rates showed evidence of decline at the end of the first two periods, but were increasing at the end of the third period, when Subarea 48.1 was closed because the subarea trigger allocation had been reached.

2.216 The Working Group noted that although the total catch in Hughes Bay during 2014/15 comprised 27% of the catch limit for Subarea 48.1, it is uncertain whether any ecological impact to krill-dependent predators ensued, as data collected at the nearest CEMP site, 13 km away in Cierva Cove, have yet to be analysed in full.

2.217 The Working Group considered WG-EMM-16/52, which presented a novel analysis to identify fishing grounds using a statistical analysis of fishing hotspots, combined with a temporal analysis, to assess persistence of these hotspots. Results indicated that the fishery is consistently concentrating in hotspots across years, particularly during those years when the catch limit is reached. These events occur mainly in the centre of the Bransfield Strait and the northern section of the Gerlache Strait, and have a duration of 3 to 5 months. In years when catch limits were reached, the identified hotspots were generally small (approximate radius 25 km), and have a high catch density (>10 tonnes km^{-2}). The analysis showed that the krill fishing fleet repeatedly visits such fishing grounds year after year, where they obtain high catches, suggesting that catch density within hotspots can index krill biomass in a given area.

2.218 The Working Group agreed that results from WG-EMM-16/17 and 16/52 demonstrate that krill fishing activity is not randomly distributed with respect to the spatial distribution of krill itself. The spatial distribution of recent fishing activity is also different from patterns found in the past, with an increased emphasis on fishing in the Bransfield and Gerlache Straits, but there is no evidence that the distribution of krill itself has changed. It was suggested that fishing activities have become more concentrated partly because of improved technologies that allow for more efficient searching and better communication among vessels. Modern fishing vessels can now locate krill more quickly and from farther away and are also more likely to recognise that other vessels are successfully fishing.

2.219 There continues to be substantial uncertainty about why krill fishing vessels choose to operate where they do when other locations have previously supported viable fishing. It is not clear why, for example, the fishery no longer focuses operations around Elephant Island, which was a historically important fishing ground where comparable catch rates were achieved and significant biomass of krill still occurs. The Working Group noted that an improved understanding about fishing patterns might be inferred from analyses of haul-by-haul and vessel monitoring system (VMS) data and urged Members to undertake such work if possible.

2.220 Concentrated fishing in predictable locations or hotspots motivates consideration of the potential for local depletion. The Working Group noted that there were few data available that addressed the question of local depletion in fishing hotspots. It was recognised that the level of krill flux through such hotspots would determine whether, and to what degree, local depletion in fishing hotspots might occur.

2.221 The Working Group also noted that WG-EMM-16/74 and 16/P12 suggested that acoustics data collected by fishing vessels could be used to estimate temporal changes in available biomass within hotspots. Such estimates might be used as a tool to avoid local depletion.

Physical and ecological conditions in areas where krill fishing effort has concentrated

2.222 Dr Watters drew from results provided in WG-EMM-16/45 to present four issues of specific relevance to discussions on CM 51-07. Several short papers, or vignettes, are compiled within WG-EMM-16/45, and, in discussions relevant to CM 51-07, Dr Watters primarily referred to vignettes 2, 5, 7 and 8 (other vignettes in WG-EMM-16/45 provide results that are relevant to the development of a stage 2 FBM strategy in Subarea 48.1):

(i) The authors of WG-EMM-16/45, vignette 2, examined the influence of oceanic and shelf circulation on the distribution of krill biomass and fishery catch and effort in Subarea 48.1 to better understand how retention and concentration mechanisms aggregate krill in fishable quantities above the background concentration. A circulation model and particle tracking were used to show that areas with high catches also tend to be areas of retention and are generally separated from the prevailing circulation. In addition, indices of krill abundance observed in the Palmer LTER study area (which is generally considered to be upstream from the fishing grounds in Subarea 48.1) were correlated with those in the US AMLR study area (which overlaps the fishing grounds in Subarea 48.1), suggesting that local depletion within retentive areas where fishing is concentrated may not be alleviated by flux on short time scales.

(ii) The authors of WG-EMM-16/45, vignette 5, examined the overlap of krill catches and predator foraging distributions using data from a large, long-term telemetry dataset on multiple species of seabirds and marine mammals during the austral summer and winter. Direct overlap, on small spatio–temporal scales, of krill-dependent predators and the krill fishery was observed to be common throughout the Antarctic Peninsula region. Overlap was prominent in local areas where krill were retained and fishing was concentrated. The authors argued that such overlap highlights the potential for competitive interactions between predators and the krill fishery and underscores the goal of the Commission to prevent localised concentration of fishing effort.

(iii) The authors of WG-EMM-16/45, vignette 7, quantified functional relationships between penguin performance and both local krill biomass and local harvest rates of krill. These functional relationships empirically demonstrate reduced penguin performance in the Antarctic Peninsula region when local krill biomass is low or when local krill catches are high relative to local biomass. The results further demonstrate that krill fishing in Subarea 48.1 may have already had negative impacts on penguin performance.

(iv) The authors of WG-EMM-16/45, vignette 8, outlined three alternatives for allocating the catch limit for krill in Subarea 48.1 among four groups of SSMUs (gSSMUs, see also paragraph 2.255). In general, alternatives that allocate a greater proportion of the catch limit to coastal SSMUs are considered to increase risks to krill-dependent predators, while those that allocate a greater proportion to the pelagic SSMUs will likely increase risks to the krill fishery.

2.223 The Working Group discussed the analyses and results summarised in WG-EMM-16/45. In response to questions, it was clarified that:

(i) local biomasses and local exploitation rates of krill were both relatively high in two out of the four periods and locations in which reduced penguin performance was observed (during summer 2009/10 in the Bransfield Strait SSMUs and during winter 2013/14 in the same SSMUs), suggesting that the estimated relationship between local harvest rate and penguin performance was not simply tracking changes in local biomass

(ii) the estimated relationship between penguin performance and local exploitation rate was not necessarily causal, noting that both causal effects and correlations were plausible

(iii) winter and summer indices of penguin performance were both used to estimate relationships with local biomass and local harvest rates under the assumption that all indices are exchangeable and by ensuring that season-specific performance indices of penguins were matched with season-specific krill indices

(iv) summer indices of predator performance were exactly coincident in time with summer estimates of krill biomass, and winter indices of predator performance lagged winter estimates of krill biomass by about 2 to 3 months

(v) each time series of penguin performance parameters was standardised to have zero mean and unit variance, thus the analysis only considered interannual variations in penguin performance

(vi) results from the analysis of penguin performance were insensitive to whether the winter data were excluded from the analysis

(vii) overlap between foraging locations of Adélie penguins and locations where fishing has occurred has been observed

(viii) assessing overlap on the basis of the joint presence (absence) of predators and fishing activities in a spatio–temporal unit was considered sufficient for the purpose of identifying locations where the risks of fishery effects on foraging krill-dependent predators may occur

(ix) krill behaviour would be expected to increase levels of aggregation in locations where ocean currents and bathymetry already lead to retention.

2.224 The Working Group reviewed the results in the light of the clarifications provided. Some participants suggested that the results of this analysis indicated plausible impacts of localised krill fishing on penguin performance. Other participants considered that the analyses did not support this conclusion. It was suggested that interactive effects be explored to disentangle the relative contributions of, and potential interactions between, fishing activity and krill abundance on measured penguin performance.

2.225 The Working Group noted, however, that continuing the current spatial allocation of the trigger level to Subarea 48.1 (25% in CM 51-07) would offer an opportunity for continued evaluation of the potential impacts to krill-dependent predators of catching nearly 155 000 tonnes per year in the subarea. The Working Group requested that the Scientific Committee highlight this issue to the Commission.

2.226 Dr Kasatkina noted that it is necessary to clarify a temporal scale for considering penguin performance as a function of variation in local krill biomass. Dr Kasatkina emphasised there is no scientifically based evidence that observed negative changes in penguin performance was stipulated by fishing activity, and such changes should also be considered in the context of penguins themselves being prey for some marine mammals. The top–down impacts of predation on penguins will further complicate the potential relationships between penguin state variability and krill fishing.

2.227 Dr Darby noted that the statistical approach used in WG-EMM-16/P07 might provide an alternative way to estimate the possible relationships between local krill biomass or local exploitation rates and penguin performance.

Methods to evaluate the risks associated with changing the spatial distribution of krill fishing

2.228 Dr Demianenko summarised WG-EMM-16/57, which proposed a new indicator, the availability index (AI). The AI integrates the existing information on the availability of a specific marine living resource (e.g. krill) to a fishery. The AI takes account of the difference in days that fishery operations are permitted via conservation measures and prevailing weather conditions as well as the difference in fishing area that is feasible given prevailing sea-ice conditions and what is permitted via conservation measures. A weighted sum of AIs for several small areas, where the weights are proportional to the distribution of the resource among those small areas, can be used to compute AI for a larger area. The authors of the paper noted that AI could be used to examine new management decisions that impact fishing activities.

2.229 The Working Group noted that it was difficult to review the AI because no examples of its application to any assessment and draft management decision were presented in WG-EMM-16/57. The Working Group recommended that, in the future, the authors demonstrate the applicability of the AI and develop it further.

2.230 Dr Constable summarised an approach, outlined in WG-EMM-16/69, which computes relative spatial risks associated with proposals to subdivide the trigger limit, or any other catch limit, among subareas, SSMUs, or other spatial units. The risk assessment integrates data that characterise spatial patterns in the krill stock, predator foraging and fishing operations. Multiple types of spatial data can be used, and each dataset (called 'factors' in the context of the risk analysis) is summarised into a spatially specific index (called a 'quantity' in the risk analysis) whose values range from zero to one (a flexible scaling function is provided in WG-EMM-16/69). For data describing spatial patterns in krill and predators, indices that equal zero indicate spatial units of critical importance, and indices that equal one indicate spatial units where the risks of krill fishing would be of no concern. For data describing spatial patterns in the krill fishery, indices that equal zero indicate spatial units that are of no value to the fishery, and indices that equal one indicate those that are of maximum value to the fishery. All indices are used to calculate the relative risks to krill, predators and the fishery within each spatial unit. To spread the risks across spatial units, all indices specific to each spatial unit are multiplied together and by the density of krill in the spatial unit. These spatially specific 'overall' indices are then divided by the sum of all the overall indices (computed across the spatial units considered in the assessment) to give a proportion of the catch limit, including the trigger limit, to be taken in each spatial unit. WG-EMM-16/69 presented example calculations for the SSMUs in Area 48 using several datasets that have previously been vetted through the Working Group. The results of that work provide support for the existing distribution of the trigger limit in CM 51-07, but the authors of WG-EMM-16/69 acknowledged that Members may wish to revise the calculations using alternative datasets and methods of summarising the data to range from zero to one.

2.231 Dr Demianenko noted that the risk-assessment framework presented in WG-EMM-16/69 is applicable together with other important criteria for making decisions on fishery management in the Convention Area. He mentioned that the risk assessment provides valuable information that can be used to focus research in zones of maximum risk to the Antarctic ecosystem and living marine resources and to prevent negative impacts from concentrated fishing.

2.232 Dr Kasatkina noted that the data describing spatial patterns for krill, predators and the fishery weight used in WG-EMM-16/69 reflect information at different spatial and temporal scales. Therefore, it is necessary to clarify how this fact would impact on the risk-assessment method to distribute the catch for FBM and what approaches would be used to provide adequate management information.

2.233 The Working Group thanked the authors of WG-EMM-16/69 and agreed that results from the risk-assessment approach summarised in the paper can be used to provide advice on CM 51-07 in the current year and on future proposals that envision spatial subdivisions of catch limits (e.g. the stage 2 FBM strategy proposed for Subarea 48.1). In all cases, the inputs and results would need to be satisfactory to the Scientific Committee, including datasets (factors) to be integrated into such risk assessments, the indices to be computed from such data and the parameters used to scale each index so that it ranges between zero and one.

2.234 The Working Group noted that several issues could ultimately be addressed in future applications of the risk assessment, including development and scaling of spatially specific indices that:

(i) appropriately characterise historic, recent and future fishing patterns, including the desirability and suitability of different fishing grounds (as might, for example, be inferred from prevailing weather patterns, sea-ice coverage, oceanographic conditions and bathymetry), given observed changes in the spatial distribution of the fishery and the known habitats of krill

(ii) address flux

(iii) explicitly account for krill consumption by fishes and flying seabirds

(iv) characterise spatial and temporal patterns in fish by-catch within the krill fishery

(v) describe temporal variability in krill biomass or predator performance

(vi) take account of the number of monitoring sites that might detect impacts should they arise

(vii) take account of seasonal (summer and winter) patterns in the spatial distributions of krill, predators and the fishery

(viii) take account of climate change.

2.235 It was acknowledged that not all of the issues outlined in the preceding paragraph can be addressed in the near term; some will need to be addressed over a period of several years. It was also noted that the risk-assessment approach is flexible, and, as new analyses for specific areas become available over time, they can be integrated into the approach.

2.236 The Working Group agreed to progress a set of scenario-based risk assessments across subareas within Area 48, including finer-scaled risk assessments across SSMUs within Subarea 48.1, to investigate potential subdivisions of the trigger limit and manage the risks of krill fishing. Given the time available before the next meeting of the Scientific Committee, it might be necessary to limit the focus of these initial risk assessments to Subarea 48.1; this could be determined by correspondence via the e-group described below. It agreed that the initial risk assessments would be updated, using new data as they become available and are vetted through the Working Group, but that the initial simple set of assessments be conducted as soon as possible, using data already available to CCAMLR.

2.237 An e-group (Conservation Measure 51-07 WG-EMM review) was established to progress the initial risk assessments, with the aim of providing further advice on CM 51-07 to the 2016 meeting of the Scientific Committee. The outcomes of the e-group discussions could provide guidance to Members conducting the initial set of risk assessments, including the priority elements for consideration; recommendations from WG-EMM to the e-group are provided in Appendix D.

2.238 The Working Group also requested that WG-FSA:

(i) review the outcomes of the initial risk assessments according to the requirements set out in paragraph 2.239

(ii) schedule this review to occur late in its meeting so that Members could more efficiently schedule travel to Hobart

(iii) forward the outcomes of the initial risk assessments, accompanied with comments from the review indicated in the preceding point, to the Scientific Committee. The Scientific Committee would then advise the Commission on CM 51-07.

2.239 The Working Group agreed that results from risk assessments intended to advise on the spatial distribution of catch limits should be presented as maps of each index (or scaled quantity) used in the risk assessment; the krill densities or biomass estimates used to calculate the proportional subdivision of the catch limits; and the proportional subdivision of the catch limit to be taken from each spatial unit. The estimates of risk indices and catch-limit proportions should also be provided in a table. These results should be accompanied with clear descriptions of, and justifications for, the factors, quantities and scaling parameters used in the risk assessment.

2.240 Given the importance of reviewing CM 51-07, the Working Group agreed that clear terminology and a concise presentation of results from the initial risk assessments will be critical to improve understanding of the approach and provide advice. The Secretariat was asked to work with Members conducting initial risk assessments to clarify communication of the approach and results.

2.241 The Working Group also agreed that, in the future, risk analyses such as those envisioned for the review of CM 51-07 should be conducted on a regular basis, and the assumptions underlying such risk assessments should be continually reviewed. Future risk analyses would provide the Scientific Committee and Commission with updated perspectives on risk as assumptions change, existing datasets improve, new datasets are vetted and changes in the ecosystem occur. The Working Group recommended that risk assessments should be added to the standing work program of WG-EMM.

2.242 Dr Demianenko noted that, to establish the spatial distribution of catch limits, the risk assessments should be considered together with information on the status of the krill stock and an assessment of the potential impacts of the fishery.

2.243 Dr Kasatkina noted that the current exploitation rates for the krill fishery in Subareas 48.1 to 48.3 were considered by the Working Group in relation to the regional trigger levels. Dr Kasatkina recalled that the trigger level for the krill fishery in Area 48 (620 000 tonnes) corresponds to the value of the maximum historical catch achieved during the 1980s and reflects neither the status of the krill stock and predators in the past nor the current status of the krill stock and predators. She noted that the estimate of unexploited biomass (B_0) and the precautionary catch limit for krill in Area 48 were revised several times using data collected during the CCAMLR-2000 Survey. Dr Kasatkina underlined that the trigger level has remained the same magnitude regardless of updates to the precautionary catch limit for krill in Area 48 from 4 million tonnes (2007) to 5.61 million tonnes (since 2011). Dr Kasatkina noted that there is no scientific-based argument for the trigger level, and it is necessary to clarify reference points for management of the krill fishery in Area 48.

2.244 Dr Darby agreed with Dr Kasatkina in that there was a lag in updating the reference exploitation rates. However, as the Commission had agreed the trigger levels and also that they could be adjusted once an FBM approach had been agreed, there was already a process in place to update catch limits in the future.

Move-on rules for krill fishing vessels

2.245 Drs Godø and Currey suggested that appropriately structured move-on rules could provide an alternative or complement to strategies that aim to manage the risks of concentrated fishing by distributing catch limits in space. They noted that the Commission is already familiar with the concept and application of move-on rules and suggested the types of parameters that would need to be considered to develop such rules.

2.246 The Working Group agreed that move-on rules may be useful for spatially distributing fishing activities to mitigate the risks of concentrated fishing, noting that WG-EMM-16/17 also highlighted how such rules could be used to reduce the risks of concentrated fishing. The Working Group was uncertain whether a single move-on rule could be equitably applied to all vessels operating in the fishery given the range of vessel-specific capacities and fishing strategies in the fleet. It was recommended that Members discuss such issues with representatives from the fishing industry and use the Conservation Measure 51-07 WG-EMM review e-group to discuss and develop ideas. As for the initial risk assessments that are planned to facilitate review of CM 51-07, a paper could be tabled for consideration by WG-FSA.

Advice to the Scientific Committee

2.247 The Working Group agreed that:

(i) the trigger level in CM 51-01 applies to a spatial scale that is larger than the subarea scale

(ii) the trigger level was not established in reference to an assessment of krill biomass or predator consumption

(iii) there are no studies that provide results supporting an increased trigger level

(iv) the entire trigger level (620 000 tonnes) has never been caught in a single fishing season

(v) the staged approach to develop FBM provides the mechanism through which the trigger limit could be revised or eliminated altogether

(vi) the spatial subdivision of the trigger level in CM 51-07 establishes stage 1 catch limits that apply at the subarea scale.

2.248 The Working Group noted that the preambular text of CM 51-07 recognises, inter alia, the needs to:

(i) 'distribute the krill catch in Statistical Area 48 in such a way that predator populations, particularly land-based predators, would not be inadvertently and disproportionately affected by fishing activity', as well as

(ii) 'provide for flexibility in the location of fishing'

and advised that any revisions to the conservation measure should aim to do the same.

2.249 The Working Group recalled its previous discussions on the trigger limit and CM 51-07 and agreed its previous advice still applies (SC-CAMLR-XXXIV, Annex 6, paragraphs 2.136 to 2.138).

2.250 The Working Group encouraged Members to participate in the e-group to progress the risk assessment approach in time for review by WG-FSA and the Scientific Committee in 2016 (Appendix D). It agreed that in the event the risk assessment discussed in paragraphs 2.228 to 2.244 is unable to provide adequate information before the next meeting of the Scientific Committee, the following advice should apply:

(i) at scales greater than, or equal to, the subarea scale, there is no evidence that the trigger limit and catch limits currently established by CM 51-07 have adversely impacted the krill stock

(ii) the subarea catch limits currently established in CM 51-07 achieve the objectives in Article II of the Convention at the subarea scale (SC-CAMLR-XXXIV, Annex 6, paragraph 2.136).

2.251 Many participants agreed that:

(i) at the subarea scale, the risks to achieving the objectives in Article II of the Convention could be managed by maintaining the subarea catch limits currently established in CM 51-07 because:

(a) conservative extrapolations of biomass estimates from recurring research surveys to subarea scales indicate that precautionary harvest rates might already be exceeded in as many as one out of every five years within Subarea 48.1 and less frequently in Subareas 48.2 and 48.3

(b) precautionary harvest rates in any subarea will be exceeded more frequently than at present if the proportional allocation of the trigger level to that subarea is increased

(ii) at scales smaller than the subarea scale, the risks to achieving the objectives in Article II could also be managed by maintaining the catch limits currently established in CM 51-07 noting that increased concentration above current levels may not be suitable at scales of SSMUs or finer scales, particularly in Subarea 48.1, because

(a) fishing activity has become concentrated into some areas that are smaller than SSMUs and which regularly retain or concentrate krill

(b) penguin performance may be impacted by locally high harvest rates on birds that are known to forage in such areas

(c) the catch limits currently established in CM 51-07 have successfully closed the fishery before such impacts have become obvious and consequential.

2.252 The Working Group also advised the Scientific Committee that a future revision of CM 51-07 should consider how catch limits could be spatially and temporally apportioned within subareas to avoid negative impacts on predator populations at smaller spatial scales, particularly in Subarea 48.1. The risk assessment approach will be developed within an e-group and prepared for review by WG-FSA-16. The Working Group also noted that buffer zones which prohibit fishing within fixed distances of the coast during specific times of the year could be considered as alternative or additional management options.

Stage 1–2 Subarea 48.1

2.253 WG-EMM-16/46, 16/47 and 16/48 described a stage-2 strategy for in-season FBM for the krill fishery in Subarea 48.1, with additional background information also contained in WG-EMM-16/45.

2.254 The papers presented the ecological background for the strategy, the decision rule for adjusting local catch limits and a series of retrospective analyses showing how the approach would work. The strategy is based on a broad foundation of work to answer questions raised by WG-EMM in 2015 (SC-CAMLR-XXXIV, Annex 6, Table 2, and other advice contained in the body of the WG-EMM report).

2.255 The decision rule in the papers is designed to adjust catches in four gSSMUs (1 = APBSW + APBSE; 2 = APDPW + APDPE + APEI; 3 = APPA; and 4 = APW + APE); it has four components:

(i) if penguin recruitment is expected to be sufficient for population maintenance, and CEMP monitoring indicates acceptable predator performance during the current breeding season, and krill biomass has increased during the present summer, the local catch limit would be increased

(ii) if penguin recruitment is expected to be sufficient for population maintenance but CEMP monitoring indicates a poor breeding season, or krill biomass has not increased during the summer, the local catch limit would not be adjusted

(iii) if penguin recruitment is expected to be so poor that the population will decline even if adult survival through the forthcoming winter is very high, the local catch limit would be decreased

(iv) if penguin recruitment is expected to be so poor that the population will decline even if almost all adults survive through the forthcoming winter, the local catch limit would be set to zero.

2.256 In the papers, the implementation of the FBM strategy includes defining a base catch limit for each gSSMU, collecting data on predators and krill, delaying the start of the fishing season until this data collection effort is underway, submitting the data to the Secretariat, increasing the frequency of catch and effort reporting by the fishery, having the Secretariat compute various state variables from the submitted data and applying the decision rule with the state variables relevant to each gSSMU, providing advance notice to fishing vessels about the outcomes of applying the decision rule, and adjusting the catch limit in each gSSMU.

2.257 The Working Group noted that the FBM strategy proposed in the papers also utilises results from fishing vessel acoustic surveys, it permits some fishing to occur prior to the 'adjustment date' so that fishing vessels have sufficient time to conduct repeat acoustic surveys. A timeline for this implementation process is proposed, detailing when particular actions would need to take place. Adjusted catch limits would only apply for a single fishing season and the implementation process would restart every year (Figure 3).

2.258 The papers assessed the impacts of missing data and used historical data to conduct retrospective analyses of the FBM strategy for two gSSMUs. These analyses demonstrated that local catch limits would have been decreased about half the time, and would not have been adjusted or might have been increased the other half of the time.

2.259 The retrospective analyses in the papers suggested that delaying the start of the fishing season but permitting some fishing to occur prior to the adjustment date can be a reasonable compromise between minimising risks to krill-dependent predators and minimising economic risks and opportunity costs for the fishery.

2.260 The authors of the FBM strategy for Subarea 48.1 suggested that it is fully consistent with the agreed definition of a stage-2 strategy, and they advocated that it should be trialled in the field.

2.261 The Working Group thanked the authors of WG-EMM-16/45, 16/46, 16/47 and 16/48 for their comprehensive body of work contributing to the development of FBM stage 2 in Subarea 48.1.

2.262 During subsequent Working Group discussions related to the proposed strategy for Subarea 48.1, the authors clarified a number of points:

(i) Lower base catch limits could have been proposed, with only upward catch increments. However, the choice of higher base catch limits with both upward and downward catch increments was selected as this was considered to be a better compromise between minimising risks to krill-dependent predators and minimising impacts on the fishery; it was also considered that the higher base limits would be more appealing to the fishery. This could incentivise them to participate in collecting the necessary data for the proposed FBM approach.

(ii) Having four gSSMUs, two of which would have a substantial base catch limit, provides more flexibility for the fishery.

(iii) The strategy proposes use of uncalibrated acoustic systems on fishing vessels as this would provide a minimum level of useable information; however, calibrated acoustic systems would help provide a more robust FBM strategy.

(iv) The strategy also utilises predator monitoring data, with some of the parameters based on CEMP or CEMP-like indices.

(v) The parameters used in the proposed FBM strategy can be reliably collected in most years; the remote camera network, recently funded by the CEMP Fund, and the ongoing collection of CEMP data provide a reliable series of input data. Logistic constraints may impact CEMP data collection in some years, but the remote camera network should provide a reliable and continuous data stream. The proposed use of CEMP data should be relatively robust to missing observations; however, the proposal includes defaults for how the decision rule would be applied when different types of data, including CEMP data, were missing.

(vi) Many factors contribute to the ecological status of both krill and penguins, however, the proposed FBM approach uses the age of penguin chicks at crèching, as this provides an early indication about the strength of the current penguin chick cohorts. This proposed leading indicator is based on many years of CEMP monitoring and all three *Pygoscelis* penguin species are used in the approach.

(vii) There are currently no analyses of leading ecological indicators for Antarctic fur seals.

Stage 1–2 Subarea 48.2

2.263 WG-EMM-16/18 reviewed the state of ecological knowledge for Subarea 48.2 and suggested that the development of any new management approach based on ecological indicators is limited by the current level of relevant ecological information. The authors proposed that there is an urgent need to improve the ecological knowledge base, but identified that this will take time. They concluded that, if the krill fishery in Subarea 48.2 is to expand beyond its current level, a new experimental approach must be developed that will help provide the ecological and management information needed by CCAMLR. WG-EMM-16/18 outlined one possible framework that has the potential to provide the types of information required. The proposed framework identifies some of the main data requirements, including oceanographic modelling, predator monitoring and fisheries acoustics. The authors proposed that the experimental framework should be evaluated periodically in order to explore initial results and to determine if the framework should be continued.

2.264 WG-EMM-16/18 noted that the proposed experimental framework might not be feasible, either because of: a lack of engagement by sufficient Members; the cost of implementing the necessary framework; or that the framework will take too long to provide appropriate management information. However, other management approaches may still be feasible for distributing effort, including (i) coastal buffers closed to fishing, (ii) closed areas during critical ecological time periods, or (iii) harvesting limits and move-on rules. However, such approaches would also require evidence that they would still achieve the objectives and an appropriate evaluation of the risks, including the risk of displacing problems elsewhere. The paper noted that the preferred option, therefore, remains an objective experimental framework that enhances science and provides evidence-based management for the future.

2.265 The Working Group recalled its discussion last year (SC-CAMLR-XXXIV, Annex 6, paragraphs 2.111 to 2.120 and 2.130 to 2.132) on this proposed FBM approach for Subarea 48.2. It noted that:

(i) acoustics surveys would be fundamental to the proposed experimental framework. It also noted that obtaining a time series of CEMP data would take some time

(ii) the distribution and abundance of predators, particularly in the western area, will be useful, as this is the current hotspot for the fishery

(iii) limitations of field data may not necessarily be an impediment to evaluate this approach. Simulations using ocean and food-web models could be used to do this evaluation within a management strategy evaluation (MSE) framework

(iv) utilisation of the region by predators from other areas will be useful to consider

(v) the establishment of the baseline data will need to be contributed to by many Members.

2.266 Dr Kasatkina noted that the framework would also require investigation of the prey–predator relationship for understanding how seals and other mammals might affect the foraging success and population state of penguins determined by authors as reference consumers of krill for developing FBM in Subarea 48.2.

2.267 The Working Group requested the Scientific Committee to consider how resources could be committed to the experimental framework in Subarea 48.2 and to develop baseline data in the subarea.

Stage 1–2 General recommendations

2.268 The Working Group noted that the proposed FBM approaches for both Subarea 48.1 and Subarea 48.2 require acoustic information from krill fishing vessels, in particular, results from acoustic surveys and estimates of relative or absolute krill stock biomass (paragraph 2.40).

2.269 The Working Group agreed that processing and analysing acoustic data so that they provide useful information was vital. It recognised that delivering these analyses required the assistance and advice of SG-ASAM. It noted that SG-ASAM has been considering the need to derive indices of krill stock biomass from fishing vessel acoustic data for some time, and agreed that this remains a very high priority.

2.270 WG-EMM agreed that to further the staged approach to FBM, it requires help and advice from SG-ASAM on:

(i) defining the spatial and temporal aspects of fishing vessel acoustic transects needed for FBM, including the location, number and frequency of transects within Subareas 48.1 and 48.2

(ii) determining the system performance and processing of acoustic data from vessels (both commercial and research) to ensure that FBM is working with the highest-quality data available.

2.271 The Working Group recognised that implementing FBM may require calibrated data to be delivered by fishing vessels at the same interval as catch reporting to CCAMLR. These data will be used for calculating acoustic estimates of biomass during the season. In order to achieve this delivery, automated on-board processing will need to be developed, including implementation of algorithms to remove noise and to package the data at appropriate spatial and/or temporal scales. Given the analytical challenges associated with these types of data, Members were encouraged to develop automated algorithms that specifically account for the advice from SG-ASAM.

2.272 The Working Group noted that a number of krill fishing vessels now have the capability of collecting appropriate acoustic data, but that some vessels are not able to provide such information. It recognised that vessels which conduct acoustic surveys could be disadvantaged over other vessels that did not conduct such surveys, as they lost potential fishing time (paragraph 2.39).

2.273 WG-EMM advised the Scientific Committee that the collection of appropriate acoustic information from fishing vessels was critical for both proposed FBM approaches and highlighted that there was a need for SG-ASAM to meet and continue its work program for delivering the necessary acoustic procedures, data and information required. It requested that the Scientific Committee set the necessary priorities for SG-ASAM so that it could complete this work, including developing procedures for processing data, undertaking comparisons between different fishing vessels, and determining appropriate statistical analyses. It also requested that the Scientific Committee bring to the attention of the Commission the importance of acoustic data from the fishing fleet, collected and processed in accordance with SG-ASAM advice, for underpinning FBM.

2.274 WG-EMM agreed that it would be necessary to liaise with the krill fishing industry following advice from SG-ASAM about how fishing-vessel derived acoustic data might contribute to the future development and implementation of FBM. It recognised that feedback from the industry about proposed data collection methods would be vital and that only when concrete proposals for each FBM strategy are available would some operators be able to provide comments.

2.275 The Working Group emphasised that for FBM to be successful, liaison through individual Members would help ensure that all operators were informed about the critical involvement of industry and about the necessary requirements for data collection. WG-EMM recognised that the Association of Responsible Krill harvesting companies (ARK) was a useful coordinating forum for some krill fishery operators, but that not all operators were part of ARK.

2.276 The Working Group recalled that the krill fishing industry has, since the FBM symposium in 2011 (SC-CAMLR-XXX, Annex 4, paragraphs 2.149 to 2.192), made considerable progress in providing acoustic information that is appropriate for krill stock assessment. It thanked all those involved in this process and encouraged others to become involved.

2.277 Dr Constable informed the Working Group that Australian scientists will continue participating in the work on FBM, including progressing work from 2015. He also indicated their desire to work with Members interested in participating in the development of CEMP and FBM for krill in Divisions 58.4.1 and 58.4.2.

2.278 The Working Group reiterated its thanks to the proponents of both FBM strategies and noted that the proposed strategies need to be owned by CCAMLR in order to progress further. It recommended that:

(i) A formal MSE assessment would help highlight potential weaknesses and strengths in the proposed strategies and would help in providing a comprehensive risk assessment. In particular, it could help evaluate whether either strategy presented a risk of instability for the fishing fleet or a risk that the conservation objectives in Article II would not be achieved. A full MSE assessment would take time, however, a partial evaluation, if clearly specified, could be feasible to provide advice in the near term.

(ii) A series of performance measures which could be used for reviewing each FBM approach and determining whether that approach was working in the field, or not, were necessary (SC-CAMLR-XXXIV, Annex 6, paragraphs 2.130 to 2.132).

(iii) Agreed timelines for advancing the work, including timelines for SG-ASAM to complete its work, are necessary. If timelines are not agreed, or are not met, further development of the krill fishery will not be feasible given the existing conservation measures and the existing advice from the Commission.

(iv) A special focus topic would be necessary during WG-EMM-17 so that the Working Group has adequate time to discuss the continued development, implementation and future review of existing FBM approaches. Special attention to ongoing and future work on FBM (e.g. Appendix E) would be particularly important.

2.279 The Working Group noted that implementing an FBM strategy will require commitment from Members to acquire, analyse and deliver data for use in the decision-making procedures. It agreed that implementation issues could be progressed in parallel with the development of FBM strategies. This is because a number of implementation requirements will be the same across different options, including:

(i) the use of fishing vessels to obtain and provide data on krill distribution, abundance and size

(ii) the provision of CEMP data at specific times of the season and at sufficient places to be useful for a management strategy

(iii) procedures for analysing the data in sufficient time for the outputs to be used in decision-making.

2.280 The Working Group requested the Scientific Committee consider how these requirements for implementation of FBM strategies could be progressed. Future development of FBM will require coordination between WG-EMM, SG-ASAM and the fishing industry. The Scientific Committee is requested to provide advice on how best to achieve this.

2.281 In order to help progress future work related to the proposed FBM approach for Subarea 48.1, representatives from the US AMLR program developed a table describing how they had addressed the extensive advice from WG-EMM-15 (Appendix E, Table 1) and a list describing how CCAMLR could address advice provided by WG-EMM-15 and WG-EMM-16 (Appendix E, Table 2), recognising that future development of the proposed FBM approach needed to involve the wider CCAMLR Membership.

2.282 WG-EMM recognised the very considerable amount of effort involved in preparing the tables in Appendix E and acknowledged that it would be extremely valuable for helping direct how the FBM approach for Subarea 48.1 should continue to develop in the future.

2.283 The Working Group thanked Dr Darby following his kind offer that Cefas, which has considerable experience in MSE, could lend analytical support to the evaluation of both FBM proposals.

2.284 The Working Group advised the Scientific Committee that in order to progress work on FBM, it will be essential for the Working Group to dedicate time to this issue, and that a focus topic to discuss the following would be advantageous during WG-EMM-17:

(i) Spatial distribution of catches for base case –

   (a) catch levels
   (b) feedback that base case is appropriate.

(ii) Implementation –

   (a) data processing and analysis
   (b) krill surveys (what will these look like and who by – e.g. fishing vessels)
   (c) CEMP coverage.

(iii) What needs to be done to satisfy the Commission that the risk of the strategy is appropriate for krill, predators and the fishery –

   (a) performance measures (trailing indicators, in-principle measures)
   (b) MSE:
      • robustness of approach to krill flux and competition amongst predators.

2.285 The Working Group emphasised that dedicating time to the proposed focus topic would mean that other topics would receive less attention in 2017. It, therefore, requested that the Scientific Committee provide guidance regarding prioritisation of FBM during WG-EMM-17.

Spatial management

Marine protected areas (MPAs)

MPA Planning Domains 3 and 4 – Weddell Sea

3.1 Prof. Brey and Dr K. Teschke (Germany) presented three updated scientific background documents for a CCAMLR MPA in the Weddell Sea: WG-EMM-16/01 (Part A: General context of the establishment of MPAs and background information on the MPA planning area); WG-EMM-16/02 (Part B: Description of available spatial data); and WG-EMM-16/03 (Part C: Data analysis and MPA scenario development). The authors summarised modifications and additions to the 2015 versions of these documents (WG-EMM-15/38 Rev. 1, 15/39 and 15/46).

3.2 The Working Group thanked all those involved in the Weddell Sea MPA planning process for their efforts in undertaking this very significant amount of work. It identified the following issues for discussion:

(i) coordination and strategy to accommodate both the Weddell Sea MPA proposal and fishery research in the planning area

(ii) spatial distribution and bathymetric range used to define the bounds of toothfish habitat and the toothfish fishing cost layer

(iii) target levels of protection for toothfish habitat (currently set at 75%)

(iv) target levels of protection for demersal fish habitat (currently set at 75%)

(v) fisheries research zones (objective 12).

3.3 In terms of a strategy to accommodate both the MPA proposal and existing research fishing in the planning area, the Working Group discussed the recommendations of WG-SAM relating to the review of research proposals in Subarea 48.6 (Annex 5, paragraph 3.40) that highlighted the need to develop the stock hypothesis for Antarctic toothfish (*Dissostichus mawsoni*) in Subarea 48.6. The specific recommendations discussed included the need for ice analysis along the southwestern shelf to better define alternatives to existing research blocks covered by ice, deployment of satellite tags to study fish movement, sub-adult surveys to monitor recruitment on the shelf, and winter surveys to detect spawning locations on northern seamounts.

3.4 The Working Group noted that satellite tagging and ice analysis in this area would be consistent with the planned objectives of the proposed MPA and with developing a stock hypothesis for *D. mawsoni*. It encouraged those Members engaged in research in Domains 3 and 4 to develop a coordinated satellite tagging program. It further noted that refining toothfish habitat and cost layers may help with considering how best to structure research fishing in the planning area and highlighted the importance of developing a consistent set of advice to the Scientific Committee from WG-SAM, WG-EMM and WG-FSA.

3.5 In a discussion on the approach to generating the toothfish potential habitat layer, Dr Teschke explained that a depth range of 400–3 100 m was used as a proxy according to habitat suitability model predictions for *D. mawsoni* compiled by the Secretariat (WG-FSA-15/64; WG-EMM-16/03, Figure 1-16). This depth range (400–3 100 m) includes suitable habitat for toothfish as predicted by the circum-Antarctic model published in WG-FSA-15/64. Furthermore, the current data layer also includes smaller-scale areas where there are no model predictions but where habitat suitability for toothfish can be inferred. The contiguous unweighted data layer was used as the potential habitat of adult toothfish for the subsequent Marxan scenario.

3.6 The Working Group recommended examining if weighting the toothfish habitat and cost layers by depth using CPUE from Subarea 48.6 or the Ross Sea is possible to refine the habitat availability predictions. It also recommended that toothfish habitat and the toothfish fishing cost layer should be bounded separately, with the fishing cost layer specified as a bathymetric range from 550 to 2 000 m according to fishing practise.

3.7 The Working Group noted that the target level of protection for toothfish habitat of 75% was chosen following stakeholder consultation, including at the second international expert workshop that recommended a range of 20 to 100%.

3.8 The Working Group noted that toothfish are a key species in the ecosystem and should have an appropriate protection value. It also noted that it is a target species and there is a distinction in the level of protection between these two aspects. It was acknowledged that in the protection levels given to toothfish within the Weddell Sea MPA proposal this difference should be reflected. In recognising these objectives, the Working Group recommended the exploration of a range of protection levels from 20% to 80% in 20% increments to assess the sensitivity of the Marxan analyses to the level of protection. It agreed that consideration of smaller increments, as appropriate, would be helpful to identify important thresholds.

3.9 The Working Group noted that there are limited data available for other demersal fish in the planning area, with some species recovering from overexploitation in adjacent areas. The demersal fish habitat layer (WG-EMM-16/03, Figure 1-17) was generated using data mostly collected from shelf waters less than 1 000 m deep but with some sampling to 3 000 m (data layer described in WG-EMM-16/02). In light of the level of uncertainty regarding the ecology and status of these species, the Working Group recommended precaution in setting the target level for demersal fish habitat protection. Exploration of a range of protection levels from 65% to 85% in 10% increments was recommended to assess the sensitivity of the Marxan analyses to the level of protection. The Working Group further recommended selected two-factor sensitivity analyses of the protection-level scenarios for toothfish and other demersal fish habitat as appropriate to explore a range of protection-level scenarios.

3.10 The Working Group noted that the MPA planning documents referred to fisheries research zone(s) that are under development as part of the MPA proposal. It recommended that information specifically on the design and objectives of the fisheries research zone(s) be presented for consideration by WG-FSA and the Scientific Committee. Of particular interest for WG-FSA would be whether fisheries research zone(s) would be established according to specific research questions, i.e. either as spatially fixed zones or on a case-by-case basis.

3.11 It further recommended that, prior to WG-FSA, the MPA proponents, Members with existing research fishing proposals within the planning domain, and other interested Members consider coordination of existing fishery research proposals and the proposed MPA objectives in this area. This could be undertaken via the Weddell Sea e-group.

3.12 Dr Freeman asked if there was any information on the extent to which Weddell Sea environmental conditions and ecology are likely to be affected by predicted climate change, and whether this had been considered in the MPA planning process. Prof. Brey explained that current models predict significant oceanographic changes to be evident in the Weddell Sea in >50 years (warm deep water moving up the Filchner shelf). Meanwhile, it remains difficult to separate long-term trends from decadal oscillations and stochastic noise.

3.13 Dr Kasatkina noted the improvements in the proposals for the MPA planning in the Weddell Sea. However, information on dominant fish species of potential commercial importance remains underrepresented. Especially data on the state of toothfish as an important component of the ecosystem are currently not available. Research surveys are needed to determine stock status and commercial potential of these fish species. She underlined that results of these investigations should be included in the scientific background document in support of the MPA planning in the Weddell Sea.

3.14 Dr Kasatkina indicated that a significant part of the Weddell Sea MPA planning area is permanently ice-covered and this fact will significantly complicate annual navigational access to the areas identified for possible protection. She noted that MPA boundaries should comply with sea-ice conditions suitable for vessel navigation, as this is an important factor for the proper implementation of assigned research tasks in designated areas.

MPA Domain 1

MPA Planning Domain 1 (Western Antarctic Peninsula and Southern Scotia Sea)

3.15 WG-EMM-16/73 introduced the Domain 1 MPA planning progress related to data sharing and future enhanced work. On 9 July 2016, an informal workshop was held with the participation of 12 Member countries. It aimed to share the technical progress on Marxan analysis made during the intersessional period, to introduce complementary analyses that could be integrated into the process, and to engage Members in different stages of analysis and preparation of support information. The Domain 1 MPA database and related information used for these analyses, including spatial layers for conservation objectives, costs and input files for running Marxan, were made available for all Members' consideration within the Domain 1 planning e-group.

3.16 WG-EMM-16/73 also introduced the idea of a CCAMLR MPA monitoring program (MPAMP) developed by scientists from Argentina, Chile, UK and USA in light of the need to secure an appropriate and centralised monitoring system for MPAs. The proposed MPAMP would be based on the concept of CEMP, for example using standard data collection methods, and selection of variables and/or species, agreed by the Scientific Committee and centralised at the Secretariat. This monitoring program could provide a useful structure to centralise the information about MPA monitoring.

3.17 The Working Group welcomed the document and the development of the informal workshop, highlighting the progress made by scientists from Argentina and Chile. It encouraged all contributors to continue this work. The Working Group noted the value of sharing data to enhance Members' participation and the potential of the CCAMLR MPAMP.

3.18 The authors highlighted the importance of the cost layer for the Marxan analysis and requested technical advice from experts on the most appropriate time periods for krill fishing activity to be considered within the Domain 1 MPA process, to account for yearly krill fishing dynamics.

3.19 The Working Group agreed the use of a 3-year period for the most recent krill fishing activity (current krill fishing pattern), extending it to 10-year periods prior to current fishing pattern (historical krill fishing patterns).

3.20 Dr Kasatkina noted that the MPA Planning Domain 1 project covered a huge area in the western Antarctic Peninsula and southern Scotia Sea. The MPA Planning Domain 1 area includes potential fishing grounds and current fishing grounds for the krill fishery and that it is contrary to CM 91-04. Moreover, the MPA Planning Domain 1 project includes the existing South Orkney Islands southern shelf MPA (SOISS MPA). Dr Kasatkina noted that the experience of the SOISS MPA showed failure of proper implementation of the monitoring program and assigned research tasks in frame of the vast designated area. She proposed that the MPA Planning Domain 1 project should be subdivided into several smaller areas for the further planning process.

3.21 Dr Santos noted that planning domains were defined and agreed by the Scientific Committee in 2011 (SC-CAMLR-XXX, paragraph 5.20). She also stated that there are no MPA boundaries defined for Domain 1.

3.22 WG-EMM-16/35 described a Marxan study undertaken to identify important benthic areas within MPA Planning Domain 1, using the conservation objectives previously agreed during Domain 1 planning workshops, and data layers that have been shared with all Members as part of this process. This separate benthic analysis provides a means to differentiate whether benthic or pelagic objectives drive the selection of areas in future combined analyses. In considering potential management options in future planning, this separate analysis may also help to determine how benthic and pelagic activities could be managed differently in some areas.

3.23 The Working Group welcomed this work, noting that there was considerable overlap between the core areas identified in this study and the areas that had been identified as important for meeting conservation objectives in other studies for Domain 1. It noted the value of shared datasets in facilitating this type of additional supporting analysis as part of the MPA planning process.

South Orkney Islands

3.24 WG-EMM-16/13 Rev. 1 is a preliminary report on the benthic research voyage carried out on board the RRS *James Clark Ross* around the South Orkney Plateau in February–March 2016. The expedition was led by the British Antarctic Survey in collaboration with the SCAR State of the Antarctic Ecosystem (AntEco) research program. It included 22 participants from nine different countries, including eight CCAMLR Members.

3.25 The aim of the survey was to understand the distribution and composition of the benthic communities associated with different geomorphic features both within and outside the SOISS MPA. It also aimed to record the locations and distributions of all species identified as vulnerable marine ecosystem (VME) indicator taxa (paragraph 3.45iii).

3.26 The survey used a range of trawled sampling gear, as well as video and camera systems, to investigate species diversity, assemblage composition, abundance and habitat zonation along the shelf break of the South Orkney Islands. The results will help to ascertain whether there are characteristic indicator species prevalent in each proxy geomorphic habitat, and assist with future habitat mapping. New species were found in most groups of animals examined on the cruise, including corals, anemones, echinoderms and polychaete worms, with many other probable new species awaiting further identification. The authors noted that more detailed results from the wide range of analyses resulting from this cruise will be submitted to the Working Group and the Scientific Committee as they become available.

3.27 This research addresses some of the requirements of the SOISS MPA research and monitoring plan. The results will help to inform and support the management of the MPA, and provide new information to evaluate the extent to which its conservation objectives are being achieved. This will form an important basis for the development of scientific advice to inform the next review of the SOISS MPA, which is due in 2019.

3.28 The Working Group welcomed the preliminary results from this survey, and noted the important connection with the SCAR AntEco program.

MPA Planning Domains 5 (Crozet – del Cano) and 6 (Kerguelen Plateau)

3.29 Prof. Koubbi presented WG-EMM-16/43 and 16/54 on the ‘Ecoregionalisation of the Kerguelen and Crozet Islands oceanic zone’ and 16/42 on the ‘Atlas of top predators from French Southern Territories in the southern Indian Ocean’. These papers add new information on Planning Domains 5 and 6 following the objectives proposed in SC-CAMLR-XXIX/13. These papers update scientific elements that were submitted to the CCAMLR Workshop on Marine Protected Areas in 2011 (WS-MPA11/09, 11/P03, 11/08, 11/P04, 11/10 and 11/P02) and to the CCAMLR Technical Workshop on Planning in Domain 5 in 2012 (WG-EMM-12/33 Rev. 1).

3.30 WG-EMM-16/43 and 16/54 listed the general conservation objectives to evaluate boundaries of ecoregions based on abiotic (geography, geomorphology and oceanography) and biotic features, including pelagic species, benthic species (including the demersal ichthyofauna), seabirds and marine mammals. There are discrepancies in the amount of data between sectors; Crozet can be considered as an area with less ecological information than Kerguelen, except for oceanography and top predators. The abiotic regionalisation of both areas was based mainly on the analysis of meso- and sub-mesoscale oceanographic features (such as fronts, retention zones, iron enrichment) which favour biological productivity linked to island mass effects.

3.31 Spatial patterns of biodiversity were determined based on spatial distributions of species and assemblages, or on species’ potential habitats estimated regionally for top predators (WG-EMM-16/42) or globally for the Southern Ocean as for mesopelagic fish (De Broyer et al., 2014). Both islands support a high biodiversity of seabirds with a high range of dispersion in the sub-Antarctic and the Polar Frontal zone (WG-EMM-16/42). However, individuals from only a few colonies are tracked, and the conclusions of the reports are also based on observations from scientific and fishing vessels.

3.32 The papers also included descriptions of spatial patterns linked to functional diversity, including location of foraging habitats of seabirds and marine mammals, essential fish habitats (only for Kerguelen) and spatial distribution of VME indicator taxa. The maps of the six ecoregions for Crozet and 18 for Kerguelen were presented, noting that the reports summarise the essential ecological characteristics supporting the delineation of these ecoregions.

3.33 Prof. Koubbi explained that the aim of this project is to extend the Crozet and Kerguelen marine reserves beyond the existing 12 n miles around some of the islands of both archipelagos. The priority areas identified show that the process should consider also areas outside the Crozet and Kerguelen exclusive economic zone (EEZ).

3.34 The Working Group recognised the integrated ecosystem approach presented in these papers and the relevance of the ecoregionalisation of the Crozet and Kerguelen oceanic zones. It welcomed the scientific progress made on these areas of Planning Domains 5 and 6. As these areas are in the most northerly part of the Convention Area, together with Prince Edward Islands, they provide a unique opportunity to study biogeographic patterns in the Subantarctic and Polar Frontal zones and to consider the potential consequences of climate change, in particular for the pelagic realm (including mesopelagic fish), seabirds and marine mammals.

3.35 The Working Group agreed that these three papers should be considered as a scientific basis to initiate future work. These areas could also be discussed more broadly in a representative system of Indian Ocean sub-Antarctic MPAs. To achieve this goal, the Working Group recommended that an e-group be established to investigate the proposal to conduct a spatial planning process in the CCAMLR area in the south of the Crozet EEZ in Planning Domain 5 and to the east of Kerguelen in Planning Domain 6, based on oceanographic features and top predator tracking. These areas have been recognised as being important, for example, for king penguin (*Aptenodytes patagonicus*) foraging in the Polar Frontal Zone south of Crozet and for elephant seals (*Mirounga leonina*) in relation to gyres to the east of Kerguelen. An e-group would facilitate community work on those areas and enable sharing of assembled data through the CCAMLR website.

3.36 The Working Group also considered the recommendation to extend discussions between CCAMLR and regional fishery management organisations (RFMOs) on the del Cano Rise and other oceanic sectors north of the Convention Area, to facilitate a regional approach. It was agreed that such interactions would be beneficial.

3.37 The Working Group highlighted the importance of these sub-Antarctic areas regarding climate change impacts, as predicted change shows a southward shift of the Polar Front and a reduction of the Subantarctic zone surface. The designation of future MPAs will need to consider potential shifts southwards of these areas. For example, it is important to take into account the different impacts of climate change, in particular, for king penguins in Crozet.

Ross Sea krill research zone

3.38 WG-EMM-16/49 provided a review of previous research undertaken on krill and krill-dependent predators in the proposed krill research zone (KRZ), part of the proposed Ross Sea region marine protected area (RSRMPA). A central aim of the proposed KRZ is to enhance research opportunities within the RSRMPA, and WG-EMM-16/49 aimed to demonstrate this potential by reviewing previous scientific work relevant to krill and krill-dependent predators in the proposed KRZ. First, it was noted that sea-ice dynamics are an important structuring force acting on krill and their predators in the proposed KRZ. Most of the research found regarded baleen whales, and indicated that whale abundance is increasing in a larger area that overlaps with the proposed KRZ. Relatively little research was found on seabirds and seals, but WG-EMM-16/49 noted breeding colonies in and around the proposed KRZ. These were reported along with buffer zones at 60 n miles in accordance with CM 51-04 (fishing for krill in the proposed KRZ would be in accordance with CM 51-04, CCAMLR-XXXIV/29 Rev. 1, paragraph 9). The authors noted that these buffer areas do not overlap with historical krill fishing in the proposed KRZ. Overall, the authors concluded that the potential importance of this area to krill and krill predators presents an important opportunity for research.

3.39 The Working Group asked for clarification on how WG-EMM-16/49 related to, and aided in, furthering the ability of the RSRMPA to meet its objectives. The authors responded that the revised proposal for the RSRMPA submitted to the Commission in 2015 had identified a specific objective relating to the KRZ (CCAMLR-XXXIV/29 Rev. 1, paragraph 3xi). In terms of furthering this objective in the future, this review aims to motivate Member countries to utilise the proposed KRZ for further research. Specifically, the proposed KRZ may be particularly important for comparing conditions with nearby Balleny Islands, which are within the proposed RSRMPA General Protection Zone (i). Being able to conduct research on spatial areas with contrasting management objectives, such as in the Balleny Islands and the proposed KRZ, is of strong scientific importance and interest.

3.40 The Working Group noted that the draft research and monitoring plan (SC-CAMLR-IM-I/BG/03 Rev. 1) would be finalised, once the RSRMPA is adopted by the Commission, to reflect the final agreement. Priority elements for scientific research and monitoring, including those specifically relating to the KRZ, are included in the draft conservation measure for the MPA proposal, and the final monitoring plan should include input from all Members. To accomplish this, a focus session at WG-EMM or a workshop could be convened in the year following the agreement of the MPA by the Commission to revise the draft research and monitoring plan to reflect all Member contributions in this area.

3.41 Dr Zhu asked the authors to clarify the potential for krill fishing in the future. Dr Watters replied that, per the draft conservation measure, krill fishing as it is proposed in the KRZ is envisioned to adhere to CM 51-04 and the requirements therein (CCAMLR-XXXIV/29 Rev. 1, paragraph 9), which include the aforementioned buffer zones and a series of fishing vessel data collection plans. If the RSRMPA is adopted, Members who want to fish for krill in the proposed KRZ would then determine how they would carry out those research aspects, which would be encouraged to align with the research and monitoring plan developed with the adoption of the RSRMPA.

3.42 Dr Godø reiterated the Norwegian continuous support to the Ross Sea MPA and its development on a scientific basis. He asked what the process of a scientific review of the proposed KRZ would be, as it has already been accepted at the Commission and whether WG-EMM and/or the Scientific Committee will review the KRZ at a future stage or whether any evaluation will remain within the Commission.

3.43 The proponents responded that there is precedence for decisions at the Commission to drive the work of WG-EMM. The specific boundary modifications regarding the KRZ were put in place to address concerns raised by a Member, an option implied in the original proposal. While the proponents acknowledged that a boundary change may raise process questions, they also recalled that the remainder of the proposed RSRMPA had already been considered and endorsed by the Scientific Committee (SC-CAMLR-IM-I, paragraphs 2.31 to 2.33).

3.44 Dr Kasatkina emphasised that scientifically based arguments for creating this KRZ were not provided when the KRZ was discussed at the close of the CCAMLR meeting in 2015, and its establishment is not adopted by all CCAMLR Members. Dr Kasatkina, therefore, asserted that discussion of future research in the proposed KRZ is premature, and noted that an investigation on krill in the Ross Sea might be undertaken in the frame of CM 24-01.

Vulnerable marine ecosystems

3.45 There were no papers submitted under this agenda item; however, the Working Group noted work relevant to VMEs in other papers, particularly in the context of MPA planning and MPA research and monitoring, including:

(i) WG-EMM-16/43 (paragraphs 3.29 to 3.37) used niche modelling predictions and VME indicator group presence/absence data in the Kerguelen Island shelf and surrounding seamounts as the basis of a benthic ecoregionalisation of the area. The distribution of soft corals, hard corals and sponge assemblages allowed the differentiation of different coherent zones with representative ecosystems for each, along with related conservation issues.

(ii) WG-EMM-16/54 (paragraphs 3.29 to 3.37) summarised the available historical data of known VME indicator taxa in the Crozet area.

(iii) WG-EMM-16/13 Rev. 1 (paragraphs 3.24 to 3.28) presented a preliminary report of a UK-led benthic research cruise around the South Orkney Plateau in 2016. One of the aims of this cruise was to record the locations and distributions of all species identified as VME indicator taxa. Initial results showed a correlation between abundance of animals from VME indicator groups and the overall diversity of seafloor life, both inside and outside the SOISS MPA. The importance of VME indicator groups such as corals, sponges and pencil urchins as habitats for other species was noted and previously unknown associations and interactions were revealed. More detailed results from this work will be submitted to WG-EMM as they become available. Further analyses will also consider how VME risk areas can be identified using the results of research sampling and photography/video, rather than data from fishing vessels.

(iv) WG-EMM-16/35 (paragraphs 3.22 and 3.23) considered the locations of existing VMEs as a basis for identification of important benthic areas for conservation in MPA Planning Domain 1.

3.46 The Working Group noted that information relevant to VMEs was also discussed in papers other than those in paragraph 3.45, which focused on VMEs as part of work in support of spatial management proposals. The Secretariat reminded Members that there is a formal VME notification process (CM 22-06, Annex 22-06/B 'Guidelines for the preparation and submission of notifications of encounters with Vulnerable Marine Ecosystems (VMEs)') and encouraged Members to report VMEs as appropriate.

3.47 The Working Group recognised that it would be very useful to have the existing VME registry (www.ccamlr.org/node/85695) more apparent for annual meetings of the Scientific Committee and its working groups so that the information could be used to support discussions of these bodies. It recommended that links to the VME registry and other pertinent information on VMEs be made in annotated agendas of the Scientific Committee and the working groups to provide ready access to this information.

Other issues for spatial management

3.48 WG-EMM-16/27 referred to the draft conservation measure that was proposed by the EU in 2015 with the aim of promoting and facilitating scientific research in newly exposed marine areas following ice-shelf retreat or collapse around the Antarctic Peninsula (CCAMLR-XXXIV/21). The proposed conservation measure would provide for the establishment of special areas for scientific study in such areas, with a designated 10-year study period during which time there would be a moratorium on all fishing activities, except for scientific research fishing activities undertaken in accordance with CM 24-01. There was broad support by the Scientific Committee in 2015 for the scientific basis of the proposal. WG-EMM-16/27 addressed a number of points for clarification that were raised by the Scientific Committee and the Commission.

3.49 In addressing these points, the authors noted that:

(i) Ice-shelf retreat can be defined as the landward movement of the ice front over a period of at least 10 years, whereas collapse may occur over a shorter time period. However, recognising the difficulties of defining the terms 'collapse' or 'retreat' in a way that is applicable for all cases, and given the unique set of physical circumstances that are likely to lead to any individual collapse or retreat event, areas for potential designation as special areas for scientific study should be proposed and considered on a case-by-case basis.

(ii) The SCAR Antarctic Digital Database (ADD) remains the best available source of information on ice-shelf and glacier margins. The most recent version (ADD v.7.0, 2016) includes new data showing changes to the ice coastline, as well as a new 'coastal change' layer showing historic ice extent across the Antarctic Peninsula region, which will be regularly updated.

(iii) The main change in the proposed conservation measure is in the operation of the 10-year moratorium. The new plan includes a two-stage process. An initial two-year period (stage 1) would begin immediately following notification of an ice-shelf collapse/retreat. During stage 1, the fishing moratorium would begin, along with a review of the available data by WG-EMM and the Scientific Committee to determine whether the area warrants designation as a special area for scientific study. Stage 2 would begin before the end of the two-year period, if agreed by the Commission, based on advice from the Scientific Committee. Once agreed, special areas for scientific study would be established for a period of 10 years.

3.50 There was general support for the proposed updates to the draft conservation measure; however, the Working Group asked for further clarification on three issues. In response to these questions, the authors clarified that:

(i) The rationale for the two-year stage 1 period is to allow for review and consideration of scientific data for the proposed special area for scientific study (noting also that this period may in fact be shorter than two years, depending on the timing of notification and consideration by the Commission). The 10-year stage 2 period is seen as an appropriate time period in which to plan and initiate scientific research activities once a special area has been designated.

(ii) To ensure appropriate initiation of a stage 1 special area, it will be important to ensure that adequate scientifically robust data are submitted during the notification process.

(iii) A retrospective analysis of past ice-shelf collapses/retreats, will help increase understanding about whether such events would have warranted a special area for scientific study designation in the recent past, and the extent to which the proposed conservation measure would have been applied. Such an analysis will be undertaken following agreement of the proposed conservation measure.

3.51 The authors thanked the Working Group for the questions, noting that consideration of these issues will be incorporated into the development of a revised draft conservation measure for submission to the Commission.

3.52 The Secretariat introduced a new section of the CCAMLR website dedicated to managing reference material entitled 'Spatial Management Resources for CCAMLR Members' (www.ccamlr.org/node/90100) that was developed in response to the recommendation of the Scientific Committee (SC-CAMLR-XXXIV, paragraphs 16.2 and 16.3). The Secretariat demonstrated how this web resource can be used by Members to easily share information, enhancing their participation in MPA planning processes. The Working Group welcomed this webpage and encouraged Members to make relevant datasets available where possible.

Ross Sea symposium

4.1 A one-day Symposium on the Ross Sea Ecosystem was held on 13 July 2016 with the general aim to give the opportunity for scientists who do not routinely attend meetings of CCAMLR to get to know where the CCAMLR interests are and also for the CCAMLR scientists to know the work being undertaken on the Ross Sea ecosystem. The symposium also aimed to promote the sharing of common interests to tackle some of the questions that CCAMLR would like to address into the future. The symposium was co-convened by Drs Ghigliotti, Olmastroni and Kawaguchi, and was attended by over 80 scientists including 30 local participants.

4.2 The Co-conveners thanked Drs E. Brugnoli (CNR-DTA) and A. Meloni (President of the CSNA), and the local organisers Drs Fioretti and Vacchi for making it possible to hold the symposium. Dr Belchier (SC-CAMLR Chair) welcomed participants and presented CCAMLR's aims and structure. Dr G. Budillon (University of Naples 'Parthenope', member of the Italian National Scientific Committee for Antarctica, CSNA) on behalf of CSNA welcomed participants and presented the Italian National Antarctic Program.

4.3 The symposium included a number of contributions spanning from oceanography to microbiology, from fish to penguins and killer whales, and the presentations were organised in the following three thematic sessions:

(i) ecosystem structure and functioning (four abstracts)
(ii) krill and fish, fisheries and their impact on the ecosystem (four abstracts)
(iii) ecosystem monitoring and conservation (11 abstracts).

4.4 The series of presentations were followed by general discussion. Key points of the discussion were:

(i) The CCAMLR community was impressed by the amount of quality science undertaken across the regional ecosystem.

(ii) The Ross Sea area is an impressively data-rich area with a wealth of long-term data being collected. Compilation of all available time series may potentially reveal concordant changes that may indicate broader-scale effects which are not evident from each individual time series analysis.

(iii) The need for stronger interaction between CCAMLR and SCAR was suggested but communications at the scientists and national delegation level, which already exists, will naturally strengthen this relation.

(iv) Importance of national capacity building was stressed, and the CCAMLR scholarship scheme for young researchers and students was suggested to be an excellent vehicle to promote involvement of the Italian scientific community in CCAMLR.

(v) Creation of an e-group for the Ross Sea ecosystem, facilitated by the Italian CCAMLR Delegates Drs Vacchi and Fioretti, to continue the momentum gained from this symposium.

(vi) The symposium functioned as an excellent dialogue for CCAMLR to connect to the host community, and it may be beneficial to organise similar events in future meetings.

(vii) An information paper on the summary of the symposium should be published, facilitated by the Co-conveners.

4.5 The symposium program and the abstracts of presentations are appended to this report (Appendix F).

4.6 The Working Group congratulated the Co-conveners for such a successful symposium, making it possible to connect the Working Group to the local scientists.

4.7 The Working Group noted that the symposium format with a large number of presentations made it difficult to discuss details of each presentation, and that CCAMLR may benefit from having a mechanism to extract key information that is relevant to CCAMLR objectives and effectively utilise this to provide advice.

4.8 The Working Group further noted that such a symposium is an excellent means for outreach but at the same time there is a trade-off since it takes a certain amount of time out of the Working Group meeting, and this should be one of the topics to be brought up and discussed at the Scientific Committee Symposium later this year.

Advice to the Scientific Committee and its working groups

5.1 The Working Group's advice to the Scientific Committee and its working groups is summarised below; the body of the report leading to these paragraphs should also be considered.

5.2 The Working Group advised the Scientific Committee and other working groups on the following topics:

(i) Krill fishing activities –

(a) publication of krill catches by month and SSMU (paragraph 2.8)
(b) notifications for 2016/17 (paragraph 2.14)
(c) escape mortality (paragraph 2.17)
(d) start date of the fishery (paragraph 2.33)
(e) collection of acoustic data and net samples (paragraphs 2.39, 2.191, 2.194 and 2.273).

(ii) Scientific observations –

(a) observer coverage (paragraph 2.48)
(b) sampling design (paragraph 2.53)
(c) collection of data on salps (paragraph 2.90).

(iii) Krill biology, ecology and ecosystem interactions –

(a) flux of krill through the ecosystem (paragraph 2.62)
(b) ecosystem-essential ocean variables (paragraph 2.94)
(c) status of whale populations (paragraphs 2.118 and 2.119).

(iv) CEMP and WG-EMM-STAPP –

(a) impact of krill fishing in Subarea 48.1 (paragraph 2.144)
(b) reference monitoring areas (paragraph 2.146).

(v) FBM –

(a) spatial allocation of the trigger level to Subarea 48.1 (paragraph 2.225)
(b) risk assessments (paragraph 2.241)

(c) trigger level and catch limits in CM 51-07 (paragraphs 2.247 to 2.252)
(d) transition from stage 1 to stage 2 (paragraph 2.284)
(e) prioritisation and coordination of further work (paragraphs 2.280 and 2.285).

(vi) Spatial management –

(a) VME registry (paragraph 3.47).

(vii) Ross Sea Symposium –

(a) outreach (paragraph 4.8).

(viii) Future work –

(a) climate change (paragraph 6.12)
(b) data management group (paragraph 6.21).

(ix) Other business –

(a) meeting papers (paragraphs 7.2 and 7.3).

Future work

6.1 The Working Group noted that future work relating specifically to FBM is discussed in paragraphs 2.278(iv), 2.280 and 2.285 and Appendix E.

Third International Krill Symposium

6.2 WG-EMM-16/34 announced the Third International Krill Symposium (http://synergy.st-andrews.ac.uk/3iks), which follows previous symposia held in 1982 and 1999. The symposium will be held in St Andrews, Scotland, in June 2017 and will consider a range of krill species including Antarctic krill. Scientists with experience in the work of WG-EMM are particularly encouraged to participate. The Co-conveners hope that the symposium will increase interaction between WG-EMM and the wider community of Euphausid researchers.

Joint CCAMLR–IWC Workshop

6.3 WG-EMM-16/12 presented an update on the drafts of the terms of reference and agenda for two joint CCAMLR–IWC workshops planned for 2017 and 2018 (SC-CAMLR-XXXIV, paragraphs 10.26 and 10.27), following consideration at IWC SC at its meeting in June 2016. These workshops will consider multispecies models of the Antarctic marine ecosystem at a scale appropriate for informing strategic management advice and set directions for future collaborative work between CCAMLR and the IWC.

6.4 The Working Group noted the following:

(i) The IWC SC had made minor modifications to the agenda of the first workshop:

(a) Item 2.3 was modified to ‘Purpose, status of, and suggestions regarding, relevant multispecies models’

(b) Item 2.4 was inserted: ‘Abundance and trends of species relevant for developing and fitting multispecies models’.

(ii) It was confirmed that the first workshop would be held as a pre-meeting to IWC SC 2017 (6 to 8 May 2017 in Slovenia). One and a half days have been allocated for the workshop by the IWC SC during the pre-meeting period, but it will be possible to continue discussions during the IWC SC as the IWC SC allows. This is a change in the strategy since this was last discussed at CCAMLR.

(iii) The geographic focus for the workshop will be the Antarctic Peninsula, but it was noted that connectivity between the neighbouring areas may also be of interest since the foraging ranges of predators may change between summer and winter and this could be different between species.

(iv) Whales, krill, penguins and seals were identified as key taxa for including in multi-species models, but it was noted that others such as flying seabirds were potentially important.

(v) The expectation is for descriptions of models and datasets on key taxa to be tabled at the first workhsop to provide an overview of what is available.

(vi) The IWC approved a budget to invite four experts, but two of their nominations (Dr Watters and Dr A. Friedlaender (USA)) are subcommittee members for the IWC SC, freeing up the budget for two more experts. Current nominations include Drs E. Plagányi (South Africa) and D. Kinzey (USA).

(vii) The current steering group consists of Drs Kawaguchi (Co-convener), T. Kitakado (Japan) (Co-convener), Watters, Currey, Trathan, Hill, Ichii and K. Kovacs (Norway) (SC-CAMLR-XXXIII, paragraph 10.26). The subgroup agreed that the Secretariat should also be represented on the steering group.

(viii) The steering group’s main tasks are to: list potential participants and presenters by January 2017; publicise the workshop to WG-EMM; consider ways of allowing remote participation in the workshop.

6.5 The Working Group agreed that:

(i) a metadata catalogue would be useful for consideration at the first workshop describing datasets and models, noting that it may be difficult to complete this by the first workshop and that such a catalogue could be progressed up to the second workshop

(ii) costings will be required for attendance of experts in order to seek support from SC-CAMLR. CCAMLR to develop a matching budget to IWC SC to invite experts

(iii) an e-group will be established to progress the development of the metadata catalogue and to consider what needs to be discussed at the first workshop

(iv) the Steering Committee consider having an introductory session to help the workshop participants to identify common goals but to recognise that the motivation and level of understanding between the two groups may be different.

6.6 Given that the workshop is proposed to take place over 1.5 days, with the understanding that there will be time during the margins of the IWC SC to continue the workshop discussions as required, the Working Group suggested that it would be useful to ask in advance for dedicated time and space to ensure this happens.

6.7 An e-group has been established to make progress on the items listed in the draft agenda (WG-EMM-16/12) for the first workshop, including reviewing the status/availability (and preparing short descriptions) of the data and models (updated from the 2008 workshop) available/being developed. The Working Group agreed that this would allow the clarification of what remains to be discussed in the first workshop, including an indication of whether 1.5 days is appropriate, that would allow the Scientific Committee to review the planning and proposed attendance at the first workshop.

Joint CEP–SC-CAMLR Workshop

6.8 WG-EMM-16/30 reported on the Joint CEP–SC-CAMLR Workshop on Climate Change and Monitoring held in Punta Arenas, Chile, in May 2016, and co-convened by Drs Grant and Penhale. This workshop produced 16 recommendations. The Co-conveners highlighted to WG-EMM Recommendation 2 – 'to encourage the articulation of clear questions to be addressed to scientific programs in order to obtain the best scientific advice relevant to the goals of the CEP and SC-CAMLR'. The report includes a process for identifying and conveying shared climate change research and monitoring needs which includes identification by WG-EMM of components of CEP's Climate Change Response Work Program (CCRWP) relevant to SC-CAMLR.

6.9 The Working Group noted the recommendations arising from the Joint Workshop (WG-EMM-16/30) and agreed that this workshop had been a productive and valuable opportunity to share information and consider issues of common interest.

ICED

6.10 WG-EMM-16/22 provided an overview of the work of the Integrating Climate and Ecosystem Dynamics in the Southern Ocean (ICED) program. ICED is a regional program of the Integrated Marine Biogeochemistry and Ecosystem Research (IMBER) program and is closely linked with SCAR. The paper highlighted scientific progress in aspects where the interests of ICED and CCAMLR overlap. It noted that ICED can help coordinate the development of activities of joint priorities. A range of multidisciplinary research is underway and considerable progress has been made in understanding the structure and functioning of ecosystems, modelling species and food webs, and with qualitative assessments of change. ICED's current major focus is to more comprehensively assess (and where possible quantify) key impacts of change on Southern Ocean ecosystems.

6.11 WG-EMM-16/71, which was also presented to the Joint CEP–SC-CAMLR Workshop on Climate Change and Monitoring, summarised knowledge of the impacts of climate change and acidification on Southern Ocean ecosystems, and the attention that SC-CAMLR has given to these impacts. It also summarised planned activities of ICED and SOOS and identified these as opportunities for SC-CAMLR and CEP to cooperate with SCAR to progress work on climate change and acidification. These activities include an ICED conference on marine ecosystem assessment for the Southern Ocean to be held in Hobart, Australia, in April 2018.

6.12 The Working Group recommended the SC-CAMLR Symposium consider whether, and how, discussions on climate change (such as those presented in WG-EMM-16/22, 16/30 and 16/71) may be considered in future working group meetings, in order to provide appropriate advice to the Scientific Committee.

Developing links with SCAR and other programs

6.13 The Working Group noted Table 2 of WG-EMM-16/30, which sets out a process for CEP and SC-CAMLR to identify and convey shared climate change research and monitoring needs to SCAR, ICED and SOOS. It noted that the related discussions and recommendations from the Joint Workshop focus on climate change issues, but agreed that the dialogue with SCAR, ICED and SOOS should be broader in scope and can draw on their expertise in a number of relevant areas, including:

(i) ICED can help with investigating the consequences of change, the development of scenarios and investigations into the implications of these changes for ecosystems and fisheries (see WG-EMM-16/22)

(ii) SOOS provides an overarching framework for observing and monitoring (see WG-EMM-16/71)

(iii) SCAR has a number of groups carrying out relevant work (e.g. AnT-ERA – Antarctic Thresholds – Ecosystem Resilience and Adaptation and AntEco).

6.14 The Working Group recognised the potential benefits of collaborations with the wider science community in terms of exchanging valuable ecological information on key taxa and regions to develop useful baselines and to understand the effects of change (e.g. consequences for predators, e.g. WG-EMM-16/P07 and 16/P08, krill, mesopelagic fish, benthic and deep-water ecosystems, invasive species, etc.).

6.15 The Working Group noted that ICED desires to have closer collaboration with CCAMLR, and to identify and address key scientific issues of interest to both groups towards improving the provision and uptake of valuable information for ecosystem-based management. This is consistent with the recommendations of the recent Joint CEP–SC-CAMLR Workshop on Climate Change and Monitoring, including those that encourage the strengthening of links between ICED and SC-CAMLR. The Working Group suggested that an initial small set of priority activities of joint interest be identified and used as a focus for strengthening links. These could include consideration of key species, regional ecosystems, scenarios and projections of change, and exploring the potential for ICED science to contribute specifically to informing key areas in CCAMLR decision-making (see e.g. paragraph 6.25).

6.16 The Working Group noted that the Secretary of the SCAR Standing Committee on the Antarctic Treaty System (SCATS) is keen to develop linkages with CCAMLR and that further discussion is planned at the SCAR Open Science Conference in August 2016. It was noted that a set of key questions from WG-EMM that could be addressed by ICED, SOOS and SCAR would be a useful contribution to these discussions (paragraphs 6.22 and 6.23 and Table 3). The Working Group also noted that a number of potential focus regions and focus topics have been raised during this meeting (e.g. Crozet and Kerguelen Islands and MPA Planning Domain 1) in this regard.

6.17 The Working Group agreed that an e-group be established to facilitate ongoing dialogue between Working Group participants and as a means of updating the group on relevant communication and progress between CEP and SC-CAMLR.

Data and information exchange

6.18 The Working Group agreed to investigate ways of facilitating information exchange with external groups. It was noted that the provision of regular summaries in this regard is a useful recommendation from the Joint CEP–SC-CAMLR Workshop (WG-EMM-16/30).

6.19 The Working Group noted that the Secretariat is preparing metadata for CEMP data which will be displayed on the CCAMLR GIS and is useful for facilitating engagement with science programs. In addition, the Secretariat has registered the CCAMLR Data Centre with the Global Change Master Directory (GCMD) (http://gcmd.nasa.gov) and is working towards making CCAMLR datasets discoverable through metadata records submitted to GCMD.

6.20 The Working Group recognised the value of working from standard datasets, especially in its work on FBM and planned work with the IWC. The Working Group agreed that such a mechanism may be implemented through the use of standard data extracts and accompanying documentation which describe each data extract and outline data quality assurance issues and updates. The matter was also discussed during WG-SAM-16 (Annex 5, paragraphs 2.17 to 2.20).

6.21 The Working Group endorsed the recommendation of WG-SAM that a data management group would be useful to provide a conduit between data users and the Secretariat.

Development of priority questions relating to climate change

6.22 The Working Group considered which components of CEP's Climate Change Response Work Program (CCRWP) (WG-EMM-16/30, Appendix 5) are of specific interest to

CCAMLR. Table 3 sets out relevant questions, actions, tasks and activities from other groups. It was recommended that this table be communicated to the Chair of the CEP. It would also be useful to make this table available to facilitate informal discussion at the SCAR Open Science Conference in August 2016.

6.23 The Working Group noted that issues 6 (marine species at risk due to climate change) and 7 (marine habitats at risk due to climate change) identified in Table 3 are of most relevance to its work. It further noted that similar priorities and questions could be identified for other issues relating to climate change that are of relevance to CCAMLR only (i.e. not included in the CCRWP). In discussing the development of such priorities, the Working Group noted that it would be important to consider the following points:

(i) What relevant work is currently underway?

(ii) What do we need to know (e.g. status and trends of species now and in the future)?

(iii) Types of advice that may be provided to the Commission, e.g. interpreting Article II under climate change; adapting management strategies to climate change; and the consequences of climate change to biodiversity.

6.24 In discussing specific questions relating to these points, the Working Group recognised that developing a better understanding of the potential effects of climate change on krill and krill fishing would include elements of:

(i) status and trends of the krill fishery

(ii) FBM

(iii) CEMP methods to evaluate the impacts of fishing, monitoring to provide ecosystem baselines and detect the impacts of environmental change

(iv) biology, ecology and dynamics of krill and its related ecosystem through scientific research and research using fishing vessels.

6.25 In relation to addressing these issues, and noting the request from the Joint CEP–SC-CAMLR Workshop for the clear articulation of research questions, the Working Group identified the following key questions (noting that further questions may be developed in due course):

(i) What are plausible scenarios for changes in the krill population in the Scotia Sea over the next 2 to 3 decades?

(ii) How might changes in the extent of seasonal sea-ice affect the accessibility of krill fishing areas?

(iii) What is the magnitude of change in krill and the krill-based food web that could be agreed to have occurred using current data sources?

6.26 The Working Group agreed that further information from SCAR and programs such as ICED, SOOS and others, would assist in addressing these questions. In particular, it identified existing ICED work and the proposed 2017 ICED workshop on developing scenarios for the effects of change on ecosystems (see WG-EMM-16/22) as relevant to addressing questions (i) and (ii). Scientists from WG-EMM are encouraged to contribute to planning this workshop.

6.27 The Working Group noted that an intersessional correspondence group (ICG) has been established by the Commission to consider approaches for enhancing consideration of climate change impacts in the work of CCAMLR.

6.28 The Working Group also agreed that, given climate-change impacts have already been observed, and such impacts are expected to continue, any revision of the management, including the staged approach under development by WG-EMM, must be suitably precautionary (paragraph 2.212 and Figure 3).

Scientific Committee Symposium and prioritisation of future work

6.29 The Working Group discussed preparation for, and key advice required for, the Scientific Committee Symposium, including priority focus topics, and noted that links to external groups in these areas (as discussed above) would be valuable. The Working Group agreed that it would be useful to distil this information and present it clearly for the Symposium.

6.30 The Working Group agreed that the following list of questions provide a useful guide:

(i) What is the key advice we need to provide to the Scientific Committee and the Commission?

(ii) What are the risks of not providing this advice?

(a) terms of reference of WG-EMM

- is the current working group structure appropriate to efficiently undertake the work?

(iii) What should be focus topics and their priorities?

(iv) How can external groups assist our work?

(v) How does the CCRWP relate to our work?

6.31 The Working Group considered the above questions in relation to specific areas of work such as FBM and noted that this type of analysis on all WG-EMM main topics would be useful.

6.32 The Working Group reviewed priorities and a work plan developed by the Convener for SC-CAMLR-XXXIV and agreed this will assist with the discussion of priorities at the forthcoming symposium. It was noted that with focus years on priorities we may only be able to cover those of high priority/risk. This list of priorities was also attached to the draft agenda of the Scientific Symposium that was distributed as SC CIRC 16/36.

Other business

Consideration of papers under Other business

7.1 The Working Group noted that there were a number of papers (WG-EMM-16/24, 16/25, 16/31, 16/32, 16/33, 16/50 and 16/P05) that had been allocated to this agenda item because there was not a more specific agenda item under which they would be considered. The Working Group did not consider these papers in detail and acknowledged that, given the large number of papers submitted to the meeting, it was unrealistic to consider all of the papers in an equivalent level of detail.

7.2 The Working Group recognised that there are scientific issues relevant to the work of CCAMLR for which it is unclear where discussion should take place, e.g. the ecosystem effects of finfish fishing, and agreed that the general question of how best to provide a forum for discussion of these issues should be considered by the Scientific Committee.

7.3 The Working Group also recommended that as part of the document submission approval process, Scientific Committee Representatives (or others with delegated authority) ensure that papers are tabled to the appropriate agenda item taking into account any pre-meeting guidance provided by the Convener. In situations where a suitable agenda item does not exist, then a discussion with the Convener may help to clarify the appropriateness of the submission of a particular paper.

Global Environment Facility proposal

7.4 The Secretariat provided a brief update on the CCAMLR Global Environment Facility (GEF) proposal for strengthening capacity for international cooperation in the ecosystem-based management of the Antarctic large marine ecosystem (SC-CAMLR-XXXIV, paragraphs 10.30 and 10.31). Letters of endorsement have been received from Chile, India, Namibia, South Africa and Ukraine and the project proposal has been submitted for the second formal review at the meeting of the GEF Council from 24 to 27 October 2016. The Secretariat hoped that the timing of the GEF Council meeting would mean that an update would available by the end of CCAMLR-XXXV.

CCAMLR Science

7.5 The Science Manager, as Editor of *CCAMLR Science*, recalled the discussion in WG-EMM and the Scientific Committee in 2015 on the review of the future role of the journal (SC-CAMLR-XXXIV, paragraphs 14.1 to 14.6). He indicated that there were only four papers from WG-EMM this year that were submitted for consideration for the journal.

CCAMLR Scientific Scholarship Scheme

7.6 The Working Group noted the presentations given by Ms Schaafsma and Dr Sytov (paragraphs 2.74 to 2.81) and recognised the importance and the success of the scholarship scheme in building capacity in the working groups and encouraged engagement in the scheme, either as mentors or applicants. The Working Group also asked for clarification from the Scientific Committee on the eligibility of scientists from Acceding States to apply to the scholarship fund.

7.7 The Working Group requested that the papers that were submitted to the Working Groups by recipients of scholarships be linked from the scholarship webpage in order to better highlight the contribution of the scheme to the work of CCAMLR.

CEMP Special Fund

7.8 The Working Group noted that there were no applications to the CEMP Special Fund this year. The Working Group also suggested that the administration of the CEMP Fund may need to be clarified in order to increase the visibility of the fund, the application process and subsequent procedures for disbursement of funds. The Working Group suggested that the Scientific Committee consider the composition of the management group, including the potential addition of the Convener of WG-EMM and the Science Manager.

7.9 Dr Watters provided an update on the project, funded by the CEMP Fund, on tracking the overwinter habitat use of krill-dependent predators from Subarea 48.1, including on the involvement of the Secretariat in managing the purchasing of satellite tags and the utilisation of existing Secretariat data management systems for VMS data to record the location data for the tracked penguins.

Antarctic Wildlife Research Fund

7.10 Dr Trathan informed WG-EMM that the Antarctic Wildlife Research Fund (AWR; www.antarcticfund.org) had received a large number of high-quality scientific research proposals in response to its second call for proposals. The AWR Scientific Advisory Group would make recommendations about these proposals in the near future so that results could be announced towards the end of the year. He also advised that following the first call for proposals, the AWR had funded research on:

- (i) foraging range and habitat preference of non-breeding penguins
- (ii) foraging behaviour of humpback whales
- (iii) ageing methodology for Antarctic krill.

The AWR envisaged that the funded research would contribute to CCAMLR’s management of the krill fishery.

Next meeting of WG-EMM

7.11 Dr Santos informed the Working Group that she will be delighted to host the 2017 meeting of WG-EMM in Argentina.

Adoption of the report and close of the meeting

8.1 In closing the meeting, Dr Kawaguchi thanked all participants and the Secretariat for their contributions to the meeting and the work of WG-EMM, and the Italian Antarctic research community for the successful one-day symposium on the Ross Sea ecosystem. He also thanked the subgroup coordinators and rapporteurs, and especially Drs Constable, Demianenko, Trathan and Watters, for facilitating the discussions on FBM. Dr Kawaguchi thanked Drs Ghigliotti and Olmastroni for co-convening the symposium and Dr Watters who also co-convened some of the Working Group sessions on krill and FBM. Dr Kawaguchi also thanked Drs Fioretti and Vacchi and colleagues at CNR for organising and supporting the meeting and symposium, and for the excellent facilities and generous hospitality. This meeting marked the end of Dr Kawaguchi's term as Convener.

8.2 Dr Watters, on behalf of the Working Group, congratulated Dr Kawaguchi for his leadership and vision during his five-year term as Convener during which time the Working Group had made substantial progress in advancing its work on FBM and spatial management. The Working Group looked forward to welcoming Dr Kawaguchi back as a participant at future meetings.

8.3 Dr Kawaguchi was presented with a small gift in appreciation of his term as Convener.

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Table 1: Summary of vessels and fishing operations notified to fish for krill in 2016/17. GW – green weight; CV – codend volume; FM – flow meter; FS – flow scale; HTV – holding tank volume; MC – meal conversion; PT – plate tray.

Member	Vessel	Method for direct estimation of GW of krill caught by product type					Processing capacity (tonnes GW/day)	Subarea/Division					
		Whole frozen	Boiled	Meal	Oil	Other product		48.1	48.2	48.3	48.4	58.4.1	58.4.2
Chile	*Betanzos*			FM			120	X	X	X			
	Saint Pierre			FS			250	X	X	X			
China	*Fu Rong Hai*	HTV	HTV	HTV			350	X	X	X	X		
	Kai Fu Hao	PT		MC			200					X	X
	Long Da	PT		MC			160	X	X	X	X		
	Long Fa	PT		MC			500	X	X	X	X		
	Long Teng	PT		MC			180	X	X	X	X	X	X
	Ming Kai	HTV		HTV			200	X	X	X	X	X	X
	Ming Xing	HTV		HTV			200	X	X	X	X		
Korea,	*Insung Ho*	HTV					160	X	X				
Republic of	*Kwang Ja Ho*	HTV	HTV	HTV		HTV (paste)	240	X					
	Sejong	HTV	HTV	HTV		HTV (peeled)	240	X	X	X			
Norway	*Antarctic Sea*			FS	FS		700	X	X	X	X		
	Juvel				FM	FM (hydrolysate, lipid complex)	250	X	X	X			
	Saga Sea			FS	FS		700	X	X	X	X		
Poland	*Alina*	HTV		MC			320	X	X	X	X		
	Saga	HTV		MC			250	X	X	X	X		
Ukraine	*More Sodruzhestva*			CV		CV (blanched and frozen meat)	250	X	X	X			
Count	18							17	16	15	10	3	3
Minimum							120						
Maximum							700						

Table 2: Summary of trawl gear proposed by vessels notified to fish for krill in 2016/17. A – panel across mouth; B – panel in net and escape window; OTM – midwater otter trawl; TMB – midwater beam trawl; C – continuous; T – traditional.

Member	Vessel	Trawl gear	Trawl technique	Net mouth		Total net length (m)	Codend mouth		Codend		Marine mammal exclusion device
				height (m)	width (m)		height (m)	width (m)	length (m)	mesh size (mm)	
Chile	*Betanzos*	OTM	T	15	22	99	3.2	3.0	28	16	A
		OTM	T	19	26	107	3.2	3.0	28	16	A
	Saint Pierre	OTM	T	15	22	99	3.2	3.0	28	16	A
		OTM	T	19	26	107	3.2	3.0	28	16	A
China	*Fu Rong Hai*	OTM	T	30	30	129	3.8	7.6	31	15	B
	Kai Fu Hao	OTM	T	30	29	268	3.4	3.4	50	20	B
	Long Da	OTM	T	15	20	135	1.2	2.2	30	15	B
		OTM	T	25	30	159	1.8	1.8	30	15	B
	Long Fa	TMB	C	20	16	152	1.5	1.5	29	16	A
	Long Teng	OTM	T	20	40	132	1.8	1.8	24	16	A
		OTM	T	20	40	175	1.8	1.8	30	15	B
		OTM	T	30	40	348	1.8	1.8	30	15	B
	Ming Kai	OTM	T	25	26	280	1.8	1.8	40	15	B
		OTM	T	26	28	185	2.0	2.0	37	15	B
	Ming Xing	OTM	T	25	26	280	1.8	1.8	40	15	B
		OTM	T	26	28	185	2.0	2.0	37	15	B
Korea,	*Insung Ho*	OTM	T	20	57	105	2.1	2.5	23	15	B
Republic of	*Kwang Ja Ho*	OTM	T	40	72	168	1.5	3.0	32	15	B
	Sejong	OTM	T	26	30	109	8.8	8.8	24	15	B
Norway	*Antarctic Sea*	TMB	C	20	20	135	3.8	3.8	28	11	A
		TMB	C	20	20	135	3.8	3.8	28	20	A
	Juvel	OTM	T	20	23	375	2.9	2.9	25	11	A
	Saga Sea	TMB	C	20	20	135	3.8	3.8	28	11	A
		TMB	C	20	20	135	3.8	3.8	28	20	A
Poland	*Alina*	OTM	T	45	45	128	2.4	2.4	36	11	B
	Saga	OTM	T	45	45	128	2.4	2.4	36	11	B
Ukraine	*More Sodruzhestva*	OTM	T	25	40	121	7.6	7.6	48	12	A
Minimum				15	16	99	1.2	1.5	23	11	
Maximum				45	72	375	8.8	8.8	50	20	

Table 3: Issues and priority questions relating to climate change. This table sets out the issues identified in the CEP's Climate Change Response Work Programme (CCRWP) that are of joint interest to CCAMLR and the CEP. The table follows the same format as the CCRWP (with corresponding numbers for ease of reference). Items in red are new items that were added during this meeting. Actions in **bold** are of particular priority to WG-EMM.

Climate-related issue	Gaps/needs/key questions	Action/task	Relevant CEP/SCAR/other activities	CCAMLR interest/involvement
1) Enhanced potential for non-native species (NNS) introduction and establishment	• Assessment of whether existing regimes for preventing NNS introductions and transfer are sufficient. Analyse management tools applied in other areas. • Assessment of risks of introducing non-native marine species. • Ongoing surveillance program to identify status of NNS in light of climate change.	b. Review of IMO biofouling guidelines to check adequacy for Southern Ocean and vessels moving from region to region. c. Undertake a risk assessment: identification of native species at risk of relocation, and pathways for intra-continental transfer, including developing regional maps/descriptions of habitats at risk of invasion. d. Undertake a risk assessment: identification of marine habitats at risk of invasion and pathways for introduction. f. Implement marine and terrestrial monitoring in accordance with established surveillance framework (pt. a) once developed.	CEP Parties to identify existing research projects relevant to surveillance and bring information to CEP 2017.	Request further information from CEP, SCAR and other programs as available.

(continued)

Table 3 (continued)

Climate-related issue	Gaps/needs/key questions	Action/task	Relevant CEP/SCAR/other activities	CCAMLR interest/involvement
3) Change to marine near-shore abiotic and biotic environment	• Understanding and ability to predict near-shore marine changes and impacts of the change. • Broader understanding of what monitoring data will be required to assess climate driven changes to the marine environment.	**a. Encourage research by national programs and SCAR and seek state of knowledge updates from SCAR on climate impacts on marine biota.** **b. Support and undertake collaborative long-term monitoring of change (e.g. SOOS and ANTOS) and seek regular state of knowledge reports from such programs.** d. Continue to work with CEP to identify the process for defining reference areas for future research. e. Maintain regular dialogue (or sharing of information) with the CEP on climate change and the Southern Ocean, in particular on actions being taken.	SCAR to assimilate current research initiatives relevant to marine environmental change. Update reports to be provided, incl. through the Environments Portal. CEP to assimilate overview of how existing research programs (such as SOOS and ANTOS) can contribute to CEP's management interests. CEP Chair to write to Steering Committees of relevant international research programs (e.g. ICED) to request regular update reports.	Request further information from CEP, SCAR and other programs as available. Maintain dialogue with CEP, including future joint workshops.

(continued)

Table 3 (continued)

Climate-related issue	Gaps/needs/key questions	Action/task	Relevant CEP/SCAR/other activities	CCAMLR interest/involvement
4) Ecosystem change due to ocean acidification (OA)	• Understanding the impacts of OA on marine biota and ecosystems.	**a. As required, encourage further research and assessment on impact of OA informed by the SCAR report.** **b. Consider forthcoming SCAR report on OA and act accordingly.** c. Review and revise where necessary existing relevant management tools to consider if they afford the best practical adaptation measure to species or geographic areas at risk from ocean acidification.	SCAR report on OA released August 2016.	Request further information from SCAR and other programs as available.

(continued)

Table 3 (continued)

Climate-related issue	Gaps/needs/key questions	Action/task	Relevant CEP/SCAR/other activities	CCAMLR interest/involvement
6) Marine species at risk due to climate change	• Understand population status, trends, vulnerability and distribution of key Antarctic species. • Improved understanding of effect of climate on species at risk, including critical thresholds that would give irreversible impacts. • Framework for monitoring to ensure the effects on *key* species are identified. • Understand relationship between species and climate change impacts in important locations/areas. • Understand systematic changes to community structure, including for example mesopelagic community structure.	**a. Encourage research by national programs and SCAR, e.g. through programs such as AntEco and AnT-ERA.** b. Consider if and how the IUCN red list criteria can be applied on a regional basis for the Antarctic in the context of climate change[1]. d. Review and revise where necessary existing management tools, to consider if they afford the best practical adaptation measure to species at risk of climate change. e. Where necessary develop management actions to maintain or improve the conservation status of species threatened by climate change, e.g. through SPS action plans.	Facilitate a program of work with SCAR, SC-CAMLR, ACAP and IUCN to provide regular update reports on the status of Antarctic species. 2018 ICED conference on Marine Ecosystem Assessment for the Southern Ocean. 2017 Krill Symposium in St Andrews.	Request further information from SCAR and other programs as available, including on the development of work on the application of IUCN red list criteria.

[1] Note that the IUCN criteria cover many aspects besides climate change, and does not necessarily identify the effects solely due to climate change. The benefit of using IUCN criteria in our response to climate change will be assessed prior to its use.

(continued)

Table 3 (continued)

Climate-related issue	Gaps/needs/key questions	Action/Task	Relevant CEP/SCAR/other activities	CCAMLR interest/involvement
7) Marine habitats at risk due to climate change	• Understand habitat status, trends, vulnerability and distribution. • Improved understanding of the effects of climate change on habitat, e.g. sea-ice extent and duration. • Improved understanding of potential expansion of human presence in Antarctica as a result of changes resulting from climate change through e.g. changes in sea-ice distribution; collapse of ice shelves.	**a. Encourage research by national programs, SCAR and other programs.** b. Review and revise where necessary existing management tools to consider if they afford the best practical adaptation measure to habitats at risk of climate change.	CEP to encourage national programs and SCAR to support and facilitate new and ongoing research activities. Update reports to be provided, incl. through the Environments Portal. 2017 proposed ICED Workshop on projections of change.	Request further information from SCAR and other programs as available, recognising existing relevant objectives and ongoing work by ICED (see WG-EMM-16/22).

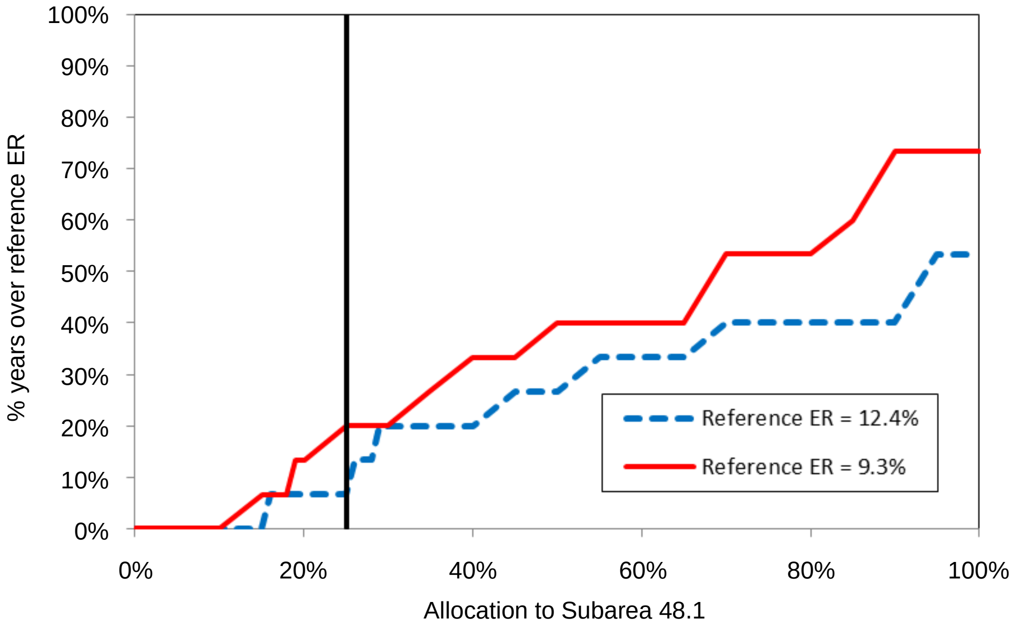


Figure 1: Potential risk of exceeding a precautionary, reference exploitation rate (ER) in Subarea 48.1 given observed variability in krill biomass (using acoustic data from the US AMLR Program) and catch limits set to fixed percentages of the trigger limit. The vertical line at 25% on the x-axis indicates the percentage of the trigger limit currently allocated to Subarea 48.1 in CM 51-07. Two reference exploitation rates are considered: 9.3% is equal to the precautionary catch limit for krill (as established in CM 51-01) divided by the estimate of krill biomass from the CCAMLR-2000 Survey; 12.4% is equal to the precautionary catch limit divided by 0.75 times the CCAMLR-2000 Survey estimate.

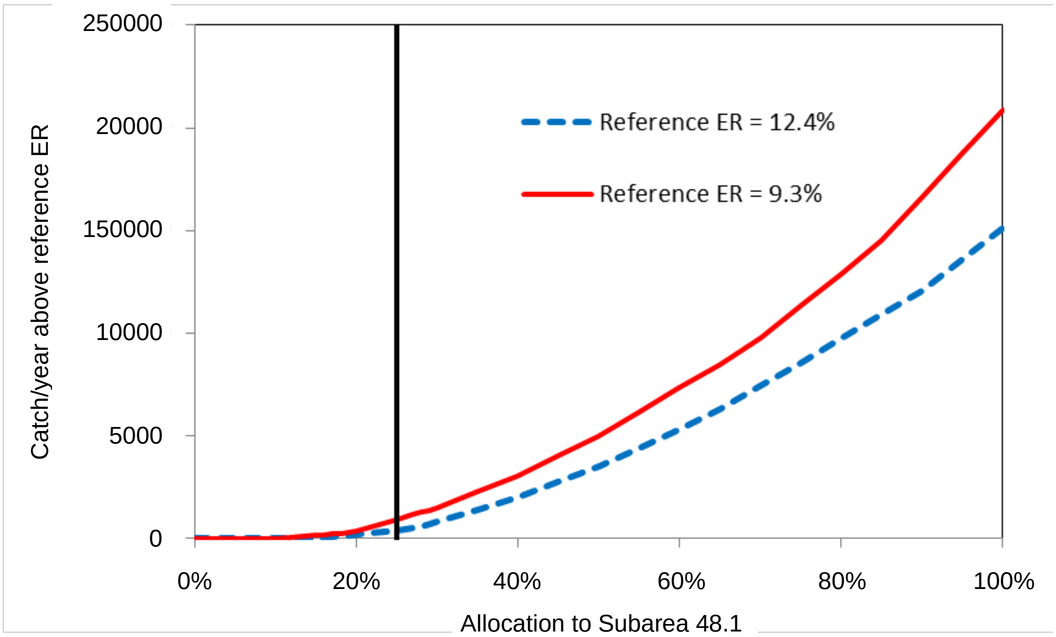
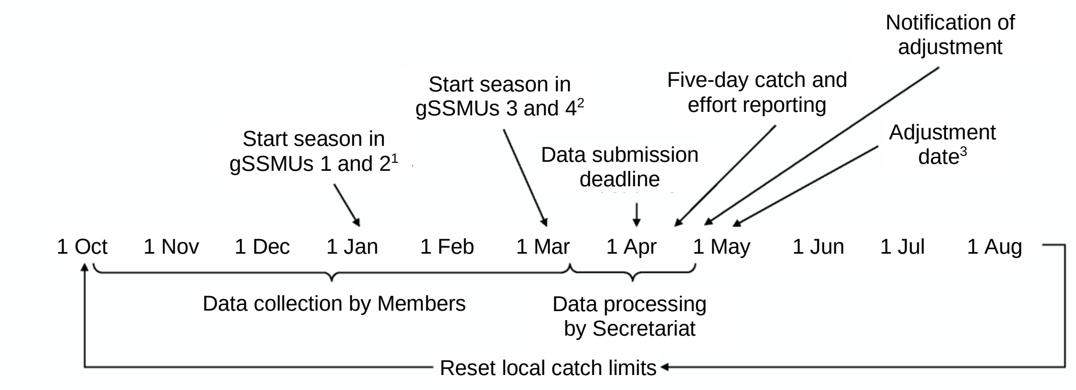


Figure 2: Potential average ‘excess’ catch during years when the exploitation rate (ER) in Subarea 48.1 might have been greater than the reference exploitation rates of 9.3% and 12.4%. The excess catch is the average amount by which the subarea catch limit would have exceeded the catch implied by one of the reference exploitation rates (e.g. 155 000 tonnes in the case of 9.3%). The vertical line at 25% on the x-axis indicates the percentage of the trigger limit currently allocated to Subarea 48.1 in CM 51-07.



[1] Initial catch limit = 100 000 tonnes.
[2] Initial catch limit = 25 000 tonnes.
[3] If adjusted catch limit > catch already taken, remaining catch limit = (adjusted catch limit – catch already taken).
If adjusted catch limit ≤ catch already taken, fishery in Subarea 48.1 is closed for remainder of season.

Figure 3: A timeline for implementation of a proposed feedback management strategy in Subarea 48.1, detailing when particular actions would need to take place each year.

Appendix A

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(Bologna, Italy, 4 to 15 July 2016)

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Appendix B

Agenda

Working Group on Ecosystem Monitoring and Management
(Bologna, Italy, 4 to 15 July 2016)

1. Introduction

   1.1 Opening of the meeting
   1.2 Adoption of the agenda and appointment of rapporteurs
   1.3 Review of requirements for advice and interactions with other working groups

2. The krill-centric ecosystem and issues related to management of the krill fishery

   2.1 Fishing activities (updates and data)
   2.2 Scientific observation
   2.3 Krill biology, ecology and ecosystem interactions
      2.3.1 Krill
      2.3.2 Ecosystem monitoring and observation
      2.3.3 Ecosystem interactions: predators
      2.3.4 Ecosystem observation and interactions: cetaceans

   2.4 CEMP and WG-EMM STAPP
      2.4.1 CEMP data
      2.4.2 Predator consumption
      2.4.3 Predator trends and dynamics

   2.5 Integrated assessment model
   2.6 Fishing vessel surveys
   2.7 Feedback management strategy
      2.7.1 Stage 1
      2.7.2 Stage 1–2 Subarea 48.1
      2.7.3 Stage 1–2 Subarea 48.2

3. Spatial management

   3.1 Marine protected areas (MPAs)
      3.1.1 Weddell Sea
      3.1.2 Domain 1
      3.1.3 South Orkney Islands
      3.1.4 Crozet Island (French EEZ)
      3.1.5 Ross Sea krill research zone

   3.2 General issues for spatial management
   3.3 Vulnerable marine ecosystems (VMEs)

4. Forum 'Ross Sea Ecosystem'

5. Advice to the Scientific Committee and its working groups

6. Future work
    6.1 CCAMLR–IWC
    6.2 ICED
    6.3 Joint CEP–SC-CAMLR Workshop
    6.4 Krill Workshop
    6.5 SC-CAMLR climate change work

7. Other business

8. Adoption of the report and close of the meeting.

Appendix C

List of Documents

Working Group on Ecosystem Monitoring and Management
(Bologna, Italy, 4 to 15 July 2016)

WG-EMM-16/01	Scientific background document in support of the development of a CCAMLR MPA in the Weddell Sea (Antarctica) – Version 2016 – Part A: General context of the establishment of MPAs and background information on the Weddell Sea MPA planning area K. Teschke, D. Beaver, M.N. Bester, A. Bombosch, H. Bornemann, A. Brandt, P. Brtnik, C. de Broyer, E. Burkhardt, B. Danis, G. Dieckmann, L. Douglass, H. Flores, D. Gerdes, H.J. Griffiths, J. Gutt, S. Hain, J. Hauck, H. Hellmer, H. Herata, M. Hoppema, E. Isla, K. Jerosch, S. Kaiser, P. Koubbi, K.-H. Kock, R. Krause, G. Kuhn, P. Lemke, A. Liebschner, K. Linse, H. Miller, K. Mintenbeck, U. Nixdorf, H. Pehlke, A. Post, M. Schröder, K.V. Shust, S. Schwegmann, V. Siegel, V. Strass, K. Thomisch, R. Timmermann, P.N. Trathan, A. van de Putte, J. van Franeker, I.C. van Opzeeland, H. von Nordheim and T. Brey
WG-EMM-16/02	Scientific background document in support of the development of a CCAMLR MPA in the Weddell Sea (Antarctica) – Version 2016 – Part B: Description of available spatial data K. Teschke, H. Pehlke and T. Brey on behalf of the German Weddell Sea MPA (WSMPA) project team, with contributions from the participants at the International Expert Workshop on the WSMPA project (7–9 April 2014, Bremerhaven)
WG-EMM-16/03	Scientific background document in support of the development of a CCAMLR MPA in the Weddell Sea (Antarctica) – Version 2016 – Part C: Data analysis and MPA scenario development K. Teschke, H. Pehlke, M. Deininger and T. Brey on behalf of the German Weddell Sea MPA project team
WG-EMM-16/04	Quantifying the escape mortality of trawl caught Antarctic krill (*Euphausia superba*) B.A. Krafft, L.A. Krag, A. Engås, S. Nordrum, I. Bruheim and B. Herrmann
WG-EMM-16/05	Reporting procedures for the continuous fishing method O.R. Godø and T. Knutsen
WG-EMM-16/06	Use of net cable in monitoring trawl and marine organisms during operations O.R. Godø

WG-EMM-16/07	Draft: Krill Fishery Report 2016 Secretariat
WG-EMM-16/08	CEMP data inventory and summary analysis Secretariat
WG-EMM-16/09	A spatial analysis of CEMP data in Area 48 to support work on feedback management in the krill fishery Secretariat
WG-EMM-16/10	An initial examination of using CPUE as a fishery performance index for the krill fishery Secretariat
WG-EMM-16/11	Observer coverage in CCAMLR krill fisheries from 2011 to 2015 Secretariat
WG-EMM-16/12	Plans for the Joint SC-CAMLR and SC-IWC Workshop 2017–2018 S. Kawaguchi and T. Kitakado (Co-conveners of the Joint SC-CAMLR and SC-IWC Workshop)
WG-EMM-16/13 Rev. 1	Preliminary report on SO-AntEco (South Orkneys – State of the Antarctic Ecosystem) benthic survey (JR15005) around the South Orkney Plateau (February–March 2016) H. Griffiths, S. Grant, K. Linse, P. Trathan and the SO-AntEco scientific team
WG-EMM-16/14	Report on the Second SCAR Retrospective Analysis of Antarctic Tracking Data Workshop Delegation of the United Kingdom
WG-EMM-16/15	High-resolution ocean modelling of the South Georgia and South Orkney Islands regions E. Young, E. Murphy and P. Trathan
WG-EMM-16/16	Start date of the CCAMLR fishing season for Antarctic krill P. Trathan and S. Hill
WG-EMM-16/17	Spatial aggregation of harvesting in Subarea 48.1, in particular during the summer and close to the coast P. Trathan and S. Hill
WG-EMM-16/18	Possible options for the future management of the Antarctic krill fishery in Subarea 48.2 P. Trathan, O.R. Godø and S. Hill

WG-EMM-16/19	Preliminary report on the South Orkneys Ecosystem Studies (SOES) field work undertaken by RRS *James Clark Ross* (JR15004) and associated field camps in January–February 2016 J. Watkins, O.R. Godø, S. Fielding, C. Reiss, P. Trathan and E. Murphy
WG-EMM-16/20	A first assessment of marine Important Bird and Biodiversity Areas for penguins in Subarea 48.1 (Antarctic Peninsula, and South Shetland Islands) and Subarea 48.2 (South Orkney Islands) K. Lorenz, C. Harris, B. Lascelles, M. Dias and P. Trathan
WG-EMM-16/21	Is current management of the Antarctic krill fishery in the Atlantic sector of the Southern Ocean precautionary? S. Hill, A. Atkinson, C. Darby, S. Fielding, B. Krafft, O.R. Godø, G. Skaret, P. Trathan and J. Watkins
WG-EMM-16/22	Integrating Climate and Ecosystem Dynamics in the Southern Ocean (ICED) programme: developing links between ICED and CCAMLR E. Murphy, R. Cavanagh, N. Johnston, E. Hofmann and A. Constable
WG-EMM-16/23	Classification of Southern Ocean krill and icefish echoes using Random Forests N. Fallon, S. Fielding and P. Fernandes
WG-EMM-16/24	By-catch of morid cods (Gadiformes: Moridae) in the CCAMLR area and adjacent areas during commercial fishing and research surveys Delegation of the Russian Federation
WG-EMM-16/25	Lipid metabolism features of Antarctic toothfish *Dissostichus mawsoni* (Nototheniidae) I.I. Gordeev, D.V. Mikryakov, N.I. Silkina and A.S. Sokolova
WG-EMM-16/26	Temporal changes in sighting density indices of baleen whales in CCAMLR Subareas 48.1 and 48.2 based on three circumpolar sighting surveys L.A. Pastene and T. Hakamada
WG-EMM-16/27	Establishing time-limited Special Areas for Scientific Study in newly exposed marine areas following ice shelf retreat or collapse in Subarea 48.1, Subarea 48.5 and Subarea 88.3 – Clarifications and options to further develop the 2015 proposal S. Grant and P. Trathan

WG-EMM-16/28	Using predators and their prey to characterise the status of the marine ecosystem at South Georgia P. Trathan, S. Fielding, S. Hill, M. Belchier and J. Forcada
WG-EMM-16/29	Monitoring variability and change in the plankton communities of the Scotia Sea through Continuous Plankton Recorder surveys G.A. Tarling, M.Z. Wootton, D.G. Johns, T.D. Jonas, E.J. Murphy and P. Ward
WG-EMM-16/30	Co-conveners' report of the Joint CEP–SC-CAMLR Workshop on Climate Change and Monitoring – Introduction for WG-EMM-16 S. Grant and P. Penhale (Co-conveners of the Joint CEP–SC-CAMLR Workshop)
WG-EMM-16/31	Diet composition of Antarctic toothfish caught in Divisions 58.4.1 and 58.4.2 in 2014/15 inferred from fatty acid stable isotope analyses Delegation of the Republic of Korea
WG-EMM-16/32	Microbial study of toothfish tissue in Divisions 58.4.1 in 2014/15 Delegation of the Republic of Korea
WG-EMM-16/33	Metabarcoding analysis of zooplankton collected from Division 58.4.1 in 2014/15 using NGS platform Delegation of the Republic of Korea
WG-EMM-16/34	Third International Symposium on Krill Secretariat
WG-EMM-16/35	Identification of important benthic areas for conservation – using shared data from the Domain 1 MPA planning process M. Bristow, S. Grant, M. Santos and A. Capurro
WG-EMM-16/36	Southern Ocean Network of Acoustics (SONA): Report on Acoustic Processing and Methods Workshop, Vigo, 24 and 25 April 2016 S. Fielding, J. Thomas, C. Anderson, A. Conchon, A. Cossio, A. Dunford, P. Escobar-Flores, J. Horne, T. Jarvis, R. Kloser and T. Ryan
WG-EMM-16/37	A bioenergetics model assessment of the prey consumption of macaroni penguins in Subarea 48.3 P.N. Trathan, L. Emmerson, C. Southwell and C. Waluda
WG-EMM-16/38	A condensed history and document of the method used by CCAMLR to estimate krill biomass (B_0) in 2010 S. Fielding, A. Cossio, M. Cox, C. Reiss, G. Skaret, D. Demer, J. Watkins and X. Zhao

WG-EMM-16/39	Some aspects of spatial–temporal variability of hydrodynamic water circulation and krill distribution in the Scotia Sea S.M. Kasatkina and V.N. Shnar
WG-EMM-16/40	Integrated analysis of the krill fishery in Area 48 (2006–2015) S. Kasatkina, P. Gasyukov and L. Boronina
WG-EMM-16/41	Analysis of the krill spatial distribution characteristics as the important factor in fishery management in Area 48 (report of the CCAMLR scholarship recipient) S.M. Kasatkina and A. Sytov
WG-EMM-16/42	Atlas of top predators from French Southern Territories in the southern Indian Ocean K. Delord, C. Barbraud, C.-A. Bost, Y. Cherel, C. Guinet and H. Weimerskirch
WG-EMM-16/43	Ecoregionalisation of the Kerguelen and Crozet Islands oceanic zone. Part I: Introduction and Kerguelen oceanic zone P. Koubbi, C. Guinet, N. Alloncle, N. Ameziane, C.S. Azam, A. Baudena, C.A. Bost, R. Causse, C. Chazeau, G. Coste, C. Cotté, F. D'Ovidio, K. Delord, G. Duhamel, A. Forget, N. Gasco, M. Hautecœur, P. Lehodey, C. Lo Monaco, C. Marteau, A. Martin, C. Mignard, P. Pruvost, T. Saucède, R. Sinegre, T. Thellier, A.G. Verdier and H. Weimerskirch
WG-EMM-16/44	Background papers considered relevant to the WG-EMM discussions on feedback management Delegation of the United Kingdom
WG-EMM-16/45	Background information to support development of a feedback management strategy for the krill fishery in Subarea 48.1 Antarctic Ecosystem Research Division, Southwest Fisheries Science Center and NOAA Fisheries
WG-EMM-16/46	Downward adjustments to local catch limits for the krill fishery in Subarea 48.1 Antarctic Ecosystem Research Division, Southwest Fisheries Science Center and NOAA Fisheries
WG-EMM-16/47	Upward adjustments to local catch limits for the krill fishery in Subarea 48.1 Antarctic Ecosystem Research Division, Southwest Fisheries Science Center and NOAA Fisheries
WG-EMM-16/48	A feedback management strategy for the krill fishery in Subarea 48.1 G.M. Watters, J.T. Hinke and C.S. Reiss

WG-EMM-16/49	A brief review of information relevant to the establishment of a Krill Research Zone within the proposed Ross Sea Region Marine Protected Area E.S. Klein and G.M. Watters
WG-EMM-16/50	Population status of Ross Sea killer whales (*Orcinus orca*, Type C) in McMurdo Sound, Antarctica, based on photo-identification studies R. Pitman, H. Fearnbach and J.W. Durban
WG-EMM-16/51	Density and geographical distribution of krill larvae on the Weddell–Scotia Confluence region during summer 2011 E. Rombolá, C. Franzosi, G. Tossonotto, V. Alder and E. Marschoff
WG-EMM-16/52	Spatio–temporal dynamics of Antarctic krill fishery: identification of fishing hotspots F. Santa Cruz, B. Ernst and J.A. Arata
WG-EMM-16/53	Preliminary modelling of potential climate-change impacts on krill and a krill-dependent predator in CCAMLR Subareas 48.1 to 48.3 E.S. Klein, S.L. Hill, G.M. Watters and J.T. Hinke
WG-EMM-16/54	Ecoregionalisation of the Kerguelen and Crozet Islands oceanic zone. Part II: The Crozet oceanic zone P. Koubbi, C. Mignard, R. Causse, O. Da Silva, A. Baudena, C. Bost, C. Cotté, F. D'Ovidio, A. Della Penna, K. Delord, S. Fabri-Ruiz, M. Ferrieux, C. Guinet, C. Lo Monaco, T. Saucède and H. Weimerskirch
WG-EMM-16/55	CEMP camera installations by Ukraine at the Galindez, Petermann and Yalour Islands penguin colonies as a part of CEMP Fund project ‘Establishing a CEMP camera network in Subarea 48.1’ Delegation of Ukraine
WG-EMM-16/56	On interim distribution of the trigger level in the fishery for *Euphausia superba* in Statistical Subareas 48.1, 48.2, 48.3 and 48.4 G. Milinevskyi and K. Demianenko
WG-EMM-16/57	The proposal of Availability Index to summarise the availability of harvested resources K. Demianenko and G. Milinevskyi

WG-EMM-16/58	Progress report of the CEMP camera network in Subarea 48.1 J. Hinke, G. Watters, M. Santos, M. Korczak-Abshire, G. Milinevsky, A. Barbos, C. Southwell and L. Emmerson
WG-EMM-16/59	The effect of abiotic factors on the reproduction of seabirds on the Argentine Islands I.V. Dykyy
WG-EMM-16/60	Biomass of Antarctic krill around South Shetland using 2-dB difference method in April 2016 Delegation of the Republic of Korea
WG-EMM-16/61	A study on calibration for commercial echosounder using the bottom backscattering strength from a fishing vessel near the South Shetland Islands in Antarctic Delegation of the Republic of Korea
WG-EMM-16/62	Report on the monitoring program of chinstrap and gentoo penguins at Narębski Point (ASPA No. 171), King George Island, since 2006 Delegation of the Republic of Korea
WG-EMM-16/63	Proposed amendments to Conservation Measure 51-06 (2014) General measure for scientific observation in fisheries for *Euphausia superba* K. Demianenko, L. Pshenichnov and G. Milinevskyi
WG-EMM-16/64	Cetaceans as indicators of historical and current changes in the East Antarctica ecosystem Y. Fujise and L.A. Pastene
WG-EMM-16/65	Krill consumption by Adélie penguins in CCAMLR Divisions 58.4.1 and 58.4.2 C. Southwell and L. Emmerson
WG-EMM-16/66	Krill consumption by crabeater seals in CCAMLR Divisions 58.4.1 and 58.4.2 C. Southwell, J. Forcada, L. Emmerson, A. Constable, S. Kawaguchi and P. Trathan
WG-EMM-16/67	Current work towards estimating krill consumption by flying seabirds in CCAMLR Divisions 58.4.1 and 58.4.2 L. Emmerson and C. Southwell
WG-EMM-16/68	Progress by WG-EMM-STAPP in estimating krill consumption by air-breathing predators within CCAMLR areas C. Southwell and P. Trathan

WG-EMM-16/69	A method for spreading the risk of localised effects of catches of Antarctic krill up to the trigger level, during the development of stage 2 of feedback management A.J. Constable, S. Kawaguchi and M. Sumner
WG-EMM-16/70	An introduction to the Southern Ocean Observing System (Paper XP18 to CEP–SC-CAMLR Workshop 2016) A.J. Constable, L. Newmman, O. Schofield, A. Wahlin and S. Swart
WG-EMM-16/71	SC-CAMLR work on Climate Change (Paper XP19 to CEP–SC-CAMLR Workshop 2016) A. Constable
WG-EMM-16/72 Rev. 1	Summary of notifications for krill fisheries in 2016/17 Secretariat
WG-EMM-16/73	Domain 1 MPA designation process: data sharing and future enhanced work M. Santos, A. Capurro and C.A. Cárdenas
WG-EMM-16/74	Using data recorded during commercial krill fishing in feedback management O.R. Godø, G. Skaret and E. Niklitschek
WG-EMM-16/75	Multiyear changes in distribution and abundance of *Salpa thompsoni* in the Western Antarctic Peninsula region A. Panasiuk, A. Słomska, J. Wawrzynek, M. Konik and A. Weydmann
WG-EMM-16/76	Acoustic monitoring and evaluation of krill in the Antarctic ecosystem Bransfield Strait and around Elephant Island during ANTAR XXI and XXII, aboard RV *Humboldt*, Peru R. Cornejo, M. Flores and J. Zuzunaga

Other Documents

WG-EMM-16/P01	Vast assembly of vocal marine mammals from diverse species on fish spawning ground D. Wang, H. Garcia, W. Huang, D.D. Tran, A.D. Jain, D.H. Yi, Z. Gong, J.M. Jech, O.R. Godø, N.C. Makris and P. Ratilal *Nature*, 531 (2016), doi: 10.1038/nature16960

WG-EMM-16/P02	Detection of growth zones in the eyestalk of the Antarctic krill *Euphausia superba* (Dana, 1852) (Euphausiacea) B.A. Krafft, M. Kvalsund, G. Søvik, E. Farestveit and A.-L. Agnalt *J. Crust. Biol*., 36 (3) (2016): 267–273, doi: 10.1163/1937240X-00002428
WG-EMM-16/P03	South Orkney Island 2016 Antarctic krill and ecosystem monitoring B.A. Krafft, G. Skaret, L.A. Krag, T. Rustand and R. Pedersen Institute of Marine Research Report, 20 (2016): www.imr.no/filarkiv/2016/05/antarctic_krill_survey_at_south_orkney_islands_2016.pdf/nb-no
WG-EMM-16/P04	Growth and shrinkage in Antarctic krill *Euphausia superba* is sex-dependent G. Tarling, S. Hill, H. Peat, S. Fielding, C. Reiss and A. Atkinson *Mar. Ecol. Prog. Ser*., 547 (2016): 61–78
WG-EMM-16/P05	Parasites of the Antarctic toothfish (*Dissostichus mawsoni* Norman, 1937) (Perciformes, Nototheniidae) in the Pacific sector of the Antarctic I.I. Gordeev and S.G. Sokolov *Polar Res*., 35 (2016): 29364, http://dx.doi.org/10.3402/polar.v35.29364
WG-EMM-16/P06	Southern right whale (*Eubalaena australis*) reproductive success is influenced by krill (*Euphausia superba*) density and climate E. Seyboth, K.R. Groch, L. Dalla Rosa, K. Reid, P.A.C. Flores and E.R. Secchi *Sci. Rep*., 6 (2016): 28205, doi: 10.1038/srep28205
WG-EMM-16/P07	Population trends and reproductive success at a frequently visited penguin colony on the western Antarctic Peninsula H.J. Lynch, W.F. Fagan and R. Naveen *Polar Biol*., 33 (2010): 493–503, doi: 10.1007/s00300-009-0726-y
WG-EMM-16/P08	Mapping Application for Penguin Populations and Projected Dynamics (MAPPPD): Data and tools for dynamic management and decision support G.R.W. Humphries, C. Che-Castaldo, R. Naveen, M. Schwaller, P. McDowall, M. Schrimpf and H.J. Lynch *Polar Rec*. (in review)

WG-EMM-16/P09	Linking population trends of Antarctic shag (*Phalacrocorax bransfieldensis*) and fish at Nelson Island, South Shetland Islands (Antarctica) R. Casaux and E. Barrera-Oro *Polar Biol*., (2015), doi: 10.1007/s00300-015-1850-5
WG-EMM-16/P10	A bioenergetics model for estimating prey consumption by an Adélie penguin population in east Antarctica D. Southwell, L. Emmerson, J. Forcada and C. Southwell *Mar. Ecol. Prog. Ser*., 526 (2015): 183–197, doi: 10.103354/meps11182
WG-EMM-16/P11	Developing priority variables ("ecosystem Essential Ocean Variables" – eEOVs) for observing dynamics and change in Southern Ocean ecosystems A.J. Constable, D.P. Costa, O. Schofield, L. Newman, E.R. Urban Jr., E.A. Fulton, J. Melbourne-Thomas, T. Ballerini, P.W. Boyd, A. Brandt, W. de la Mare, M. Edwards, M. Eléaume, L. Emmerson, K. Fennel, S. Fielding, H. Griffiths, J. Gutt, M.A. Hindell, E.E. Hofmann, S. Jennings, H.S. La, A. McCurdy, B.G. Mitchell, T. Moltmann, M. Muelbert, E. Murphy, T. Press, B. Raymond, K. Reid, C. Reiss, J. Rice, I. Salter, D.C. Smith, S. Song, C. Southwell, K.M. Swadling, A. Van de Putte and Z. Willis *J. Mar. Sys*., 161 (2016): 26–41
WG-EMM-16/P12	Distribution, density and relative abundance of Antarctic krill estimated by maximum likelihood geostatistics on acoustic data collected during commercial fishing operations E.J. Niklitschek and G. Skaret *Fish. Res*., 178 (2016): 114–121, http://dx.doi.org/10.1016/j.fishres.2015.09.017 0165-7836
WG-EMM-16/P13	Demographic effects of extreme weather events: snow storms, breeding success, and population growth rate in a long-lived Antarctic seabird S. Descamps, A. Tarroux, Ø. Varpe, N.G. Yoccoz, T. Tveraa and S.-H. Lorentsen *Ecology and Evolution*, (2014), doi: 10.1002/ece3.1357
WG-EMM-16/P14	Large-scale oceanographic fluctuations drive Antarctic petrel survival and reproduction S. Descamps, A. Tarroux, S.-H. Lorentsen, O.P. Love, Ø. Varpe and N.G. Yoccoz *Ecography*, 39 (2016): 496–505, doi: 10.1111/ecog.01659

WG-EMM-16/P15	At-sea distribution and prey selection of Antarctic petrels and commercial fisheries S. Descamps, A. Tarroux, Y. Cherel, K. Delord, O.R. Godø, A. Kato, B.A. Krafft, S.-H. Lorentsen, Y. Ropert-Coudert, G. Skaret and Ø. Varpe *PLoS ONE* (2016) (in press)
WG-EMM-16/P16	Size and stage composition of age class 0 Antarctic krill (*Euphausia superba*) in the ice-water interface layer during winter/early spring F. Schaafsma, C. David, E. Pakhomov, B. Hunt, B. Lange, H. Flores, J.A. van Franeker *Polar Biol*., (2016), doi: 10.1007/s00300-015-1877-7
WG-SAM-16/36 Rev. 1	The integrated krill assessment model for Subarea 48.1 with future catches meeting alternative decision rules D. Kinzey, G.M. Watters and C.S. Reiss
WG-SAM-16/37	Independent peer review of an integrated stock assessment model for Antarctic krill (*Euphausia superba*) conducted by the Center for Independent Experts J. Rusin, D. Kinzey and G. Watters
WG-SAM-16/38	Preliminary results of a dedicated cetacean sighting vessel-based krill survey in East Antarctica (115°–130°E) during the 2015/16 austral summer season K. Matsuoka, A. Wada, T. Isoda, T. Mogoe and L.A. Pastene
WG-SAM-16/39	Using effective sample sizes to evaluate the efficiency of length samples collected by at-sea observers in the krill fishery in Subarea 48.1 N. Kelly, S. Kawaguchi, P. Ziegler and D. Welsford

Recommendations to the Conservation Measure 51-07 WG-EMM review e-group in respect of initial risk assessments to review Conservation Measure 51-07

1. The Working Group recommended that the Conservation Measure 51-07 WG-EMM review e-group provide guidance to Members conducting initial risk assessments to review CM 51-07, on all issues identified in this appendix. The e-group should also provide guidance on issues identified in paragraph 2.234.

2. The Working Group also recommended that Members conducting initial risk assessments for consideration at the 2016 meeting of WG-FSA prioritise two points:

(i) the assembly of data layers contributing to the factors describing spatial patterns for krill, predators and the fishery based on available data as follows:

(a) use the ‘factors’, ‘quantities’, datasets and scaling parameters identified in WG-EMM-16/69 as a starting point for their work

(b) evaluate scenarios with fishing patterns indexed from data collected or reported during the most recent three years (this would be considered the current fishing pattern), data collected or reported during 10-year periods prior to the current fishing pattern (these would be considered historical fishing patterns), and projections of how the fishing pattern may change over the coming five years

(c) consider historical fishing patterns that are indexed by the maximum value of fishing effort or catch achieved within each spatial unit over the time period examined in the risk assessment

(d) consider the spatial density of fishing operations, as indicated by separate analyses of haul-by-haul data, to define both the historical and current fishing patterns

(e) consider using the relative importance of each spatial unit to the reproductive performance of krill throughout Area 48 as a ‘factor’ in the risk assessment

(f) consider indexing the values of spatial units as sources or sinks for krill using information from particle-tracking studies

(g) consider the use of krill habitat variables such as those described by Silk et al. (2016) and a ‘factor’ that indexes primary production (e.g. using satellite data)

(h) consider using predator occupancy data (e.g. data derived from at-sea observations or predator-tracking studies) if estimates of predator demand are found to be unsuitable

(ii) the development of means of communication and use of language that is clear and understandable at the commission level.

Reference

Silk, J.R.D., S.E. Thorpe, S. Fielding, E.J. Murphy, P.N. Trathan, J.L. Watkins and S.L. Hill. 2016. Environmental correlates of Antarctic krill distribution in the Scotia Sea and southern Drake Passage. *ICES J. Mar. Sci*., doi:10.1093/icesjms/fsw097.

Details of how the US AMLR Program has addressed the advice from WG-EMM-15 in relation to the feedback management (FBM) approach for Subarea 48.1

(G. Watters, C. Reiss, J. Hinke, M. Goebel, E. Klein, A. Dahood and D. Krause)

1. In order to help progress future work related to the proposed feedback management (FBM) approach for Subarea 48.1, representatives from the US AMLR program developed the following tables describing how they had addressed the extensive advice from WG-EMM-15 (Table 1) and a list describing how CCAMLR could address advice provided by WG-EMM-15 and WG-EMM-16 (Table 2) (see paragraph 2.281).

Table 1: Progress in addressing advice from WG-EMM-15, this table includes references to papers submitted to WG-EMM-16 or elsewhere; some references include a 'V' to indicate individual 'vignettes' within those papers.

Advice from WG-EMM-15	Issue	Progress and notes	Papers submitted to WG-EMM-16 or elsewhere
Table 2 – Estimation of base catch limit	The integrated model and its diagnostics to be reviewed by WG-SAM.	Diagnostics reviewed by WG-FSA-15 and model reviewed by WG-SAM-16. Model is not currently considered suitable to provide advice. The stage 2 proposal in WG-EMM-16/48 does not require catch limits to be estimated from an integrated model. Rather, the proposal in WG-EMM-16/48 can be adapted to use catch limits estimated from an integrated model when those estimates become available.	WG-SAM-16/36 Rev. 1, WG-SAM-16/37
	Revise decision rules for krill.	Alternative approaches to estimate the reference biomass used in decision rules for krill have been presented to WG-EMM-15 and WG-SAM-16. Discussion on this issue has been limited and neither working group has agreed to revise the reference biomass. The stage 2 proposal in WG-EMM-16/48 does not require catch limits to be estimated from an integrated model. Rather, the proposal in WG-EMM-16/48 can be adapted to use catch limits estimated from an integrated model when those estimates become available.	WG-SAM-16/36 Rev.1, WG-SAM-16/37

(continued)

Table 1 (continued)

Advice from WG-EMM-15	Issue	Progress and notes	Papers submitted to WG-EMM-16 or elsewhere
	Identify data required from the krill fishery (e.g. standardised acoustic transects and net hauls).	SG-ASAM provided guidance on standard transects for Subarea 48.1 in 2015 (SC-CAMLR-XXXIV, Annex 4, Figure 1). WG-EMM-16/48 identified additional candidate transects near Anvers Island, Joinville Island and in the Gerlache Strait for gSSMU 4. Transects for the Antarctic Peninsula Pelagic Area SSMU are also proposed in WG-EMM-16/48. The stage 2 proposal in WG-EMM-16/48 does not require that echosounders on fishing vessels be calibrated if those vessels repeat surveys in a standardised fashion.	WG-EMM 16/47 V2, WG-EMM-16/48
	Integration of additional data available for assessment (e.g. krill length-frequency data from CEMP).	Contingent on progress on the development of the integrated model.	
Table 2 – Decision rule to adjust catches up from the base	Design acoustic surveys to be undertaken by fishing vessels.	WG-EMM-16/47 V2 demonstrated how repeat surveys on standardised transects could provide biomass indices necessary to determine local biomass trends of krill.	WG-EMM-16/47 V2
	Define CEMP indicators to be used as ‘traffic lights’ in decision rule, including threshold values that determine whether an indicator is ‘green’ (upward adjustment possible) or ‘red’ (upward adjustment not possible).	WG-EMM-16/47 V1 provided an analysis of CEMP datasets derived from penguin and fur seal studies in Subarea 48.1. Identification of red or green light conditions is informed by a threshold value of standardised predator performance that is determined from a meta-analysis of CEMP parameters provided in WG-EMM-16/45 V7.	WG-EMM-16/45 V7, WG-EMM-16/47 V1
	Determine the level of adjustment that would be applied (e.g. the increase in catch would be proportional to increased density observed during fishing vessel surveys).	WG-EMM-16/47 V2 provided an analysis of the use of simple ratios of biomass that are estimated from surveys, on standardised transects that are repeated during the course of the fishery.	WG-EMM-16/47 V2
	Evaluation of decision rule.	WG-EMM-16/47 V3 provided an evaluation of a decision rule to adjust catches up. Retrospective analyses of historical data in Subarea 48.1 suggest that ‘adjust up’ conditions would have occurred roughly 33% of the time.	WG-EMM-16/47 V3

(continued)

Table 1 (continued)

Advice from WG-EMM-15	Issue	Progress and notes	Papers submitted to WG-EMM-16 or elsewhere
Table 2 – Decision rule to adjust catches down from the base	Identify appropriate groups of SSMUs from penguin tracking data.	WG-EMM-16/45 V1 provided justification for four candidate SSMU groupings.	WG-EMM-16/45 V1
	Determine default 'allocation factors' for groups of SSMUs.	Several candidate allocation fractions have been identified. WG-EMM-16/45 V8 provided three candidate options. WG-EMM-16/48 also identified a 'default' static allocation but suggested that an assessment-based allocation for the four groups of SSMUs would ultimately be preferable.	WG-EMM-16/45 V8, WG-EMM-16/48
	Parameterise species-specific decision rules for adjusting catch on the basis of fledging mass and age at crèche.	A decision rule for adjusting catches down has been proposed in WG-EMM-16/46 V6. The rule is based on age-at crèche and is not species specific. Rather, the rule proposed to use the minimum standardised mean age at crèche across all species considered to adjust catches. The analysis that used to support age at crèche as the primary indicator is provided in WG-EMM-16/46 V2.	WG-EMM-16/46 V2, WG-EMM-16/46 V6
	Evaluation of decision rule.	WG-EMM-16/46 V4 provided an evaluation of a decision rule to adjust catches down. Retrospective analyses of historical data in Subarea 48.1 suggest that 'adjust down' conditions would have occurred roughly 30−40% of the time.	WG-EMM-16/46 V4
Paragraphs 2.140(i–iii), 2.160(i), 2.161(v)(f)	Consider krill flux, including the implications of krill behaviour, and evaluate krill biomass relationships between SSMUs.	Circulation within Subarea 48.1 was considered using drifter data and particle transport simulations from a ROMS. The krill fishery appears to target krill that occur in retentive areas, and foraging predators overlap with the krill fishery therein. Comparison of Palmer LTER and US AMLR time-series data on krill indicate coherent variation in krill abundance throughout Subarea 48.1, suggesting that sources of krill within the subarea will not always provide abundant krill to replace those that die in the retentive areas. Krill generally tend to migrate towards the coast in winter.	WG-EMM-16/45 V2, WG-EMM-16/47 V2

(continued)

Table 1 (continued)

Advice from WG-EMM-15	Issue	Progress and notes	Papers submitted to WG-EMM-16 or elsewhere
Paragraphs 2.147, 2.160(i), 2.161(iii)	Evaluate CPUE in relation to krill density, including whether SSMU-scale krill surveys indicate the proportion of krill vulnerable to the fishery. Assess whether CPUE is useful for quantifying variability and trends in SSMU-scale krill biomass.	Nominal CPUEs of the krill fishery have been compared to local biomass estimates from surveys conducted by the US AMLR Program. Clear relationships between nominal CPUE and research survey biomass estimates were not identified. Given the completely uncoordinated 'sampling designs' by the fishery and the US AMLR Program, it seems that substantially more complicated methods (e.g. an integrated assessment model) are needed to link fishery data to data from research cruises. Available data do indicate, however, that research vessels generally catch krill over a wider range of sizes than are caught by the fishery, with smaller krill more likely to be caught during research surveys.	WG-EMM-16/45 V3
Paragraph 2.152(i)	Develop indicator of fishery performance using sea-ice imagery.	Analyses of sea-ice imagery and fishing activities in Subarea 48.1 indicate that fishing activities are reduced when sea-ice coverage reaches about 30% and may be stopped altogether when coverage reaches about 50%. Retrospective analyses of the decision rules proposed in WG-EMM-16/48 indicate that sea-ice coverage will mediate the amount of krill that is ultimately taken by the fishery when a stage 2 strategy is implemented in Subarea 48.1. Note also that, inter alia, sea-ice coverage was considered as a component of a fishery-specific 'availability index' proposed in WG-EMM-16/57, and the Working Group considered this index in the context of discussions on CM 51-07.	WG-EMM-16/45 V4, WG-EMM-16/48
Paragraphs 2.137(iv), 2.160(iii), 2.161(v)(a)	Examine predator–fishery overlap at different temporal and spatial scales.	Predator-tracking and fishery data indicate overlap at a range of temporal and spatial scales. In general, overlap increases with increasing temporal and spatial scale. Tracking data from two CEMP sites in the South Shetland Islands indicate particularly high overlap in the Bransfield Strait and on the continental shelf north of Livingston Island. In general, overlap occurs in areas where krill are retained, which are areas where fishery 'hot spots' have been identified (WG-EMM-16/52).	WG-EMM-16/45 V5

(continued)

Table 1 (continued)

Advice from WG-EMM-15	Issue	Progress and notes	Papers submitted to WG-EMM-16 or elsewhere
Paragraphs 2.107, 2.135(iv), 2.143(ii–iv), 2.160(iv), 2.161(v–vi), 2.214	Explore and characterise functional relationships between krill and krill predators, including the effects of current fishing activities on krill-dependent predators.	A functional relationship between the magnitude of local krill biomass and penguin performance is indicated, with performance expected to be low when local krill biomass is in the order of 104 tonnes; high performance is expected when local krill biomass is in the order of 106 tonnes. A weaker functional relationship between local krill biomass and performance of Antarctic fur seals is indicated. An analysis of penguin performance in relation to local exploitation rates of krill indicates plausible impacts of locally concentrated krill fishing, with lower performance when the difference in orders of magnitude between local biomass and reported catch is less than, or equal to, one.	WG-EMM-16/45 V6, V7
Paragraph 2.137(viii)	Consider using krill consumption by predators within different SSMUs as a basis for distributing catch limits.	Previous work considered by WG-EMM (e.g. Hill et al., 2007) provided estimates of krill consumption in each SSMU. There have been no updates of these estimates, and they have been used to indicate an alternative basis for distributing catches among groups of SSMUs. It is acknowledged that previous modelling work (e.g. Plagányi and Butterworth, 2012; Watters et al., 2013) indicated that using estimates of krill consumption as the basis for distributing catch limits would lessen risks to krill-dependent predators but increase risks to fishery performance.	WG-EMM-16/45 V8

(continued)

Table 1 (continued)

Advice from WG-EMM-15	Issue	Progress and notes	Papers submitted to WG-EMM-16 or elsewhere
Paragraphs 2.143(i), 2.148(iii), 2.160(v)	Examine predator performance during ‘critical years’ and improve understanding of how CEMP indices might be related to changes in abundance over the long term.	A model of Adélie penguin population dynamics has been fitted to available band-resight data; this model was then used to simulate population growth rates under different scenarios with initial perturbations that negatively affect survival followed by longer-term conditions in which survival is purposefully tuned to promote population growth. Results indicate that weak recruitment during the initial perturbations can have long-term impacts on population growth rates. Thus, it is possible to use the results to identify the recruitment rates needed for population maintenance. Any CEMP index that can reliably predict recruitment in advance can thus be used in a management strategy that aims to maintain resilience of penguin populations. Complementary, but separate, results from an analysis of data collected during long-term banding and breeding phenology studies demonstrate that age at crèche can usefully predict cohort strength of penguins, with cohorts composed of birds crèching at relatively young ages likely to be relatively weak. The stage 2 strategy proposed in WG-EMM-16/48 thus includes a decision rule parameterised to adjust local catch limits when observations of mean age at crèche lead to expectations of weak penguin cohorts.	WG-EMM-16/46 V1, V2, V4
Paragraphs 2.151(iii), 2.156, 2.170, 2.185, 2.211	Development of standard camera-based methods to collect CEMP-related indices of predator performance as effective alternatives or complements to existing standard methods, including image analysis and comparison to existing standard methods.	Methods to analyse nest-level photographic observations of breeding success and chronology have been developed, and initial work to compare photo-based estimates of breeding success and chronology to estimates based on CEMP Standard Methods A6 and A9 has been conducted. Results indicate that photo-based estimates of breeding success and chronology are comparable to those made with the standard methods. With support from the CEMP Fund, six Members have established a CEMP camera network in Subarea 48.1. The network has nodes that are distributed throughout the subarea and can observe several hundred penguin nests, with Adélie, chinstrap and gentoo penguins all being observed.	WG-EMM-16/46 V3

(continued)

Table 1 (continued)

Advice from WG-EMM-15	Issue	Progress and notes	Papers submitted to WG-EMM-16 or elsewhere
Paragraphs 2.109, 2.110, 2.164(i)	Parameterise one or more decision rules for a stage 2 strategy, including specifying thresholds, acceptable probabilities that these thresholds are exceeded and the nature and level of adjustment that would occur through application of the rules. The expected consequences of applying these rules should be quantified in terms of risks, mean effects and variability in the effects, including the consequences for catches. The consequences of applying the decision rules can be evaluated using retrospective analyses in the short term and management strategy evaluations (MSEs) in the long term.	Retrospective analyses of three decision rules have been completed: a marginal rule to decrease local catch limits, a marginal rule to increase local catch limits, and a combined rule that can be used to both decrease and increase local catch limits. The marginal retrospective analyses indicate that the rules for downward and upward adjustment would, if implemented separately, lead to adjustments about 30–40% of the time. Results from the retrospective analysis of the combined decision rule indicate that downward adjustments to catch limits would have been made about half the time and upward adjustments would have been made up to 10% of the time. The expected value of applying the combined decision rule (including proposed, initial catch limits of 100 000 tonnes each in the Bransfield Strait and the combined coastal SSMUs north of the South Shetland Islands) has been estimated as 163 000 tonnes, and the variance in adjusted catches is less than, or equal to, the variance in actual catches.	WG-EMM-16/46 V4, WG-EMM-16/47 V3, WG-EMM-16/48
Paragraphs 2.109, 2.135(iii), 2.148(i–ii), 2.170, 2.214	Evaluation of CEMP data to detect temporal and spatial variations in predator performance, including as they relate to krill availability and how CEMP data can be aggregated across sites, species, etc.	The stage 2 strategy proposed in WG-EMM-16/48 utilises CEMP data from multiple sites and species to possibly increase local catch limits. The CEMP data were standardised and then an average value of all CEMP indices of performance during the breeding season and relevant to a group of SSMUs (where the location of the CEMP site determines its relevance to a group of SSMUs) is used as an overall index of performance. A separate analysis of covariation among CEMP indices collected in Subarea 48.1, summarised as CSIs, suggested an increased level of concordance in the period since 2008 (WG-EMM-16/09).	WG-EMM-16/47 V1
Paragraphs 2.109, 2.150, 2.164(iii), 2.168, 2.169, 2.225, 2.230	Consider the use of fishing vessels to collect data for use in stage 2, including undertaking krill surveys to assess within-season dynamics of krill and providing data to SG-ASAM to aid survey design and analysis.	Fishing vessel acoustic data were not submitted to SG-ASAM-16. As an alternative, acoustic data from the US AMLR Program were analysed, and results from this analysis suggest that fishing vessels could potentially track within-season changes in krill biomass by conducting repeat surveys of two transect lines.	WG-EMM-16/47 V2

Table 2: Description of how CCAMLR can address future work on implementing FBM in Subarea 48.1. Each issue (row) is organised into one of three future work categories: (i) 'Spatial distribution of catch for base case' describes analytical approaches to establish a base catch level, and then spatially distribute and evaluate future catch levels within Subarea 48.1; (ii) 'Implementation' describes data processing, analysis and survey details that will be required to implement FBM; (iii) 'Performance measures' describes approaches to evaluate the real and potential performance of the proposed FBM approach with respect to krill, predators and the fishery.

Advice from WG-EMM – year and paragraph numbers	Issue	Notes
Spatial distribution of catch for base case		
2015 (Table 2)	Estimation of base catch limit using integrated assessment model, including alternative estimates of the reference biomass to be used in decision rules for krill and fitting to additional data (e.g. krill length-frequency data from predator diet studies).	Further development of the integrated assessment model can be addressed in parallel with implementation of stage 2.
2015 (2.121ii)	Further development of approaches to apportion catch limits between management areas.	Work to advise on spatial apportionment of catch limits based on assessment of relative risks and using methods derived from those presented in WG-EMM-16/69 will be ongoing and can be conducted in parallel with implementation of stage 2.
2015 (2.144)	Identification of potential, precautionary no-take buffer zones around predator colonies.	Evaluation of buffer zones can be conducted in parallel with implementation of stage 2, noting that initial analyses of krill catch as a function of distance from land have already been conducted (WG-EMM-16/17), that the SSMUs were partly based on summer foraging ranges of krill-dependent predators, and that more recent tracking data can be used to consider the time that predators spend at different distances from their colonies.
Implementation		
2016 and 2015 (Table 2)	Specify data required from the krill fishery (e.g. number, frequency and location of standardised acoustic transects and net hauls).	SG-ASAM is requested to provide additional clarification on survey requirements for fishing vessel transects and the numbers of net hauls required for characterising krill length-frequency distributions that are necessary for biomass estimation, etc.
2015 (2.176i)	Continuing facilitation of meetings with fishing industry stakeholders to encourage participation of fishing vessels in collecting acoustic data.	Meetings with industry stakeholders are likely to occur over the long term and continue beyond implementation of stage 2 to stages 3 and 4 of FBM.

(continued)

Table 2 (continued)

Advice from WG-EMM – year and paragraph numbers	Issue	Notes
2015 (2.149)	Development and implementation of future surveys that cover spatial scales similar to that of the CCAMLR-2000 Survey.	It is unclear whether new surveys of this scale will be conducted in the near future; costs are substantial.
Performance measures		
2015 (2.140iii)	Assessment of krill behaviour and implications of such behaviour for krill flux.	A work program to study krill behaviour and flux should be designed by WG-EMM, will be ongoing, and can be conducted in parallel with implementation of stage 2.
2015 (2.160iv), 2.161vd)	Examination of the response of predators to variability in krill density.	The data that were used to describe the functional relationship between penguin performance and local krill biomass in WG-EMM-16/45 could also be used to examine the functional relationship between penguin performance and krill density. This work can be conducted in parallel with implementation of stage 2.
2015 (2.160vi)	Using models to explore competition between krill-dependent predators.	The ecosystem model developed by Watters et al. (2013) includes functionality to explore different degrees of competition between krill-dependent predators. This work can be conducted in parallel with implementation of stage 2.
2016 and 2015 (2.110)	Evaluation of decision rules with simulation models (management strategy evaluation (MSE)), empirical analyses of time-series observations (retrospective analyses), and/or other methods.	Full MSE of the strategy proposed in WG-EMM-16/48 could be pursued in parallel with the implementation of stage 2.
2015 (2.161vb)	Evaluating whether penguins are attracted to fishing vessels.	See next row.
2015 (2.161ve)	Considering using at-sea observations of predators (presumably from observers) as a way to establish predator–fishery overlap.	At-sea observations of predators would likely be necessary to evaluate whether penguins are attracted to fishing vessels. Acoustic data collected by research vessels indicate extremely fine-scale overlap of predators and fishing vessels can be observed (see e.g. WG-EMM-16/19). This work can be conducted in parallel with implementation of stage 2.

References

Hill, S.L., K. Reid, S.E. Thorpe, J. Hinke and G.M. Watters. 2007. A compilation of parameters for ecosystem dynamics models of the Scotia Sea – Antarctic Peninsula region. *CCAMLR Science*, 14: 1–25.

Plagányi, É.E. and D.S. Butterworth. 2012. The Scotia Sea krill fishery and its possible impacts on dependent predators – modelling localized depletion of prey. *Ecol. Appl*., 22 (3): 748–761.

Watters, G.M., S.L. Hill, J.T. Hinke, J. Matthews and K. Reid. 2013. Decision-making for ecosystem-based management: evaluating options for a krill fishery with an ecosystem dynamics model. *Ecol. Appl*., 23 (4): 710–725.

Appendix F

Symposium on the Ross Sea Ecosystem
(Bologna, Italy, 13 July 2016)

(Available in English only)

Symposium on the Ross Sea Ecosystem
(Bologna, Italy, 13 July 2016)

Program

Introduction (Co-conveners) (9:00–9:10)

Ecosystem structure and functioning

1. Castagno et al. Temporal variability of the circumpolar deep water inflow onto the Ross Sea continental shelf (9:10–9:20)

2. Rivaro et al. Ocean acidification state in the Ross Sea surface waters: physical and biological forcing (9:20–9:30)

3. Celussi et al. Ocean ventilation effect on microbial metabolism in the Ross Sea (9:30–9:40)

4. di Prisco and Verde. The Ross Sea and its rich life: research on molecular adaptive evolution of Antarctic organisms and the Italian contribution (9:40–9:50)

Krill and fish, fisheries and their impact on the ecosystem

5. Leonori et al. Dynamics of middle trophic level of the Ross Sea pelagic ecosystem (9:50–10:00)

6. Ghigliotti et al. The coastal fish fauna of Terra Nova Bay, Western Ross Sea: from the first baseline information to the ongoing research on two key species, the Antarctic silverfish and the Antarctic toothfish (10:00–10:10)

7. Caccavo et al. Population structure of *Pleuragramma antarctica* in the Ross Sea (10:10–10:20)

Coffee break (10:30–11:00)

8. Currey et al. Ecological effects of the fishery for Antarctic toothfish in the Ross Sea region (11:00–11:20)

Discussion (11.30–12.30)

Lunch break (12.30–14.00)

Ecosystem monitoring and conservation

9. La Ferla et al. Microbial community inhabitants in the Ross Sea (14:00–14:10)

10. Calizza et al. Biodiversity organisation in a species-rich Antarctic ecosystem: insights from food web ecology for ecosystem monitoring, management and conservation (14:10−14:20)

11. Schiaparelli and Cummings. The Antarctic Near-shore and Terrestrial Observation System (ANTOS) network in the Ross Sea (14:20–14:25)

12. Olmastroni. Seabirds as sentinels of ecosystem change (14:25–14:35)

13. Lauriano and Panigada. Habitat use of the Ross Sea killer whale in Terra Nova Bay by means of satellite telemetry: a support to the conservation measures in ASPA 173 (14:35−14:45)

14. Zappes et al. Genetic studies of the Weddell seal in the Ross Sea: a closer look on the colonies in Mario Zucchelli Station area (14:45–14:50)

15. Corsolini and Cincinelli. Persistent organic pollutants (POPs) in abiotic and biotic compartments of the Ross Sea ecosystems: from the past to the future (14:50–15:00)

16. Benedetti et al. Ecotoxicology and use of bioindicators for monitoring the Ross Sea (15:00–15:10)

17. Bergami et al. PLastics in ANtarctic EnvironmenT – the PLANET International scientific project aimed to assess both the presence and impact of micro and nanoplastics to Antarctic marine biota (15:10–15:20)

18. Caccia et al. Modular portable robotic systems for the non-invasive observation of Ross Sea coastal ecosystem (15:20–15:30)

Coffee break (15.30–16.00)

19. Vacchi et al. The Antarctic silverfish, a keystone species in a changing ecosystem (M. Vacchi, E. Pisano, L. Ghigliotti (Eds)). Springer Book Series '*Advances in Polar Ecology*' (Short Note)

Discussion (16:05–17:30)

Temporal variability of the circumpolar deep water inflow onto the Ross Sea continental shelf

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The intrusion of Circumpolar Deep Water (CDW) is the primary source of heat, salt and nutrients onto Antarctica's continental shelves and plays a major role in the shelf physical and biological processes. Different studies have analysed the processes responsible for the transport of CDW across the Ross Sea shelf break, but until now, there are no continuous observations that investigate the timing of the intrusions.

Also, few works have focused on the effect of the tides that control these intrusions. In the Ross Sea, the CDW intrudes onto the shelf in several locations, but mostly along the troughs. We use CTD observations and a moored time series placed on the outer shelf in the middle of the Drygalski Trough in order to characterise the spatial and temporal variability of CDW inflow onto the shelf. Our data span from 2004 to the beginning of 2014. In the Drygalski Trough, the CDW enters as a 150 m thick layer between 250 and 400 m, and moves upward towards the south. At the mooring location, about 50 km from the shelf break, two main CDW cores can be observed: one on the east side of the trough spreading along the west slope of Mawson Bank from about 200 m to the bottom and the other one in the central-west side from 200 m to about 350 m depth. A signature of this lighter and relatively warm water is detected by the instruments on the mooring at bottom of the Drygalski Trough. High frequency periodic CDW intrusion at the bottom of the trough is related to the diurnal and spring/neap tidal cycles. At lower frequency, a seasonal variability of the CDW intrusion is noticed. A strong inflow of CDW is observed every year at the end of December, while the CDW inflow is at its seasonal minimum during the beginning of the austral fall. In addition an interannual variability is also evident. A change of the CDW intrusion before and after 2010 is observed.

Ocean acidification state in the Ross Sea surface waters: physical and biological forcing

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The Ross Sea is vulnerable to Ocean Acidification (OA) due to its relatively low total alkalinity and because of increased CO_2 solubility in cold water. OA induced decreases in the saturation state (Ω) for calcite and aragonite have potentially serious consequences for Antarctic food webs. Throughout the ocean, mesoscale processes (on spatial scales of 10−100 km and temporal ranges from hours to days) have first-order impacts on phytoplankton physiochemical controls and are critical in determining growth patterns and distribution. The circulation of the surface waters in the Ross Sea is affected by the presence of small-scale structures such as eddies, fronts and filaments, which can penetrate deep below the surface layer and hence influence the intensity of the bloom by supplying nutrients and trace elements, such as iron. Little is known about the effects of mesoscale structures on the carbonate system, but predicting future surface OA state and estimating future CO_2 fluxes on a regional scale require understanding of the mesoscale processes controlling the carbonate system.

To this purpose, water samples were collected in January 2014 in the framework of Ross Sea Mesoscale experiment (RoME) Project to evaluate the physical and biological forcing on the carbonate system at distance between stations of 5–10 km. Remote sensing supported the determination of the sampling strategy and helped positioning each sampling station. Total alkalinity, pH, dissolved oxygen, phytoplankton pigments and composition were investigated in combination with measurements of temperature, salinity and current speed. Total inorganic carbon, sea water CO_2 partial pressure and Ω for calcite and aragonite were calculated from the measured total alkalinity and pH. In addition, continuous measurements of atmospheric CO_2 concentration were completed. Different mesoscale physical features, such as fronts and eddies were observed in the investigated areas, which influenced the distribution of chemical parameters and of phytoplankton community in terms of biomass concentration (Chl-a) and species composition. The carbonate system properties in surface waters exhibited mesoscale variability with a horizontal length scale of about 10 km. Our results document substantial spatial heterogeneity and complexity in surface water carbonate system properties and the magnitude of the CO_2 flux at a horizontal length scale of about 10 km, emphasising the importance of mesoscale events to regional biogeochemistry. We believe that the resolution of these short length scale distributions provides insight into the biogeochemical dynamics which drive surface and subsurface variability in the Ross Sea.

Ocean ventilation effect on microbial metabolism in the Ross Sea

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A deep knowledge on the ocean C cycle functioning is fundamental to predict the consequences of increased CO2 in the atmosphere. Current researches indicate that the amount of CO2 fixed in deep marine systems via chemosynthetic processes is comparable to the one taken up by photosynthetic organisms in the lit portion of the water column. Despite the pressing need, we still lack of information on the deep sea biodiversity and metabolism of the Southern Ocean and in particular of the Ross Sea (Pacific sector of Antarctica). The Ross Sea represent a key study area because (1) it is a system where dense water masses with different features are formed, potentially involved in different quantity and quality of organic matter export to the deep sea and (2) these water masses, eventually forming the Antarctic Bottom Water (AABW), act as an engine for global ocean circulation, ventilating 60% of the whole ocean mass.

During two oceanographic cruises in Southern Ocean (austral summers 2014 and 2016) we have performed 64 incubation experiments in order to understand the C fluxes in the dark portion of the Ross Sea (200–2000 m). We evaluated dissolved inorganic C uptake (via chemosynthesis) and production (via respiration) together with dissolved organic C utilisation (via heterotrophic production) and release (via excretion or viral lysis). The study focussed on the newly formed, organic carbon-rich High Salinity Shelf Water (HSSW), on the oxygen-depleted Circumpolar Deep Water (CDW), and on the Antarctic Bottom Water.

Results indicate that in the three water masses (in the same depth range) marine microbes behave at different rates. The fastest bulk chemosynthetic C fixation, heterotrophic production and respiration were measured in the oxygen- and organic C-rich HSSW. Significantly lower values were found in CDW, whereas AABW maintained the metabolic signature typical of both parental water masses showing intermediate values. Excretion/lysis data were negligible or not measurable (below the detection limit of the method). Prokaryotic abundance mirrored the trend observed in metabolic activities. The per-cell normalisation of C uptake and production did not reveal significant differences among the water masses indicating that metabolism do not spatially vary at the single organism-level.

Overall, these data indicate that the signature of newly-formed water masses significantly affect the metabolism of microbes living in Antarctic Bottom Water possibly having profound implications for the global bathypelagic biogeochemistry.

The Ross Sea and its rich life: research on molecular adaptive evolution of Antarctic organisms and the Italian contribution

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The involvement of Italy in Antarctic research dates back to 1985, when Mario Zucchelli Station (MZS), the former TNB Station, was established in Terra Nova Bay. This presentation is an overview of the research in marine biology performed in the last 30 years by the authors' team in the Ross Sea.

Fundamental questions (with special attention to the molecular bases) have been addressed, related to cold adaptations evolved by a wide array of marine organisms (*fish, birds, urchins, whales*, *seals* and *bacteria*) along with progressive cooling in this area, also analysed when relevant in comparison with other important areas, i.e. the Peninsula, the Weddell Sea, the sub-Antarctic and the Arctic. In recent years, the urge to extend these studies to the north has become stronger; and comparison with the Arctic is developing within the IPY program Team-Fish.

The basic approach integrated ecophysiology with molecular aspects, in the framework of biodiversity, adaptation and evolution. This comprehensive research has special meaning in view of the control that Antarctica exerts on the world climate and ocean circulation. Polar organisms are exposed to strong environmental constraints, and we need to understand how they have adapted to cope with these challenges, and to what extent current climate changes will impact on adaptations.

The important role of the poles in Global Change has awakened great interest in the evolutionary biology of the organisms that live there. The Antarctic is a natural laboratory and the Ross Sea is one of its most important sectors. In contrast to the Arctic and the Peninsula, the Ross Sea is not hit by warming, but this might only be temporary. Marine biology has easy access to complex ecosystems and richness of organisms, from mammals to microbes.

The Ross Sea is rich of science/logistics facilities. McMurdo Station and Scott Base became active in the 50's; in recent years, the Ross Sea is being selected by other nations to install their stations. Thanks to investigations facilitated by this infrastructure network, as an example, the suborder Notothenioidei is one of the best known fish groups in the world for many aspects, in particular the molecular bases of adaptations to extreme conditions. There is compelling evidence for widespread changes in polar ecosystems due to climate change. The study of cold-adapted organisms will allow to look at the impact and consequences of anthropogenic challenges on species distribution.

The challenging agenda for the next decade will be to incorporate thinking along the physiological/biochemical viewpoint into evolutionary biology. Such approach can provide answers to the question of how polar marine organisms will respond, and whether they will be able to develop resilience, to ongoing Global Warming, already in full action in the Peninsula and in the Arctic, and foreseen to occur soon in the Ross Sea. The importance of comparing the resilience of organisms thriving in the as yet unimpacted Ross Sea with those of the warming Peninsula (and with the Arctic) will steadily increase, also because of possible predictions regarding lower latitudes.

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Dynamics of middle trophic level of the Ross Sea pelagic ecosystem

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Since 1989/90, the Acoustic Group of Institute of Marine Sciences of Research Council of Italy (CNR-ISMAR) carried out eight acoustic surveys in the Ross Sea to obtain important data on the two krill species, Ice krill (*Euphausia crystallorophias*) and Antarctic krill (*Euphausia superba*), constituting the 'Middle Trophic Level (MTL)' of this area. Their biomass, the geographical distribution and the demography were estimated and the relations with the environment (CTD and XBT samplings) were studied in the years. The last large scale survey was in 2004, then two small scale surveys were done in 2014 and 2016. The investigated area is included in the statistical division 88.1 and concerns the western part of the Ross Sea (from Lat. 77° to Lat. 68° S and from Victoria Land to Long. 180° E) for a total of around 80000 n miles ^{2}. In 2009 a study concerning Antarctic Silverfish (*Pleuragramma antarctica*) was started in order to better explain the exceptional abundance of the species belonging to the 'Top-Trophic Level (TTL)' which characterises the Ross Sea (marine mammals and birds). Its distribution area overlaps partly with that of *Euphausia crystallorophias* in the coastal area of western Ross Sea (mainly juveniles) and partly with that of *Euphausia superba* (adults and juveniles) in the north-central area of the Ross Sea, far offshore. During the oceanographic cruises the study area was monitored acoustically with a multifrequency modality (38, 120 and 200 kHz) by means of a SIMRAD EK60 scientific echosounder on board R/V Italica. Periodical pelagic trawls were performed targeting the key species with improved efficiency in capture due to the connection between the echosounder and the integrated trawl monitoring system SIMRAD ITI, giving information on net position in the water column.

The aim of the project is to continue past analyses on this matter performing a scientific survey possibly covering at least the area within the cores of the two krill populations, quite well known from past surveys, and the silverfish.

Another interesting possibility would rely on the installation of a moored echosounder in the study area of the survey, the Simrad WBAT (Wideband Autonomous Transceiver) with a 70 kHz transducer in order to analyse the seasonal krill variations in abundance and localisation in the water column, in function of ice cover variations.

The main objectives of this research are: to improve the knowledge on biologic and acoustic aspects concerning the two main species of Ross Sea krill; to improve the knowledge on acoustics parameters that allow the discrimination of Antarctic silverfish and to allocate specific echotraces to this species; to assess the biomass and spatial distribution of the three species of MTL in the area; to use the three MTL species as model-organisms; to study the interactions between the physical and biological environment (spatial distribution of the three species); to study the temporal variations of thermohaline characteristics and krill abundance in the area; to refine the knowledge on krill and silverfish Target Strength with the use of Simrad EK80 scientific echosounder working in broadband modality to obtain a better discrimination of the species and more precise estimations of their biomass.

The coastal fish fauna of Terra Nova Bay, Western Ross Sea: from the first baseline information to the ongoing research on two key species, the Antarctic silverfish and the Antarctic toothfish

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Ecological studies on the coastal fish community at Terra Nova Bay (TNB) date back to the 3rd Italian Antarctic Expedition (1987-1988), following the settlement of the Italian Mario Zucchelli Station (74°41'S, 164°07'E) in the Western Ross Sea. At that time Italy had just received the status of Consultative Member of the Antarctic Treaty. Being a largely unexplored area, the aim of those first pioneering studies was to draw a general picture of the local assemblage. Over years, owing to repeated summer surveys, such a goal has been largely achieved, as we now have quite detailed information on the fish fauna at TNB up to 500 m depth that includes not only species diversity, distribution and relative abundance, but also trophic ecology and reproductive features for the most of the species. The combination of traditional catch-based methods and in situ observations through Remotely Operated Vehicles (ROVs) allowed to document several aspects of the fish ecology and behaviour, including parental care in icefish species.

Here we will provide an overview on the ongoing researches on two key-stone fish species of the Ross Sea ecosystem, whose information on biology and ecology is claimed for proper management of the future Ross Sea Region MPA: the Antarctic silverfish (*Pleuragramma antarctica*) and the Antarctic toothfish (*Dissostichus mawsoni*).

Researches on the Antarctic silverfish in the area increased following the discovery of the first, and only known to date, nursery area for the species northern to TNB, in an area thereafter named Silverfish Bay. Thousands of eggs develop and hatch there, within the platelet ice under the sea-ice cover. Such a unique feature has been recognised in its outstanding scientific relevance, and has contributed to the establishment of the Antarctic Specially Protected Area (ASPA) n.173 Cape Washington and Silverfish Bay. Under the umbrella of PNRA, the nursery area has been continuously monitored from 2005 to 2013, and monitoring still is a priority of ongoing research at ISMAR, CNR, Genoa. The backbone of such researches are conventional methods and remotely operated video surveys; acoustics, in collaboration with New Zealand scientists of NIWA, and winter sampling at Jang Bogo Station, in collaboration with Korean colleagues of KOPRI, are expanding the geographic and seasonal investigation timeframe.

The Antarctic toothfish hasn't historically been targeted by researchers at TNB, however it has occasionally been caught by trammel nets (Antarctic expedition 1990-1991), and specifically targeted by small vertical longline fishing through holes in the sea-ice (Antarctic expedition 2002-2003). Improvement of the biological and ecological knowledge on this top predator in the Ross Sea ecosystem is within the goals of the ongoing collaborative research with New Zealand that include land-based activities at McMurdo Sound and TNB and participation in CCAMLR-sponsored off-shore surveys in the Ross Sea Region.

Population structure of *Pleuragramma antarctica* in the Ross Sea

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Research into the early life stages of *Pleuragramma antarctica* is essential to understanding how oceanographic variation will impact spatial distributions over time. *P. antarctica* collected near the Antarctic Peninsula and the Ross and Weddell Seas between 1989 and 1997 were the first to show evidence of weak population structure at the circum-Antarctic scale using mitochondrial DNA sequences (Zane et al., 2006).

This weak structuring of *P. antarctica* could either be explained by high levels of connectivity, or is indicative of inadequate sampling and markers. Thus, studies employing microsatellite markers with the potential to reveal finer genetic differences using more sampling sites on a smaller geographic scale were undertaken. A first investigation in the Antarctic Peninsula revealed significant structuring despite strong circumpolar currents moving through these areas (Agostini et al., 2015).

A microsatellite based population structure analysis was recently planned on larvae collected in the austral summer of 2013 from Terra Nova Bay and the Bay of Whales in the Ross Sea, morphologically identified as *P. antarctica*. Poor preservation precluded microsatellite amplification in these larvae, but successful amplification of the 16S rDNA and the *D-Loop* region of mitochondrial DNA was achieved. Sequence alignment with known GenBank sequences for *P. antarctica* and several related notothenioids confirmed the species identity of larvae as *P. antarctica*. This work supported evidence of a newly discovered nursery ground for *P. antarctica* in the vicinity of the Bay of Whales (Brooks & Goetz, 2014) and showcased the use of mitochondrial DNA to test morphological identification when examining spatial distributions of marine organisms that depart from expectation (Caccavo et al., 2015). An ongoing effort to understand the circumpolar connectivity of *P. antarctica* using microsatellite markers in individuals both from the initial mitochondrial DNA study, as well as newly collected samples from the Weddell Sea, shows a marked differentiation between *P. antarctica* from Terra Nova Bay and from areas of the Antarctic Peninsula and Weddell Sea. Microsatellites revealed stronger differentiation between the Terra Nova Bay groups collected in 1996 and 1997 but as in the initial analysis with mitochondrial DNA, failed to achieve significance. Successful population analyses in other areas of the Southern Ocean support the utility of such an endeavor in the Ross Sea. Greater sampling efforts are imperative to forge an understanding of population structure in the Ross Sea, where few such studies exist and for which new specimens are vital to addressing these questions. Furthermore, nursery grounds in the Ross Sea that might support *P. antarctica* populations at a circumpolar scale are at risk from the changing extents of seasonal polynyas in this crucial Southern Ocean habitat.

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Ecological effects of the fishery for Antarctic toothfish in the Ross Sea region

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In this presentation, the potential ecological effects of the fishery for toothfish in the Ross Sea region are discussed under five broad headings.

1. Effect of the fishery on by-catch species: The main by-catch species are macrourids (*Macrourus whitsoni* and *M. caml*), icefish (mainly *Chionobathyscus dewitti*), skates (mainly *Amblyraja georgiana*), eel cods (*Muraenolepis* spp.) and deep-sea cods (*Antimora rostrata*).

2. Effects of the fishery on the prey of toothfish: Except for skates, the main by-catch species are also the main prey items for toothfish, and “predation release” effects are discussed.

3. Effects of the fishery on the predators of toothfish: The main predators of toothfish in the Ross Sea region include Weddell seals, type-C (“fish-eating”) killer whales and sperm whales. Effects of the fishery on these predators will be related to: (a) the ecological dependence of the predator on toothfish; (b) the potential for the fishery to reduce the availability of toothfish as prey to these predators.

4. Effects on habitat: The effect of the fishery on structure-forming benthic invertebrates (“vulnerable marine ecosystems”) is discussed in terms of the (a) footprint of the fishing gear (how much of the sea-bed is affected by long-lines); (b) impact of the fishing gear on a particular habitat; (c) spatial overlap between a particular habitat and fishing effort.

5. Cascading ecosystem effects: The potential for the fishery to affect the wider ecosystem through indirect or second-order effects is discussed. In particular, could the recent doubling of the number of Adélie penguins breeding in the south-west Ross Sea be related to fishing?

The state of knowledge on each of these potential ecological effects is presented, and measures to avoid, mitigate or manage the risks are described. Finally, research that is underway or planned on the potential ecological effects of the Ross Sea toothfish fishery is presented.

Microbial community inhabitants in the Ross Sea

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The microbial assemblage plays a key role in the costal and pelagic food web of the Ross Sea; it controls many processes, including primary production, turnover of biogenic elements, degradation of organic matter and mineralisation of xenobiotics and pollutants. Prokaryotic abundance and activity shift significantly over the annual cycle as sea ice melts and phytoplankton blooms develop. Marine microbes in the Ross Sea exhibit a diversity which also depends on the timing, location and sampling method; research devoted to this group is increasing, using also genetic and molecular approaches in surface and deep waters.

Our contribution will focus on the presentation of microbial data (standing stock and activity, as well as diversity and biotechnological potentialities of bacterial isolates) collected in the Ross Sea (coastal and pelagic) from 1988 to 2016, in the framework of the Italian National Programme for Antarctic Research (PNRA). Particular emphasis will be given to the inter-annual and decadal variability of microbial community in coastal and pelagic zones of the Ross Sea.

Biodiversity organisation in a species-rich Antarctic ecosystem: insights from food web ecology for ecosystem monitoring, management and conservation

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The Ross Sea is considered the most pristine marine ecosystem on Earth. The absence of direct anthropogenic pressure, in association with substantially stable environmental conditions over a geological scale, resulted in high levels of biological diversity, mainly represented by benthic invertebrate consumers. In turn, marked seasonality in light and sea-ice coverage control biological productivity in the region. This forced benthos to adapt to pulsed resource inputs and to prolonged periods of resource shortage, in association with low temperature and physical disturbance. Disentangling these mechanisms will improve our understanding of biodiversity organisation and adaptation in the Ross Sea ecosystem and our ability to conserve and manage biodiversity under a global change scenario. Indeed, diversity and temporal fluctuation of resource inputs are key ecosystem properties promoting species coexistence, and modification of sea-ice dynamics associated to climate change are expected to alter the relative contribution of different resource guilds to benthic consumers. While adaptive physiological mechanisms to extreme physical conditions in polar biota have been relatively more investigated, trophic-functional mechanisms underlying adaptation, resource partitioning and species coexistence are poorly understood. This hinders a mechanistic understanding on if and how variations in sea-ice coverage and resource supply will rebound into changes in species composition, food web dynamics, and biodiversity loss within the Ross Sea ecosystem.

Our research in the Ross Sea focused on the description of food web organisation and adaptation to changes in sea-ice coverage and resource inputs at Terra Nova Bay, which represented an exceptional natural laboratory to study the effect of sea-ice dynamics on the ecological community. By mean of stable isotope analyses of numerous taxa, we described both vertical (i.e. feeding) and horizontal (i.e. competition) ecological links subtending to species coexistence and nutrient flux across trophic levels. The description of spatial and temporal variations in food web structure can be key to unravel mechanisms linking climate change and its ecological consequences both at the population and community level, providing early signals of subtle ecological changes which could lead to species exclusion that could not be inferred based on physicochemical data alone. As a part of our results, we observed a highly diverse and “packaged” biological community. The food web seemed to be highly adapted to the seasonal availability of different resource inputs, including detritus, benthic, sympagic and pelagic primary production. Indeed, species were able to vary their diet following changes in resource inputs associated to sea-ice dynamics. Inputs of sympagic algae to benthic consumers (both in shallow and deep waters) were key to relax interspecific niche overlap and species packaging during the summer months. Abundant species were found to differentiate their trophic niche on alternative resource axes, which reduced competition for food, plausibly improving the fitness of competitors. In turn, the feeding choices of species had a profound effect on the configuration and coupling of energy pathways within the food web. This had implications for nutrient and contaminant transfer within the ecosystem, and provided a direct link between the functional response of populations and effects of climate change at the ecosystem level.

Thus, biodiversity organisation at Terra Nova Bay seemed to be highly adapted to the dynamic stability of the Antarctic environment on one hand, and to the seasonal sea-ice dynamics and release of sympagic production on the other hand. Ecological theory suggests that such dynamic stability in environmental conditions and resource input could be a key factor allowing for the observed elevated “packaging” of species along the trophic niche axis, and hence the high biodiversity level characterizing our study area. We argue that rapid environmental modifications associated to climate change and to potential anthropic activities impacting the Ross Sea food web could represent an unprecedented ecological change which could have profound implications for food web stability and biodiversity persistence, with a high risk of species extinction and relevant changes in nutrient transfer across trophic levels as a consequence.

The Antarctic Near-shore and Terrestrial Observation System (ANTOS) network in the Ross Sea

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The Antarctic Near-Shore and Terrestrial Observation System (ANTOS) is a SCAR Action Group, established in August 2014. Its major aim is to foster and facilitate collection and sharing of long-term automated climate and associated environmental observations across Antarctica and national programs. In August 2015, a workshop was held to develop an implementation plan for ANTOS and focused on the key characteristics of locations, parameters to measure, frequencies, scales and gradients of measurement, and technical requirements needed to establishing a network of marine and terrestrial observation systems, which are now available to the scientific community. In the present contribution we will outline the state-of-the-art for the Ross Sea coastal sites and illustrate the ongoing monitoring activities performed in the Ross Sea under the Italian, New Zealand and Korean Antarctic research programs and in accordance to ANTOS implementation plan.

Seabirds as sentinels of ecosystem change

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The Ross Sea, despite its relatively small size, contains one of the largest concentrations of marine birds in the World (e.g., 38% and 26% of the World breeding populations of Emperor and Adélie penguins, respectively). The high biodiversity at both species and communities level make the area between Terra Nova Bay and Wood Bay, along the mid Victoria Land coast, a site of important ecological and scientific value. Terra Nova Bay and Wood Bay have been included as Important Bird Areas in Antarctica by BirdLife International. The penguin colonies are located in well-defined sites between 17 and 75 km from each other. Other species, such as skua and petrel, breed in ice/snow-free areas scattered along the same coastline. Seabird and marine mammal concentrations and distribution highlight the importance of this stretch of Victoria Land's coast to these species during the Antarctic summer. Numerous studies conducted by Italian researchers and others since the mid-1980s have contributed greatly to the knowledge about the present ecological communities in this area. Italian biologists (University of Siena, within the PNRA) have been studying seabirds and collecting standardised data using CCAMLR protocols, as well as employing other methods, since 1994. This research has described effects relating to annual changes in the population and the ecosystem, at both local and regional levels. Long term individual survival rate estimation together with reproductive parameters (i.e. breeding success) has revealed the dynamics of growth or decline of the populations and highlighted environmental factors that may influence these trends. Seabirds, and especially penguins, provide "warning signals" of ecosystem change, which is why the long-term research studying their life cycles and population dynamics are particularly important. Climate is known to affect seabirds on both long and a short-term bases. It appears to be responsible for summer prey availability and distribution and to affect directly or indirectly survival in wintering areas. Nonetheless increasing human activities such as research station operations and building, tourism and the development of fisheries may be responsible for disturbances both locally and on a regional scale in the Antarctic and Ross Sea ecosystems. Summer foraging habitats, and likely wintering foraging areas, of penguins may overlap with the potential fishing grounds. Interannual population size appear to be intimately connected to local environmental variables (i.e. food accessibility and availability, local weather), which can have a direct effect on one or more demographic parameters (e.g. chick survival) or behaviour (i.e. adult feeding strategies). Therefore, as the food web is altered the value of penguin population trends as indicator of climate change can be in turn negatively affected. It is of particular importance to promote the conservation of these indicator species in the Antarctic ecosystem and to recommend mitigation measures in areas affected by the growing human impact, as required by the Protocol on the Environmental Protection to the Antarctic Treaty. Colonies having long-term time series of data are of special value and need to be protected from direct human impacts.

Habitat use of the Ross Sea killer whale in Terra Nova Bay by means of satellite telemetry: a support to the conservation measures in ASPA 173

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The Ross Sea Killer whale (*Orcinus orca*) is known to be a fish eating species. In northern Terra Nova Bay presence and occurrence of this ecotype has been described in 2004, nevertheless information on habitat use and the relationship with preys are still not available for this area. From mid-January to mid-February 2015, ten killer whales were equipped with location-only satellite (SPOT) and additional vertical behaviour (SPLASH) transmitters, to investigate horizontal and vertical movements. Mean transmission period was 28.6 days (range=19-44; SD=8.79). The whales predominantly engaged in feeding activities along the pack ice edge, between the Campbell Ice Tongue and Cape Washington (Closs Bay). After 9 days spent in this area, the whales began heading north with consistent route along the Ross Sea towards Culman Island, Cape Hallet and Cape Adare. Gradually, they left the Antarctic waters and travelled constantly undertaking a long-distance migration (4,700 nm) towards subtropical waters close to New Zealand.

Vertical behaviour data indicate more deep diving activities in the tagging area than in the northward route; the diving activities reported are in the foraging range for the Silverfish (*Pleurogramma antarcticum*), which is known to occur from mid-water to up 500 m. Terra Nova Bay is a nursery ground for the Silverfish, a keystone species for the lower and higher trophic level, including the Antarctic Toothfish (*Dissostichus mawsoni*). The occurrence and the behaviour of Ross Sea killer whales in the Silverfish Bay Antarctic Special Protected Area (ASPA n°173) and in surroundings is indicating a key role of the area for the killer whales life stage. This deserves an update of the existing management measures in the area also considering the development of the research activities and the related infrastructures such as the gravel runway proposed.

Genetic studies of the Weddell seal in the Ross Sea: a closer look on the colonies in Mario Zucchelli Station area

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Weddell seals (*Leptonychotes weddellii*) have the most southern distribution among all mammals, with breeding colonies that spread along the whole Antarctic coast. Several genetic, behavioural and population studies on this species can be found in literature, but almost all of them have been concentrated on the colony of McMurdo Sound. The present work is the first analysis of the genetic diversity of two colonies, Terranova Bay and Wood Bay, both located in the Ross Sea area. Their genetic structure was analysed and results compared with those already available from McMurdo.

Dloop and CytB (with different mutation rates) were used to estimate the effective number (Ne) of the whole Ross Sea population, test the possible recent expansion of the colonies and observe the variation and distribution of the haplotypes. 15 microsatellite markers were used to obtain the Ne for the colonies and tested for a possible genetic structure.

Both mtDNA fragments showed a Ne of around 50,000 females for the whole Ross Sea population. Expansion test using mismatch distribution was positive, and the beginning was around 58,000 years, a little later than McMurdo (81,000 years), but always during the last glacial cycle. Haplotype analysis showed a high diversity (Hd > 0.90), and the quantity of exclusive haplotypes varied from 43% to 81%, huge values, if we consider that all these colonies are very close to each other. So Antarctic seals tend to present a high intraspecific haplotype variation, with large populations that persist for long periods of time, perhaps due to the lack of human hunting and terrestrial predation. Microsatellites analysis showed very low differentiation between the colonies, confirming that they are indeed part of the same population. This was also confirmed by the number of most likely clusters (K=1). The Ne value for both colonies was estimated in around1,340 individuals.

Our results show that Weddell seals undergone through a demographic expansion since the last glacial cycle and that today they present a local remarkable genetic variation, with large populations that persist for long periods of time in the same area. These patterns are likely a consequence of their high site fidelity, lack of human hunting and terrestrial predation. Nevertheless, as a top predator mammal, the role of this species in the Ross Sea is crucial, and its demographic dynamics should be monitored to follow the future changes of such an important ecosystem.

Persistent organic pollutants (POPs) in abiotic and biotic compartments of the Ross Sea ecosystems: from the past to the future

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Atmospheric long range transport (LRT) is the major responsible for advection of Persistent Organic Pollutants (POPs) as gases and aerosols to the polar regions. Cold condensation and subsequent bioaccumulation has led to their occurrence in polar animals, with consequent effects, ranging from interference with sexual characteristics to dramatic population losses. In the last decades, various studies have shown the presence and bioaccumulation of POPs in Antarctic abiotic and biotic compartments, with concentrations in top predators sometimes higher than those found in industrialised part of the world. Among the pollutant of greatest concern, there are organochlorine pesticides (i.e. DDTs, DDE, HCB, HCHs, CHLs), polychlorinatedbiphenyls (PCBs), polychlorinated dibenzo-dioxins and –furans (PCDDs/Fs) halogenated flame retardants (HFRs, e.g. polybrominated diphenyl ethers, PBDEs), and others. The Stockholm Convention (www.chm.pops.int) considers reducing/banning, future production, and use of these chemicals as a top priority. POPs reach Antarctica by LRT or are released from scientific stations. For instance, because fire risk is very high in Antarctica due to the very dry air, there was a large use of HFRs in buildings and furniture of stations for those built when there were no restrictions on flame retardants use; the construction of new stations and landing routes in the Ross Sea (in progress or recently completed) can be a further HFR source. Due to global warming, melting glaciers could represent a secondary, likely important, source of POPs in the seawaters. In fact, glaciers represent a cold trap for atmospherically-derived POPs and provide records of the deposition of POPs over time. With melting, their remobilisation from these reservoirs allow POPs to enter in the Antarctic food webs and thus biomagnify from the low trophic levels (e.g. larvae, krill) to the higher ones. For instance, the PCB peak concentrations found in *Trematomus bernacchii* in 2001 and 2005 as well as the highest concentrations also reported in 2005 for p,p'-DDE and PBDEs may be affected by the iceberg B-15, that calved from the Ross Ice Shelf in March 2000: contaminants may be released during iceberg melting. The climate change and other human impacts, i.e. increasing human presence due to new scientific stations and related transport of people and equipment, a likely increasing of fishing activities and touristic cruise can affect the Ross Sea ecosystems. Fishing and air and maritime traffic contribute to the contaminant release (POPs, polycyclic aromatic hydrocarbons, PAHs) and the synergy among contaminant release, human presence, climate change, fishing exploitation may affect the Ross Sea ecosystem structure, functioning and health. Moreover, krill seem to bioaccumulate higher POP amount than predicted on the base of their trophic position, thus being at risk as well as all the krill-dependent species.

The challenge of the scientific community for the future should be a coordinated monitoring based on specific and shared criteria of sampling and reporting of data. This is a very important key-point especially in the light of the possible delay of contaminant transport and deposition in the Antarctic region, of the increasing air and maritime traffic. All these human impacts, together with an increase of the fishing exploitation, may affect the health of ecosystem, its homeostasis and the population equilibrium.

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Ecotoxicology and use of bioindicators for monitoring the Ross Sea

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The use of bioindicators and ecotoxicological responses is of particular importance in the Ross Sea Region for the possibility to early detect the impact of anthropogenic activities or future scenarios of climate change. Among the organisms monitored around the Italian Station at Terra Nova Bay, the scallop *Adamussium colbecki* revealed an elevated sensitivity of cellular biomarkers toward different pollutants and environmental stressors like temperature and acidification.

The natural enrichment of cadmium at Terra Nova Bay and the elevated basal concentrations in biota influence the responsiveness of organisms toward this element and other organic pollutants. Notothenioid fish have a limited capability to metabolise PAHs with important consequences in case of oil spill events. Male specimens of *T. bernacchii* from TNB also exhibit vitellogenin gene expression, and the marked seasonality of this estrogenic response seems to be associated to trophic transfer of cadmium or some natural estrogen in the diet during the austral summer. Oxidative responses have a fundamental role for larval development of *Pleuragramma antarctica* within platelet ice, but they also modulate the sensitivity of this key pelagic fish to prooxidant chemicals. These examples highlight that polar ecotoxicology should carefully evaluate specific adaptation mechanisms in endemic sentinel organisms when assessing the impact of anthropogenic activities or variations of environmental factors in these areas.

PLastics in ANtarctic EnvironmenT- the PLANET International scientific project aimed to assess both the presence and impact of micro and nanoplastics to Antarctic marine biota

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The presence of trillions of pieces of plastic debris throughout the world oceans has been internationally recognised as one of the most important worldwide threats for marine ecosystems alongside with loss of biodiversity, ocean acidification and climate change. Although Antarctica has been historically seen as a remote region physically isolated by the Antarctic Polar Front, macroplastics (> 1 cm) have been reported in the Southern Ocean since the 1980s and, more recently, south of the Antarctic Convergence (South Georgia Islands). This might be due in part to increasing local human impacts, such as fishing, tourism and activities from scientific stations, but they may also be potentially transported from transboundary sources. Currently, there is a lack of information concerning the presence of micro- (< 5 mm) and nanoplastics (< 1 µm) in the Antarctic marine environment resulting from weathering and fragmentation processes of this macrodebris. The PLANET project (PLastics in ANtarctic EnvironmenT) launched in 2015 by the Italian National Antarctic Research Programme is an international network among research groups having continued experience in Antarctica, led by Italian researchers jointly with Brazilian (University of Sao Paulo, PROANTAR) and Australian (University of Tasmania), partners all sharing common interests and objectives concerning plastic pollution in the Antarctic marine environment. The aim of PLANET is to evaluate the presence of micro and nanoplastics in the Antarctic marine environment and study the potential impact on marine biota in terms of bioaccumulation, toxicity and trophic transfer. Within the PLANET project, specific regions located south of the Antarctic Convergence are considered, including South Georgia and the South Shetland Islands and also the Ross Sea, all representative of Antarctic marine environments subject to a range of human impacts. Initial studies have included accurate sampling of water and biota in order to determine the amount of micro- and nanoplastics, as well as examining their effects in organisms at different trophic levels (e.g. phytoplankton, krill, scallops, fish and seabirds). The role of bacteria is also under investigation. Our preliminary results confirm the widespread presence of plastic debris of different sizes (both macro- and micro-) and polymeric nature in the Antarctic terrestrial and aquatic environment as well as in organisms from various trophic levels collected from around the Ross Sea region. The recent increasing involvement of more Italian researchers and international Polar Institutions (Instituto Antarctico Chileno and the British Antarctic Survey), will help facilitate our understanding of the wide spread nature of micro and nanoplastics contamination in the Antarctic marine environment. The creation of a network of researchers in this emerging field is necessary in order to develop the first ecological risk assessment to be used for policy decisions focused on the conservation of the Antarctica.

Modular portable robotic systems for the non-invasive observation of Ross Sea coastal ecosystem

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In the last years, the Institute of Intelligent Systems for Automation of the Italian National Research Council developed, starting from the projects POLE e RAISE, portable robotic technology for the observation of underwater environment in polar regions, including under-ice.

Activity focused on the scientific objective of sampling larvae and eggs of Antarctic Silverfish in the platelet ice as well as observing the process of formation of the platelet ice itself during the winter.

To this aim a couple of technologies were applied in Terra Nova Bay and surrounding areas:

1) adaptation of a commercial mini-ROV with a custom sampler for under-ice operations with light logistics, transportable by helicopter

2) development and installation of a persistent under-ice monitoring system equipped with cameras and multi-parametric gauge

and a portable highly automated ROV, P2-ROV, for monitoring and sampling of biological samples inside the platelet ice was developed.

Current research aims at extending the concept of portable under-ice ROV to develop a family of modular portable underwater, semi-submersible and surface robotic vehicles able to support the study of the water masses from air-ice interface to the seabed.

Discussion with marine scientists is fundamental for the development of suitable tools for non-invasive monitoring and sampling of the Ross Sea ecosystem.

The Antarctic silverfish, a keystone species in a changing ecosystem (M. Vacchi, E. Pisano, L. Ghigliotti (Eds). Springer Book Series 'Advances in Polar Ecology'

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As the prevalent plankton-feeder of the intermediate trophic level, and main prey of top predators, the Antarctic silverfish plays a pivotal role in the trophic structure of the High-Antarctic coastal system, and in its patterns of energy flow. Important evolutionary changes in body density and buoyancy places this small fish at one extreme of the notothenioid evolutionary/ecological axis from benthic to secondary pelagic life style. Indeed, the Antarctic silverfish is the only known notothenioid living all stages of its life throughout the water column, from eggs to adults.

Its abundance and ecological relevance, together with peculiar evolutionary adaptations, fully justifies the interest for this species of a wide community of Antarctic scientists. The discovery of the first (and only known to date) nursery area for the Antarctic silverfish, in Northern Terra Nova Bay, Ross Sea, has further propelled researches aimed at clarifying the relationship of early life stages with the ice canopy, a crucial issue in the light of the ongoing environmental changes.

Thirteen chapters roping in high level competences of over 30 scientists from 10 countries, the book aims at providing the scientific community with an updated overview of the Antarctic silverfish biological and ecological information, including perspectives for future monitoring, conservation and management.

The volume, included in the Springer Book Series "Advances in Polar Ecology" (editor-in chief D. Piepenburg), is organised in three thematic sections: 1) Evolutionary history and adaptation; 2) Ecology and life cycle; 3) Protection initiatives.

Given the high scientific quality of contributors and referees, the book is expected to be a comprehensive review on the species, but also an advancement in our knowledge on the coastal Antarctic ecosystems, including those of the Ross Sea.

Publication is scheduled for early 2017.

Report of the Working Group
on Fish Stock Assessment
(Hobart, Australia, 3 to 12 October 2016)

Contents

Report of the Working Group on Fish Stock Assessment

(Hobart, Australia, 3 to 12 October 2016)

Opening of the meeting

1.1 The meeting of WG-FSA was held in Hobart, Australia, from 3 to 12 October 2016. The Convener, Dr D. Welsford (Australia), opened the meeting and welcomed participants (Appendix A). As this meeting of WG-FSA was slightly shorter than previous meetings, Dr Welsford encouraged all participants to engage in discussion and where differences of views existed that these be presented as different testable hypotheses rather an simply as statements of positions.

1.2 Mr A. Wright (Executive Secretary) extended the Secretariat's warm welcome to all participants and Mr T. Jones (Secretariat) provided an overview of the web-based meeting support provided by the Secretariat.

Organisation of the meeting and adoption of the agenda

2.1 The work plan for WG-FSA at this meeting was focused on providing advice on:

- non-target catch in CCAMLR fisheries
- setting appropriate catch limits for research activities involving toothfish
- methods for the analysis of toothfish catch data.

Dr Welsford reminded the Working Group that, while some of the work of the meeting may be considered in subgroups, all substantive discussions, and particularly discussions leading to advice to the Scientific Committee, would be conducted in plenary.

2.2 The Working Group reviewed and adopted the agenda with the addition of an item dealing with assessments and management advice for toothfish in Subareas 48.3 and 58.6 and Divisions 58.5.1 and 58.5.2 (Appendix B).

2.3 Documents submitted to the meeting are listed in Appendix C. While the report has few references to the contributions of individuals and co-authors, the Working Group thanked all the authors for their valuable contributions to the work presented to the meeting.

2.4 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).

2.5 The report was prepared by M. Belchier (UK), P. Burch (Australia), P. Brewin and C. Darby (UK), N. Gasco (France), S. Hanchet (New Zealand), C. Jones and D. Kinzey (USA), K.-H. Kock (Germany), K. Large (New Zealand), D. Maschette (Australia), D. Ramm, K. Reid and L. Robinson (Secretariat), M. Söffker (UK), S. Somhlaba (South Africa) and P. Yates (Australia).

Review of all available information and stock assessments for fisheries

IUU activities

3.1 The Secretariat presented WG-FSA-16/24 that provided area-specific information on illegal, unreported and unregulated (IUU) activity that could be incorporated into the relevant fishery reports so that stock assessment results can be presented with information on IUU fishing activity (SC-CAMLR-XXXIV, paragraph 6.5).

3.2 The Working Group welcomed the fishery-specific updates on IUU activity and agreed that these should be included in the relevant Fishery Reports.

3.3 The Working Group noted that there has been an increase in the detection of IUU activities in Subarea 48.6 in the last three years, in particular in research block 486_3 in the area on Maud Rise, that included both unknown vessels sightings and the recovery of gillnet gear. The Working Group also noted the first evidence of IUU fishing from Subarea 48.2 reported by Ukraine who recovered gillnet gear during research fishing in March 2016.

3.4 Ms S. Lenel (Secretariat) also updated the Working Group on the ongoing investigation of IUU catch recovered from the vessel *Andrey Dolgov* (see COMM CIRCs 16/47, 16/54, 16/62 and 16/77) that had been identified as Antarctic toothfish (*Dissostichus mawsoni*) and so was, therefore, likely to have come from within the Convention Area (however, also see paragraph 3.102 on the occurrence of *D. mawsoni* in the South Pacific Regional Fisheries Management Organisation (SPRFMO) area).

Champsocephalus gunnari in Subarea 48.3 and Divisions 58.5.1 and 58.5.2

C. gunnari South Georgia (Division 48.3)

3.5 The fishery for mackerel icefish (*Champsocephalus gunnari*) in Subarea 48.3 operated in accordance with Conservation Measure (CM) 42-01 and associated measures. In 2015/16, the catch limit for *C. gunnari* was 3 461 tonnes. Fishing early in the season was conducted by one vessel using midwater trawls and the total reported catch was 2 tonnes as of 14 September 2016. Details of this fishery and the stock assessment of *C. gunnari* are contained in the Fishery Report.

3.6 The Working Group noted that catches of *C. gunnari* in Subarea 48.3 are usually higher in the second half of the season, and that lack of catch at the beginning of the season results from low effort exerted by the fishery. The Working Group also noted that the vertical distribution of *C. gunnari* has been shown to be highly dependent on krill availability in this subarea. The low observed catch is likely due to low catchability of *C. gunnari* by midwater gear, rather than a change in stock abundance in 2015/16.

3.7 Details of the stock assessment for *C. gunnari* in Subarea 48.3 for 2015/16 and 2016/17 are provided in WG-FSA-15/25 Rev. 1. The catch limits calculated from the assessment for *C. gunnari* in Subarea 48.3 were 3 461 tonnes for 2015/16 and 2 074 tonnes for 2016/17 (SC-CAMLR-XXXIV, paragraph 3.103 and CCAMLR-XXXIV, paragraph 5.19).

3.8 The Working Group agreed that a catch limit for *C. gunnari* in Subarea 48.3 of 2 074 tonnes for 2016/17 be carried forward.

C. gunnari Kerguelen Islands (Division 58.5.1)

3.9 A short-term assessment of *C. gunnari* in Division 58.5.1 was conducted after the 2015 icefish-specific biomass survey PIGE (PoIsson des GlacEs) (WG-FSA-16/53). The assessment was implemented using the generalised yield model (GYM). A bootstrap procedure was applied to the survey data to estimate the demersal biomass of *C. gunnari* in this division. The bootstrap estimated the mean demersal biomass at 130 336 tonnes for the northeast shelf and 0 tonnes for the Skiff Bank, with a one-sided lower 95% confidence interval of 58 781 tonnes for the northeast shelf. The CCAMLR harvest control rule, which ensures 75% biomass escapement after a two-year projection period, yielded a catch limit of 8 278 tonnes for 2015/16 and 6 701 tonnes for 2016/17. A second projection that considered one year of fishing only, yielded a catch limit of 14 474 tonnes in 2016/17.

3.10 The Working Group noted that the area in the south of the survey strata appears to have consistently higher catch rates across the three POKER surveys (WG-FSA-14/07) and the more recent PIGE survey and recommended a stratification of the northeast shelf stratum in future.

3.11 Upon reviewing the PIGE survey data, the Working Group noted that there was one large haul which appeared to be unduly influencing the bootstrap biomass estimates. The Working Group suggested that the assessment be revised, with this haul excluded, consistent with the approach performed in Subarea 48.3 in 2013 which showed that the bootstrap biomass estimates were highly sensitive to the inclusion of the single high-abundance station (SC-CAMLR-XXXII, Annex 6, paragraph 4.3).

3.12 The revised short-term assessment of *C. gunnari* in Division 58.5.1 was conducted. A bootstrap procedure was applied to the survey data after the removal of the high-abundance haul to re-estimate the demersal biomass of *C. gunnari* in this division. The bootstrap estimated the mean demersal biomass at 81 302 tonnes for the northeast shelf and 0 tonnes for the Skiff Bank, with a one-sided lower 95% confidence interval of 49 268 tonnes for the northeast shelf. The harvest control rule, which ensures 75% biomass escapement after a two-year projection period, yielded a catch limit of 6 938 tonnes for 2015/16 and 5 618 tonnes for 2016/17. A second projection that considered one year of fishing only in 2016/17, yielded a catch limit of 12 130 tonnes.

3.13 The Working Group noted that the 2015 estimated biomass for the northeast shelf is over 10 times higher than that estimated from the previous three surveys (2006, 2010 and 2013). The Working Group noted that this result may not be unusual as abundance of *C. gunnari* tends to be highly variable. The Working Group also noted that a 10-fold increase in estimated biomass had occurred in Division 58.5.2 between 2008 and 2009 (WG-FSA-09/33).

3.14 Dr S. Kasatkina (Russia) noted that it is necessary to use an acoustic survey for clarifying the vertical distribution of *C. gunnari* in relation to the traditional trawl survey method. The existence of pelagic fish will result in an underestimation of fish biomass where only the demersal biomass is sampled.

3.15 The Working Group requested that the Scientific Committee seek clarification from France as to whether there would be a fishery for *C. gunnari* in Division 58.5.1 in the 2016/17 CCAMLR season.

C. gunnari Heard Island (Division 58.5.2)

3.16 The fishery for *C. gunnari* in Division 58.5.2 operated in accordance with CM 42-02 and associated measures. In 2015/16, the catch limit for *C. gunnari* was 482 tonnes. Fishing was conducted by one vessel and the total reported catch up to 14 September 2016 was 469 tonnes. Details of this fishery and the stock assessment of *C. gunnari* are contained in the Fishery Report.

3.17 The Working Group noted that Australia has undertaken a random stratified trawl survey in Division 58.5.2 during April 2016 (WG-FSA-16/23). It noted that the calculated density of Patagonian toothfish (*Dissostichus eleginoides*) was half that of 2015 but similar to that of the long-term average for the survey. The *C. gunnari* density was five times that of 2015 and nearly three times the average. For the managed by-catch species, catch rates were lower than the average for macrourids, close to average for unicorn icefish (*Channichthys rhinoceratus*) and only one-third the average for grey rockcod (*Lepidonotothen squamifrons*). Conversely, the density of aggregated skates was higher than both 2015 and the long-term average. The catch of invertebrates in the 2016 survey was two times higher than average, due in part to the greater abundance of jellyfish, which was almost five times higher than average. Data for *C. gunnari* from this survey were included in the preliminary assessment for *C. gunnari* (WG-FSA-16/26) in Division 58.5.2.

3.18 The Working Group noted the usefulness of providing side-by-side length-frequency plots for Divisions 58.5.1 and 58.5.2 to investigate whether the higher catch rates of *C. gunnari* in both areas could be indicative of a single recruitment event across the area (Figure 1).

3.19 The Working Group considered that it was difficult to determine whether there was a single recruitment event in Divisions 58.5.1 and 58.5.2 from the one year of data as shown in Figure 1 and that further investigation of comparative trends in length frequencies of catches of *C. gunnari* in these divisions over time would be useful.

3.20 A short-term assessment of *C. gunnari* in Division 58.5.2 was conducted using data from the random stratified trawl survey in Division 58.5.2 during April 2016 (WG-FSA-16/23). The cohort structure was determined using CCAMLR's mixture analysis (CMIX) procedure with the best fit to the survey length distribution achieved when the population was estimated to consist of five components, i.e. year classes 1+ to 5+, with the 2+ cohort containing the largest number of fish. A GYM provides a stock projection using a one-sided lower 95% confidence bound of total biomass of 3 955 tonnes of age 1+ to 3+ fish from the 2016 survey and fixed model parameters.

3.21 Estimates of yield indicated that 561 tonnes of *C. gunnari* could be taken in 2016/17 and 402 tonnes in 2017/18, allowing 75% escapement of biomass after two years.

3.22 The Working Group recommended that the Scientific Committee consider a catch limit for *C. gunnari* in 2016/17 of 561 tonnes and of 402 tonnes in 2017/18.

Dissostichus spp. in Subareas 48.3, 48.4, 88.1 and 88.2

Dissostichus eleginoides in Subarea 48.3

3.23 The fishery for *D. eleginoides* in Subarea 48.3 operated in accordance with CM 41-02 and associated measures. In 2015/16, the catch limit for *D. eleginoides* was 2 750 tonnes. Fishing was conducted by six vessels using longlines and the total reported catch was 2 195 tonnes. Details of this fishery and the stock assessment are contained in the Fishery Report.

Management advice

3.24 The catch limit for 2016/17, as specified in CM 41-02, is 2 750 tonnes.

D. eleginoides in Subarea 48.4

3.25 The fishery for *D. eleginoides* in Subarea 48.4 operated in accordance with CM 41-03 and associated measures. The catch limit for *D. eleginoides* in Subarea 48.4 in 2015/16 was 47 tonnes. The total reported catch by two vessels was 41 tonnes. Details of this fishery and the stock assessment of *D. eleginoides* are contained in the Fishery Report.

Management advice

3.26 The catch limit in CM 41-03 for *D. eleginoides* for 2016/17 is from a biennial assessment (SC-CAMLR-XXXIV, paragraph 3.116) and, accordingly, would remain at 47 tonnes.

D. mawsoni in Subarea 48.4

3.27 The fishery for *D. mawsoni* in Subarea 48.4 operated in accordance with CM 41-03 and associated measures. The catch limit for *D. mawsoni* in Subarea 48.4 in 2015/16 was 39 tonnes. The total reported catch by two vessels was 28 tonnes. Details of this fishery and the stock assessment of *D. mawsoni* are contained in the Fishery Report.

3.28 WG-FSA-16/39 reported on the distribution of fishing and tag releases during 2015/16 and the results of the Chapman tag-based biomass estimate. Fishing occurred throughout the island chain with a predominance in the southeast on one seamount, which resulted in tag releases and recaptures coming mainly from that area in 2016. While the concentration of tags in one area can result in an underestimation bias, the authors noted that at present, the aggregation of recaptures in 2016 did not drive the results of the biomass estimation and the impact of this bias was considered to be low due to the short time of residency of the tags in the area.

3.29 In 2016, 22 tags were recaptured, of which 8 were within-year recaptures, 12 from the previous year and 1 each from the 2014 and 2013 releases. The biomass estimate for *D. mawsoni* in Subarea 48.4 was calculated first using the tag population method agreed at WG-FSA-15 (SC-CAMLR-XXXIV, Annex 7, paragraphs 4.22 to 4.27) and then limiting tag availability to three years at liberty as agreed at WG-SAM-16 for other *D. mawsoni* population estimates where the populations are located around seamounts (Subareas 48.6 and 88.2) (Annex 5, paragraph 2.28).

3.30 The Working Group noted that the observed short residence time for tagged *D. mawsoni* on the seamounts in Subarea 48.4 is similar to other *D. mawsoni* seamount stocks, and endorsed the limitation of tag availability to three years in the population estimation for *D. mawsoni* in Subarea 48.4.

3.31 The calculation assumed a natural mortality rate of M = 0.13, a tag loss rate of 0.0064 and an initial release tagging mortality rate of 0.1. Due to high variability in the population estimates across years, a geometric mean of the relatively short time series was used as the basis for the final stock abundance of 1 000 tonnes. At a harvest rate of $\gamma = 0.038$, this would indicate a 2016/17 yield of 38 tonnes for *D. mawsoni* in Subarea 48.4.

3.32 The Working Group noted that the short residence time for tags on the seamounts implied that, similar to other *D. mawsoni* stocks, the Subarea 48.4 fish caught on these seamounts most likely represents part of a wider stock. The Working Group also noted that it is, therefore, important to gather additional data to enable the development of a stock hypothesis for this region and, consequently, that the proposed longline survey (see WG-FSA-16/40 Rev. 1) should be a high priority. The Working Group noted that the collection of such information is outlined within the survey plan submitted in WG-FSA-16/40 Rev. 1, which sets out to evaluate the potential links of the Subarea 48.4 *Dissostichus* spp. to the wider area.

Management advice

3.33 The Working Group recommended that the catch limit for *D. mawsoni* in Subarea 48.4 should be set at 38 tonnes for 2016/17 based on the results of this analysis.

Dissostichus spp. in Subarea 88.1

Capacity

3.34 WG-FSA-16/05 presented an update of the metrics of capacity and capacity utilisation initially described in WG-SAM-14/19, which have subsequently been used for annual monitoring of trends in capacity in exploratory toothfish fisheries in Subareas 88.1 and 88.2. The updated metrics show the same pattern as the metrics based on the data up to 2016 and do not indicate an excess capacity in the fishery. As indicated previously, based on a measure of potential daily fishing capacity and the catch limit for an area, the notified fishing capacity in some management areas is in excess of the level that would allow the Secretariat to forecast and issue a timely closure notice using the current fishery forecasting procedure.

3.35 The Working Group noted that, while it was evident that an excess capacity would occur if all vessels that notified for some fisheries arrived simultaneously, this situation had not occurred to date potentially because fewer vessels fished than had notified.

3.36 The current method for subarea catch forecasting and closure notification was considered to be adequate for the current fishery dynamics. Small overruns have occurred in recent years in some small-scale research units (SSRUs), but the overall catch limit for the stock has not been exceeded and, therefore, risk of stock over-exploitation has not been increased.

3.37 Nevertheless, the Working Group noted that it was important to maintain the monitoring of the capacity trends and highlight potential situations where an excess of fishing capacity might make closure forecasting difficult. For instance, overcapacity could be an issue in areas with small catch limits, high catch variability, and where substantial numbers of vessels enter simultaneously. The Working Group agreed that the Secretariat should monitor the number of vessels notifying and then subsequently fish in a subarea in each year, in order to follow any increasing capacity trend that would indicate that the current monitoring procedure is likely to be put under stress.

3.38 Dr Kasatkina noted that opening of closed areas in the offshore areas of Subarea 88.1 would help to spread the fishery wider within the subarea and reduce the potential of reaching overcapacity in the inshore fishery.

3.39 Dr Kasatkina further noted that only after the opening of all closed SSRUs, the analysis of real situation on reaching overcapacity in the fishery should be provided. She recalled that Russia provided this proposal to the Scientific Committee and Commission (CCAMLR-XXXIV, paragraph 5.41; SC-CAMLR-XXXIV, paragraph 3.201; SC-CAMLR-XXXII/06).

3.40 The Working Group noted that opening of the other SSRUs was a matter for the Commission on advice from the Scientific Committee, and WG-FSA and the Scientific Committee had previously provided advice on the spatial management of the area, including the potential for opening offshore areas.

3.41 The Working Group noted that opening closed SSRUs would not address the potential problem of a large number of vessels notifying for specific SSRUs and thus creating a situation of overcapacity on a smaller scale than that of the subarea.

Dissostichus spp. in Subarea 88.1

3.42 The exploratory fishery for *D. mawsoni* in Subarea 88.1 operated in accordance with CM 41-09 and associated measures. In 2015/16, the catch limit for *Dissostichus* spp. was 2 870 tonnes, including 40 tonnes set aside for the Ross Sea shelf survey and 100 tonnes set aside for the Ross Sea winter survey. Fishing was conducted by 13 vessels using longlines, and the total reported catch was 2 684 tonnes. Details of this fishery and the stock assessment are contained in the Fishery Report.

Ross Sea shelf survey

3.43 The Working Group noted that a report on the results of the 2016 Ross Sea shelf survey and proposal for a survey in 2017 had been presented to WG-SAM (WG-SAM-16/16).

3.44 The Working Group recalled the advice last year by the Scientific Committee (SC-CAMLR-XXXIV, paragraph 3.190) and Commission (CCAMLR-XXXIV, paragraph 5.34) that the survey be continued in 2017 with a catch limit of 40 tonnes for each of the 2015/16 and 2016/17 seasons, and that, as in previous years, the catch could be taken from the catch limit on the Ross Sea shelf.

3.45 The Working Group recommended that its advice from 2015 with a catch limit for *D. mawsoni* in Subarea 88.1 of 2 870 tonnes, including 40 tonnes set aside for the Ross Sea shelf survey, be carried forward for 2016/17.

3.46 WG-FSA-16/37 reported the results of the first winter longline survey to be conducted in Subarea 88.1 during June and July 2016. A total of 55 longline sets were completed in the four strata, and 55.2 tonnes of *D. mawsoni* and 3.4 tonnes of *D. eleginoides* were caught.

3.47 Spawning and spent *D. mawsoni* were captured during the survey on undersea features to the northwest of stratum 1. Gonad staging and gonadosomatic indices (GSIs) suggest that males in spawning condition may aggregate earlier than females and that spawning begins in early July. There was a higher proportion of male fish caught during the survey than during the summer fishery (73% vs. 60–65%), and the sex ratio varied substantially among sets.

3.48 Nineteen fish eggs (probably from *D. mawsoni*) were captured using a plankton net in the top 200 m of the water column. This is the first such record in the Convention Area. Eggs from two running ripe females were successfully fertilised and developed for several days in flow-through incubators. Egg buoyancy measurements, conducted with fertilised eggs in density gradient cylinders, are at present being analysed and compared with CTD data to indicate the depth of neutral buoyancy. The authors recommended that a survey be carried out from mid-July to August to further document the temporal extent of spawning, although much of the likely spawning habitat is under sea-ice at that time.

3.49 The Working Group noted that one 137 cm *D. mawsoni* was recaptured in SSRU 881B after it had travelled at least 674 km since its release in SSRU I in January 2016 and showed a GSI of 15.3%. This is consistent with the hypothesised autumn migration of fish from the slope to the north for spawning.

By-catch

3.50 WG-FSA-16/13 Rev. 1 presented an analysis of the by-catch reported by vessels in the Ross Sea toothfish fishery. The analysis focused on toothfish catch-per-unit-effort (CPUE) (kg/1 000 hooks), by-catch CPUE (kg/1 000 hooks) and the normalised target catch to by-catch ratio, noting distinct differences in the mean (and distribution) of the toothfish and the by-catch CPUE.

3.51 The analysis highlighted that target catch to by-catch ratios varied across years and by small-scale management unit (SSMU) and among longline gear types. The author considered that the spatial–temporal heterogeneity in toothfish and non-target species distribution in the Ross Sea, but not the longline vessels and the Flag States, should be considered as the primary cause of the observed variability in the target catch ratio in the Ross Sea. The observed influence of the longline gear types (autoline, trotline and Spanish longlines) on CPUE and the target to by-catch ratios demonstrated varying catchability (or efficiency) among the fishing gears both in relation to toothfish and non-target taxa.

3.52 The author noted that in order to improve the estimates of by-catch in the Ross Sea in the context of achieving the objectives of CCAMLR Article II, investigations of the spatial–temporal heterogeneity in toothfish and non-target fish distributions should be conducted for the Ross Sea, as well as preparation of instructions for of methodology for standardised fishery data collection and recording on board vessels.

3.53 The Working Group discussed the analysis conducted in WG-FSA-16/13 Rev. 1 in comparison with the previous analysis conducted by the Secretariat in WG-SAM-15/23. It noted that while there were differences between areas and gear types in by-catch rates, there was also a difference between Member vessels reporting within the regions and groups as determined by a multivariate analysis of the data. How the data are collected by the vessels – by observers or the vessels – was also a significant factor in the reported rates.

3.54 Following the analysis of differences in reporting rates between Member vessels conducted for WG-SAM-15, the Secretariat had sent a request to Members for a copy of the instructions sent to the observers, on how to record by-catch; all had responded apart from Russia.

3.55 The Working Group noted that WG-FSA-16/13 Rev. 1 and WG-SAM-15/23 used different methods but also addressed different questions. The conclusions were similar, for example both indicated a high level of spatio–temporal variability in the by-catch data. In addition to the spatial effects, WG-SAM-15/23 looked specifically at vessel effects (which was a proxy for whether observers or vessels report by-catch data), taking spatio–temporal variability into account. The Working Group recommended that, in such analyses, data should be standardised, the standardisation depending again on the question asked by the analysis.

3.56 The analyses highlighted the need that instructions for by-catch reporting need to be clarified (paragraphs 5.14 and 6.19 to 6.21) to improve instructions to vessels and to make data collection more user-friendly through training tools and instructional videos. The Working Group also noted that the camera trials reported in WG-FSA-16/43 could be useful to help in this process (paragraph 5.6).

3.57 The Working Group discussed the effects of gear type on by-catch rates and recommended further analysis based on existing data. There is already advice on suitable methods for such an analysis from WG-SAM-15 (SC-CAMLR-XXXIV, Annex 5, paragraph 2.28). WG-SAM considered that CPUE standardisation and generalised linear mixed models (GLMMs), or a case-control approach as used in the Ross Sea (WG-SAM-13/34) to compare by-catch rates from vessels fishing in close proximity to each other, could be applied to account for spatial variability, however, the method would need further development to account for different bait type etc.

Fishing operation characteristics

3.58 Following analysis of catch and effort data conducted at WG-SAM-16 (Annex 5, paragraphs 4.5 to 4.20), WG-SAM had requested that during the intersessional period before WG-FSA a review be conducted with the aim of developing: 'a set of diagnostics and clear criteria to assess the likelihood that a vessel is operating as would be expected in normal research fishing activities, so that the Working Group could provide advice to the Scientific Committee. It noted characterising research fishing activities and the operation of vessels would be helpful in developing diagnostics and criteria.'

3.59 WG-FSA-16/36 described the typical steps involved in demersal longline fishing operations for toothfish in CCAMLR fisheries and linked those steps to the variables recorded as part of the CCAMLR catch and effort data reporting system. The authors described the statistical properties of the recorded variables and how they may vary among different factors that make them useful to understand fishing activities, and useful for error trapping or data validation.

3.60 The authors noted that strong functional relationships were identified between some of the variables. For example, the time taken to haul a line increases non-linearly with the increase in the number of toothfish in the catch, as each fish is required to be gaffed aboard and removed from the line. This effect is compounded by fish size and the requirement to tag fish, which further slows the hauling process. The process proved useful to detect errors during data validation. The authors suggested that analysis also identified where values were outside of the vessel's normal statistical distributions and could potentially be used to indicate a need for additional error-checking or to seek additional information using other associated vessel records. Further, the authors noted that multivariate analyses would be a useful approach to investigating these data.

3.61 The Working Group thanked the authors for helping to develop the discussions and providing examples of relationships between variables that could be evaluated for the review process initiated by WG-SAM.

3.62 The Working Group noted that the authors identified some sets where very large numbers of hooks were recorded. It was suggested that these could be from trotlines where large numbers of hooks are set in clusters, these lines might therefore have a low catch rate per hook number and that this gear type may provide an explanation for high hook count rather than errors in data recording. Dr L. Pshenichnov (Ukraine) offered to provide additional information to further assist in the understanding of the trotline method where various configurations using bunched hooks are employed.

3.63 The Working Group noted that a comparison between the C2 data and the observer data to determine whether hauls with unusually long durations were the result of interruptions to the hauling process as the latter is recorded by the observers but not in the C2 data.

3.64 Dr Kasatkina noted that it was incorrect to summarise the hauling time data from all available longline sets taken by all fishing vessels in Subareas 48.2, 48.4, 48.5, 48.6, 58.4, 88.1, 88.2 and 88.3 for all years up to, and including, the 2015/16 fishing year without reference to the gear types, catch and hook number per set. Moreover, a vessel hauling speed should be strongly dependent on catch and number of hooks as well as on vessel power and power of the on-board winch for hauling.

3.65 The Working Group noted that it was important to understand relationships within the data that were being analysed, for instance hauling time was likely to be strongly dependent on the vessel and gear characteristics. The Working Group emphasised that catch, CPUE, gear type and hook number should be included in such analyses as important variables of fishing performance as shown in this paper. The Working Group suggested that in the future, analysis of longline fishery data should be detailed by subdivision and SSRU, to improve the ability to detect relationships between variables describing catch and effort.

3.66 The Working Group discussed the patterns that might arise in catch and effort data due to fishing operations and whether routines could be developed to detect systematic errors in incoming catch and effort data. Such routines could also include review processes at vessel level, that could evaluate whether data were internally consistent. It was noted that such a screening process could contribute to the data quality control or validation rules as being developed by the Secretariat (Agenda Item 7) and also individual Members. The Working Group encouraged Members to submit details of their data quality control procedures to the Secretariat to support this work.

3.67 The Working Group also noted that the inclusion of summaries of data preparation and analysis methods provided in appendices to working papers were helpful in providing transparency and understanding of the use of CCAMLR data in presentations to the working groups (WG-SAM-16/18 Rev. 1 and 16/39) and encouraged Members to provide similar appendices in the future.

3.68 The Working Group discussed the analysis outlined in WG-FSA-16/36 where it was agreed that the descriptions of the fishing process could form the basis for the development of hypotheses to evaluate patterns in the data recorded by fishing vessels and observers. In order to develop statistical models for the fishing process, the Working Group noted that data are not available on vessel freezing capacity and fish processing rates and recommended that fishery notifications should include this information.

3.69 Dr Kasatkina presented WG-FSA-16/14, an analysis of the toothfish fishery data in the northern part of the Ross Sea (SSRUs 881B, C and G) using haul-by-haul data from the CCAMLR database for the period 1997 to 2015. The variability of catch per haul (kg) and CPUE (kg/1 000 hooks) depending on the hauling duration (min) and hauling speed (min/1 000 hooks) were analysed. She noted that her analysis showed that there is a possible presence of number of high CPUE and catches, which are outside the upper limit of 99.7% confidence interval of the data range. She considered that these CPUE and catch values are statistically unreliable and questionably high with respect to the fishery data in the year under consideration. Dr Kasatkina considered that the total catches identified as above 97.5% within SSRU as well as catches beyond the 97.5% interval obtained by State flagged vessels may be significant. She considered it is necessary to clarify how these catches and CPUE beyond the 97.5% interval were obtained and how they should be treated; also that the current approach to analyse longline fishery data in the presence of variable CPUE values does not allow revealing adequate information for decision-making.

3.70 The Working Group noted that the same analysis conducted by Dr Kasatkina had previously been presented at WG-SAM (WG-SAM-16/26 Rev. 1). WG-SAM had concluded that the statistical inferences that Dr Kasatkina had made from the distribution of the CPUE data were invalid for a number of reasons:

(i) the statistical distribution of CPUE data is generally lognormally distributed and this had not been considered by the analysis

(ii) the statistical metric that Dr Kasatkina had used to examine the CPUE data values (the 95th, 97.5th percentiles) is a quantile, not a confidence interval, and will always have data values above them as they are characteristic of all data and, therefore, there is no statistical power in inferences made using them in isolation.

3.71 The Working Group noted that in WG-FSA-16/14, Dr Kasatkina had:

(i) claimed that the analysis conducted had been requested by the Scientific Committee and Commission. The Working Group was unable to find the references to these requests in the records of those meetings

(ii) presented results from vessels flagged to the UK and New Zealand, but had failed to present results from other Members. The Working Group requested that Dr Kasatkina provide support for her conclusion that the data from these Members had differing properties to all of the other data collected.

3.72 Dr Kasatkina noted that in accordance with current practice used by WG-SAM and WG-FSA in the presence of high CPUE values (kg/1 000 hooks), those are questionable or unusual, it is recommended to analyse:

(i) reconciliation of VMS data with reported catch location data
(ii) the relationship between hauling duration and CPUE
(iii) the relationship between hauling speed and CPUE.

It is important to understand whether current approaches to analyse longline fishery provide adequate information for decision-making. She further noted that the survey proponents agreed to undertake further analysis of the data collected from the SSRUs 882A–B north survey in 2015, with a particular focus on CPUE (kg/1 000 hooks) variability, haul duration and haul speed and include comparison with all exploratory and closed area fishing and research studies and provide a report to WG-SAM-16 and WG-FSA-16.

3.73 Dr Kasatkina also noted that analysis of SSRUs 881B, C and G, as the adjacent areas to the SSRUs 882A–B north survey, was provided taking into account that 'the high CPUE values obtained at the survey area were similar to those observed in the adjacent SSRU 881C' (SC-CAMLR-XXXIV, paragraphs 3.200 and 3.201; CCAMLR-XXXIV, paragraphs 5.38 to 5.41). That analysis of CPUE values in SSRUs 881B, C and G for several years in the context of the above said was shown in WG-SAM-16/26. WG-FSA-16/14 showed analysis of catch per set and CPUE values for the period 1997–2015. In this period the main catch falls on two countries' share: New Zealand 73% and the UK 22%. The maximum catch per set and CPUE values were also achieved by these two fleets (Table 1-6). In view of this, obtained results were shown under example of vessels flagged to the UK and New Zealand.

3.74 Dr Kasatkina noted that it is very important to analyse the statistics of catch and then present the results. Confidence interval (CI) estimation is used for different types of process in stock assessment regardless of the normal distribution function. The values higher than upper 99.7 CI limits are considered statistically unreliable (Brandt, 2003). In the practice the confidence interval of 99.7% is the criterion for rejection of outlying observations.

3.75 The Working Group noted that it was unable to locate any support for the statement in paragraph 3.74 in the cited reference by Brandt (2003).

3.76 Dr Kasatkina noted that in some cases hauling rate was constant, and did not change significantly across a range of catches. In her opinion hauling time for the 50 tonnes and 40 tonnes should be significantly higher than the hauling time for the main part of catches between amount to 10 or 50 tonnes. Dr Kasatkina further indicated that longline fishery was characterised by a small dependence between the longline hauling (min and min/1 000 hooks) and the catch per haul (kg) and the CPUE (kg/1 000 hooks). The correlation coefficient was in the range 0.05–0.3 (in several seasons coefficient made up 0.4–0.6). But regardless the dependence there is a possible presence of high CPUE and catch, which are outside the upper limit of confidence interval of 99.7% CI.

3.77 Dr Kasatkina highlighted that high CPUE values in the range from 3 000 kg/ 1 000 hooks up to 8 076 kg/1 000 hooks for UK-flagged vessels (seasons 2005–2015) and from 3 000 kg/1 000 hooks up to 9 024 kg/1 000 hooks for New Zealand-flagged vessels (seasons 2001–2014) were achieved at a practically unchanged hauling speed (Figures 11 and 12). It is unclear how the hauling time remained practically unchanged, if the catch per haul varied over a wide range from 13–15 tonnes to 35 tonnes for UK-flagged fishery and up to 50 tonnes for New Zealand-flagged fishery.

3.78 Dr Kasatkina noted that she only used data from the UK and New Zealand as examples report data significant of questionable high data. She recalled that in the SSRUs 881B, C and G the main catch falls on two countries' share: New Zealand 73% and the UK 22%. The maximum catch per set and CPUE values were also achieved by these two fleets. She stated that it is very difficult to explain how the high value catches were obtained with the same hauling time.

3.79 The Working Group recalled the discussions around WG-FSA-16/36 and the results found therein, which highlighted the non-linear relationship between hauling time and catches (paragraphs 3.59 and 3.60).

3.80 The Working Group noted that the examples chosen by Dr Kasatkina, notably data from the UK and New Zealand, were at present not considered questionable, or significantly unusual, by CCAMLR or its working groups. In the examples shown in WG-FSA-16/14, for the years where high CPUE values were highlighted, there were equally very low CPUE values, including lines with zero catches, however, those were not highlighted by Dr Kasatkina in the paper.

3.81 Dr Kasatkina noted that just high CPUE values are the focus of this study as well as the CCAMLR and its working groups. Obtained results showed the high CPUE values and catches identified above 97.5% may result in significant total catch in SSRU. Therefore, it is necessary to clarify of how the questionable high catches (i.e. beyond the 99.7% CI) were obtained. How the questionable high catches and CPUE values beyond the 99.7% CI should be treated.

3.82 The Working Group noted that CCAMLR and its working groups worked towards understanding patterns in catches and catch rates, and the focus was not on high values of CPUE but rather on the pattern of CPUEs (SC-CAMLR-XXXII, Annex 4, paragraph 4.18). The values highlighted by Dr Kasatkina were neither questionable nor significantly anomalous, as shown by the wide range of catch rates reported for all vessels operating in this region, including SSRUs 881C–G, over several years. It requested that Dr Kasatkina provide results for all vessels operating in this region to place the results shown for UK and New Zealand into the regional context.

3.83 Dr Darby noted that, as shown in WG-FSA-16/36, the relationship between hauling time and catch was not a linear relationship and that Dr Kasatkina had not tested for increasing haul time with catch, but only shown the distribution of CPUE data and highlighted high catches from her example Members. As noted by WG-SAM, there are high and low catches in the catch and CPUE data from all Members and the presence of a few high values was a natural part of the data characteristics.

3.84 Dr Kasatkina recalled her intervention in paragraph 3.64 and noted that WG-FSA-16/14 provided more corrected analysis of dependence between the hauling time and the catch per haul as well as between CPUE and hauling speed, using only normalised variables (by 1 000 hooks) for autoline gear in the northern Ross Sea.

3.85 Dr Kasatkina recalled that the main catch falls on New Zealand and UK amounted to 95%. The maximum catch per set and CPUE values were also achieved by these two fleets. Data examined together provided the same results.

3.86 The Working Group, apart from Dr Kasatkina, supported the review of the previous analysis of this approach by WG-SAM (Annex 5, paragraph 4.10) and agreed that occasional high (and often low) CPUE values occur in the data from all Member's vessels and were not anomalies. Other properties of the data such as patterns, as examined in WG-FSA-16/36, would likely provide a better approach to the identification of inconsistent datasets.

3.87 The Working Group, apart from Dr Kasatkina, agreed that her inferences concerning the data recorded by New Zealand and the UK were based on an inappropriate analysis of the statistical properties of the data. Her claims that the data were anomalous were not scientifically justified.

3.88 Dr Kasatkina stated regardless of the future consideration there are the presence of high values of catch and CPUE values being outside the upper limit of confidence interval of 99.7% CI and recorded with unchanged hauling time and speed. These data are the most high catch and CPUE over all available data from Subareas 48.2, 48.5, 88.1, 88.2. Therefore, it is important to estimate quality of these data and clarify how these data should be treated.

3.89 Dr Kasatkina noted that there was no any evidence or results of satisfactory analysis presented by WG-FSA to indicate realistic the above said data.

Future work

3.90 The Working Group discussed a general approach to the analysis of fishery data. Analyses should consider the use of standardised data to evaluate the patterns for a range of metrics and consider them together. Simple distributional analyses were considered helpful in developing an understanding of fishing patterns and screening data for errors, but typically a range of factors interact with each other, and thus multivariate analyses should be explored that take into account factors such as vessel, gear type, fishing depth, spatial distribution of hauls, number of fish, biological information such as fish size (large fish may take longer to haul) etc. Analyses of the data should be conducted following the establishment of hypotheses that can then be evaluated statistically by fitting models using multivariate methods such as generalised linear models (GLMs), GLMMs, generalised additive models (GAMs) etc.

3.91 WG-FSA recalled the previous discussions by WG-SAM-16 (Annex 5, paragraphs 4.18 and 4.19) which highlighted the importance of:

(i) asking clear questions
(ii) developing hypotheses before analysis
(iii) using analysis with a clear methodology
(iv) showing steps and choices in model selection
(v) presenting appropriate diagnostics.

3.92 WG-FSA agreed that WG-SAM be requested to develop analytical approaches such as:

(i) metrics to screen data for transcription errors to ensure data are internally consistent

(ii) models, including diagnostics, to detect systematic patterns in data that are departures from expected distribution.

3.93 To test metrics, a dataset that includes quarantined data should be used as an example as the quarantined data have already been established as being inconsistent with the other data.

3.94 WG-FSA emphasised the importance of collaborative work and noted the offer by New Zealand to work together with others (Annex 5, paragraph 4.20) to develop the methods. The UK, Australia and Russia all agreed that they would support the process and other Members were invited to participate in the online discussions through the existing WG-SAM e-group.

Satellite tagging

3.95 WG-FSA-16/57 reported the deployment by the USA and New Zealand of 10 pop-up satellite archival tags (PSATs) of two tag types on the southern Ross Sea shelf in the austral summer, and five PSATs on the northern seamounts in the austral winter. All fish were also double tagged with standard CCAMLR dart tags. Releases were distributed across five different SSRUs within Subarea 88.1.

3.96 For the 10 tags released on the southern Ross Sea shelf, all were programmed to pop-off on 1 February 2017, about one year from release. However, one of the tags (SeaTag-MOD #1662) became detached from the fish (either shed or popped off) on 24 February 2016, about 43 miles east-southeast of the release location. Three of the northern seamount tags were programed to pop off on 1 February 2017, after about eight months at liberty. The other two were programed to pop off on 1 February 2018 or after about 20 months at liberty.

3.97 WG-SAM-16/08 presented the preliminary results of PSAT studies on *D. mawsoni* in the Mawson Sea (Division 58.4.1). Three PSATs were released in 2014/15, and one of them was retrieved on the fish in 2015/16 and the preliminary results from the retrieved tag were presented. Despite being at liberty for 366 days, the tagged fish was re-caught only 4.3 km from the position of release.

3.98 The tag recorded that the fish moved vertically in temporal patterns that appeared to show seasonal behaviour. This was characterised by average (for the recorded time series) variability in vertical movement at the depth to which it returned after release. A second period of almost no vertical movement and during the austral winter was followed by a period of intense vertical movement high in the water column or at shallow depths during the austral spring.

3.99 The Working Group thanked the authors for presenting the results of their work, noting that this is the second record from a satellite tag reported to WG-FSA. In both cases, the tags were collected from fish that had been re-caught rather than popping off. The Working Group noted that the types of vertical movement recorded by the tag have been recorded for other species where the vertical movements noted in the spring were considered to be associated with spawning behaviour.

D. mawsoni in Subarea 88.2

Research surveys in SSRUs 882A–B

3.100 The exploratory fishery for *D. mawsoni* in Subarea 88.2 operated in accordance with CM 41-10 and associated measures. In 2015/16, the catch limit for *Dissostichus* spp. was 619 tonnes. Fishing was conducted by nine vessels using longlines, and the total reported catch was 618 tonnes. Details of this fishery and the stock assessment are contained in the Fishery Report.

3.101 The Working Group discussed the proposal for a second longline survey of toothfish in the northern Ross Sea region (SSRUs 882A–B) submitted to WG-SAM (WG-SAM-16/15).

3.102 The Working Group agreed that with the recent report of catches in the SPRFMO area to the north of the proposed survey area (SC-CAMLR-XXXV/BG/32), information on the distribution of the stock in this area was a high priority. Links between the distribution of *D. mawsoni* in the CCAMLR and SPRFMO areas will need to be considered in the future, especially in relation to tracking the origin of toothfish on the commercial markets.

3.103 Dr Kasatkina stated that analysis of survey SSRUs 882A–B was incomplete and this analysis does not meet the recommendation of Scientific Committee (SC-CAMLR-XXXIV, Annex 7, paragraph 4.104; CCAMLR-XXXIV, paragraph 5.41) and WG-SAM-16 (Annex 5, paragraph 4.29).

3.104 The Working Group noted that SC-CAMLR-XXXIV, Annex 7, paragraph 4.104 was an attributed statement by Dr Kasatkina which had not been adopted by Scientific Committee; consequently, WG-FSA sought advice from the Scientific Committee as to how to proceed in the case that:

(i) an attributed statement, which was not agreed and adopted as advice, is later treated as such by a Member

(ii) analyses suggested by a Member in an attributed statement are not then conducted by that Member to its own satisfaction.

3.105 Dr Kasatkina made the following statement on the survey SSRUs 882A–B:

> 'I cannot support the proposal for a second step of longline survey of toothfish in the northern Ross Sea region (SSRUs 882A–B) in season 2016/17, the survey data in the northern region of SSRUs 882A–B from the first step in 2015 should be placed into quarantine until a satisfactory analysis of the high CPUE records has been completed.'

3.106 The Working Group, apart from Dr Kasatkina, agreed that the analyses submitted to, and reviewed by, WG-SAM and WG-FSA have not indicated any unusual patterns in the data from the survey conducted in the north of SSRUs 882A–B independently by New Zealand, the UK and Norway with observers from Spain and South Africa. Consequently, there was no case for the quarantining of data collected by the five Members.

3.107 Dr Kasatkina presented WG-FSA-16/16, a research program on resource potential and life cycle of *Dissostichus* species from SSRU 882A in 2016–2019. The paper had been presented previously to WG-SAM.

3.108 Dr Kasatkina, in a response to a request to provide details of the partner vessel, noted in the proposal that Russia invites a Member vessel to take part in research program. This invitation is shown in WG-FSA-16/16. Otherwise, Russia is able to provide research program to herself.

3.109 The Working Group noted that the design of the survey was appropriate for its objectives but requested a list of the milestones for the proposal and the time in which they were expected to be delivered so that the timescale of the project could be evaluated. There were no further comments on the survey objectives or design during WG-FSA.

3.110 The Working Group noted that WG-FSA-16/16 Rev. 1, Table 2, provided a timeline to achieving objectives. However, it did not have time to review the timeline.

3.111 WG-FSA-16/46 described a multivariate approach to examining patterns in research fishing activities using the SSRUs 882A–B north survey as an example, specifically looking at hauling times and factors affecting this. A GLM was fitted to hauling times and established that there was no significant difference in hauling times, after adjustment for other factors, between the survey vessels fishing outside of the survey and during it.

3.112 The Working Group noted that the fitted model established that line length (also a proxy for number of hooks), number of toothfish caught and weight of toothfish caught were important factors in influencing the hauling time. Significantly, it was noted that the catch and effort variables recorded could be correlated and may mask variation explained by a biological process, such as the fine-scale distribution of fish.

3.113 Dr Kasatkina noted that there are no any rationales for summarising available data in Ross Sea region regardless of types of gears. Hauling time was analysed as the indicative variable without reference to catch and hooks number and type of gear. She noted that

WG-FSA-16/46 only showed that hauling duration from the survey without reference to number of hooks and catches were within the confidence boundary estimated from all available data in the Ross Sea region. This result was predictable taking into account wide range of fishing data.

3.114 Dr Darby noted that some factors will be correlated, for example numbers of hooks being correlated to length of line, and, therefore, hook number was included in the model fit.

3.115 Dr Kasatkina recalled that the results of the first year of the two-year longline survey for toothfish in the northern Ross Sea region (SSRUs 882A–B north) showed anomaly high CPUE values, reaching to 5 280 kg/1 000 hooks (SC-CAMLR-XXXIV, Annex 7, paragraph 4.102). At the same time, the high catches were obtained from greater depths (1 900 m or more) outside the main area of *D. mawsoni* distribution.

3.116 Dr Kasatkina highlighted that CPUE values of higher than 5 000 kg/per 1 000 hooks constitute only eight sets from 2 500 sets or 0.3% of all available longline sets from exploratory fisheries in in the adjacent SSRUs B, C an G while they comprise two out of the 18 longline sets (or 22 % obtained during the 2015 survey in SSRUs 882A–B).

3.117 Dr Kasatkina emphasised that it was not provided satisfactory analysis to clarify the sources of this high questionable CPUE and correspondent catches. Analysis of the vessel monitoring system (VMS) data with reported haul locations was not conducted also.

3.118 Dr Kasatkina stated that analysis of survey SSRUs 882A–B was uncomplete and this analysis does not meet the recommendation of Scientific Committee (SC-CAMLR-XXXIV, Annex 7, paragraph 4.104; CCAMLR-XXXIV, paragraph 5.41) and WG-SAM-16 (Annex 5, paragraph 4.29).

3.119 The Working Group noted that it requested from Dr Kasatkina the hypotheses that she would like to see tested and the quantitative criteria that she would need to have addressed in order to accept data. It also noted that, despite these requests, no information has been provided by Dr Kasatkina on what these hypotheses and criteria would be. Further, given the analyses already undertaken and presented to WG-SAM and WG-FSA, the scientific basis for dissatisfaction of Dr Kasatkina with data from these surveys remains unclear to the Working Group.

3.120 Dr Kasatkina supported application of GLM by the authors for multivariate analysis of fishing data. However, she proposed to use GLMM (i.e. GLM with mixed effects) that will provide approach for more detailed analysis of fishery data.

3.121 The Working Group noted that there was a series of stages to the development of the model, before reaching the final fit, that would provide a useful point for discussion, including alternative model structures, the correlation between variables and the error model. A subgroup was convened to examine these issues.

Amundsen Sea region (SSRUs 882C–H)

3.122 WG-FSA-16/45 presented work on the characterisation of the toothfish fishery and tagging program in the Amundsen Sea region (SSRUs 882C–H) between 2014/15 and

2015/16. A total of nine inter-season tagged fish were recaptured in the southern research blocks, providing key information on the size of the population in this area. Eleven tagged fish were recaptured in the north (SSRU 882H). This paper presented data for inclusion in the stock assessment for the Amundsen Sea region.

3.123 Mrs Large explained to the Working Group that a lack of ageing data in the southern area meant that only a single age–length key (ALK) could be used in the analysis of that region, while in the northern area, enough data is available to utilise annual ALKs for some of the years. She also noted that there had been no movement of tag-recaptured fish between research blocks, and, therefore, movement across research blocks and between the north and south areas has yet to be resolved.

3.124 WG-FSA-16/44 reported on progress towards a two-area stock assessment model for *D. mawsoni* in the Amundsen Sea region (SSRUs 882C–H). The region was split into two main 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.

3.125 Two-area stock assessment models were first developed for the region in 2014 and refined in WG-SAM-14 and WG-SAM-15. This earlier work highlighted the need to collect mark-recapture data in the south to help inform the estimation of biomass in the south. This update developed further the two-area stock models, including two years of new data collected under the research plan.

3.126 The results suggested that the research plan has been successful in providing tags and biological data that have started to inform the model, in particular the size of the fish population in the south. The authors recommend that the current research plan be extended for a further two-year period so that additional mark-recapture data can be collected, particularly from the south, and that the models be developed further in the intersessional period. Sensitivity and simulation runs could be done to further examine the data needed to inform the estimation of biomass in the south.

3.127 Some of the assumptions behind the two-area modelling approach were discussed by the Working Group. The Working Group noted that mainly small (50–100 cm long) fish were found in the south, mainly large (130–170 cm long) fish were found in the north, and that few fish of an intermediate size had been found in the region. Thus, it might take a number of years before fish tagged in the south were large enough to mature and migrate to the north. The Working Group also noted that larger fish in the south were in quite localised locations which had only been fished in two years and so there might be a low chance of recapture of large fish in the south.

3.128 The Working Group also noted that the model estimates of biomass in the south were very sensitive to the weighting applied to the tag data from the south. It recognised that when additional tag recaptures were available from the south, it would have the effect of increasing the weighting given to the tag data from this area. In this sense, the weighting assumption should be further examined between areas.

3.129 The Working Group recalled previous requests by the Scientific Committee for further ageing of otoliths held by other Members in order to obtain full age frequencies for all years fished in the north and the south (e.g. SC-CAMLR-XXXII, paragraph 3.169). This was discussed further with respect to data-poor fisheries (paragraph 4.126).

Management advice

3.130 The Working Group noted that the aim of the two-year research plan had been to increase the amount of tagging being carried out in the area and to ensure the likely recapture of those tagged fish by the use of research blocks (SC-CAMLR-XXXIII, paragraph 3.168). On the basis of updated Chapman estimates for SSRU 882H and research block 882_2, which showed that the current catch limits were consistent with CCAMLR's precautionary approach, the Working Group agreed that a two-year extension of the research program in this region could continue.

3.131 The Working Group agreed that the number of tagged fish available for recapture would be increased by increasing the tagging rates in both the southern and northern areas. The current tagging rates are 1 tag per tonne in SSRU 882H and 3 tags per tonne in SSRUs 882C–G. It recommended that these rates should be increased to 5 tags per tonne in SSRUs 882C–G and to 3 tags per tonne in SSRU 882H.

D. eleginoides in Subarea 58.6 and Division 58.5.1

D. eleginoides Kerguelen Island (Division 58.5.1)

3.132 The fishery for *D. eleginoides* in Division 58.5.1 is conducted in the French exclusive economic zone (EEZ). In 2015/16, 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 31 July 2016 was 3 814 tonnes. Details of this fishery and the stock assessment are contained in the Fishery Report.

3.133 WG-FSA-16/54 presented an updated stock assessment of *D. eleginoides* at Kerguelen Islands (Division 58.5.1 inside the French EEZ), which included new von Bertalanffy growth parameters and catch-at-age data, a new tag shedding rate parameter and the inclusion of estimated removals due to depredation.

3.134 The Working Group congratulated the authors on the continued development of the model and noted that the recommendations arising from WG-FSA-15 had been incorporated in the current assessment model. The Working Group also noted that age readings by Ifremer (France) and CEFAS (UK) had shown a lag of one year in length-at-age trends. The Working Group recommended direct age comparisons between laboratories to evaluate the reason for this lag.

Management advice

3.135 The Working Group agreed that the catch limit set by France of 5 050 tonnes in 2016/17 was consistent with the CCAMLR decision rules in the model runs presented.

3.136 No new information was available on the state of fish stocks in Division 58.5.1 outside areas of national jurisdiction. The Working Group, therefore, recommended that the prohibition of directed fishing for *D. eleginoides*, described in CM 32-02, remain in force in 2016/17.

D. eleginoides Crozet Islands (Subarea 58.6)

3.137 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. In 2015/16, the catch limit for *D. eleginoides* was 1 000 tonnes. Fishing was conducted by seven vessels using longlines and the total reported catch up to 31 July 2016 was 534 tonnes. Details of this fishery and the stock assessment are contained in the Fishery Report.

3.138 WG-FSA-16/52 presented an updated stock assessment of *D. eleginoides* at Crozet Islands (Subarea 58.6 inside the French EEZ). Outputs from a series of model runs were considered which included, inter alia, estimates of whale depredation and new von Bertalanffy growth parameters estimated from Kerguelen age data. The Working Group congratulated the authors on the continued development of the model and noted that the recommendations arising from WG-FSA-15 had been incorporated in the current assessment model.

Management advice

3.139 The Working Group agreed that the catch limit set by France of 1 300 tonnes in 2016/17 was consistent with the CCAMLR decision rules in the model runs presented.

3.140 No new information was available on the state of fish stocks in Subarea 58.6 outside areas of national jurisdiction. The Working Group, therefore, recommended that the prohibition of directed fishing for *D. eleginoides*, described in CM 32-02, remain in force in 2016/17.

Research to inform current or future assessments in 'data-poor' fisheries (e.g. closed areas, areas with zero catch limits and Subareas 48.6 and 58.4) notified under Conservation Measures 21-02 and 24-01

Exploratory fishery notifications in 2016/17

4.1 The Working Group noted Members' notifications to fish in exploratory fisheries for *Dissostichus* spp. in 2016/17 (CCAMLR-XXXV/BG/05 Rev. 1, see also www.ccamlr.org/en/fishery-notifications/notified). These notifications followed a pattern similar to recent seasons, and notifications for 2016/17 were as follows:

(i) Subarea 48.6 – 3 Members and 3 vessels
(ii) Division 58.4.1 – 5 Members and 5 vessels
(iii) Division 58.4.2 – 4 Members and 4 vessels
(iv) Division 58.4.3a – 2 Members and 2 vessels
(v) Subarea 88.1 – 10 Members and 21 vessels (2 vessels have been withdrawn)
(vi) Subarea 88.2 – 8 Members and 19 vessels (2 vessels have been withdrawn).

There were no notifications submitted for the exploratory fishery in Division 58.4.3b or for new fisheries.

4.2 The Working Group noted that the research plans for exploratory fisheries in Subareas 48.6 and 58.4 were submitted to WG-SAM-16 for review (Annex 5).

Making activities targeting toothfish consistent
with CCAMLR's regulatory framework

4.3 The Secretariat presented two papers to the Working Group on making activities targeting toothfish consistent with CCAMLR's regulatory framework (CCAMLR-XXXV/14 and BG/09). This work follows the paper presented by the Scientific Committee Chair last year (CCAMLR-XXXIV/17 Rev. 1) that resulted in the Commission agreeing that there are analogous research activities targeting toothfish that have the same aims and review process but are either conducted under conservation measures, or under an agreement of the Scientific Committee and Commission that is captured in report text. Given the confusion this causes, the Commission requested the Secretariat work with Members in the intersessional period to ensure this inconsistency was resolved through the revision of existing conservation measures and the creation of new conservation measures (CCAMLR-XXXIV, paragraph 9.21).

4.4 The aim of the work presented in CCAMLR-XXXV/14 and BG/09 was to develop proposals for new conservation measures, or propose changes to existing measures, to ensure all activities targeting toothfish are consistent with CCAMLR's regulatory framework. Comparing research activities in Divisions 58.4.3a and 58.4.4b provided an example of the current inconsistencies. The research conducted in Division 58.4.3a is classified as an exploratory fishery and is regulated under CM 41-06, while Division 58.4.4b does not currently have its own set of regulations clearly stated in a conservation measure and is regulated under CM 24-01, which makes it exempt from other conservation measures. However, both research activities are trying to achieve the same objective of providing an assessment of toothfish biomass and catch limits consistent with the CCAMLR decision rules. Despite this similarity, the regulations are very different. For example, in Division 58.4.4b no by-catch limits apply, it is unclear how regulations on catch overruns would apply (given there are no catch limits specified in a conservation measure) and five-day reporting is required, rather than daily reporting. Additionally, a vessel engaged in research may not be required to be authorised under CM 10-02 and/or to provide VMS data.

4.5 The proposal showed that generally all the components that were necessary for resolving inconsistencies were in existing conservation measures, but some small changes were required along with the establishment of a clear hierarchical structure (see Figure 2).

4.6 The proposal also showed that if there was agreement to the changes required to create the hierarchical relationship between the relevant conservation measures, and the changes to the preliminary paragraphs of CM 21-02 were made applicable to all activities targeting toothfish, the Annex in CM 24-01 would be moved into CM 41-01 and all of these research activities will be subject to the same specifications/regulations.

4.7 The Working Group thanked the Secretariat for taking this work forward and agreed that the proposed changes would not only make the scientific advice provided by WG-FSA and the Scientific Committee more transparent, but also improve the efficiency of reviewing these research activities in WG-SAM and WG-FSA.

4.8 The Working Group also agreed that specifying the species that is being targeted (i.e. *D. mawsoni* or *D. eleginoides*) in the title and text of conservation measures, rather than the non-species specific *Dissostichus* spp. that is currently present in all relevant conservation measures, would be very beneficial in providing clarity to the Commission and any external parties on which species was being targeted and managed in particular areas. This would mean that toothfish fisheries such as in Subarea 88.1 that have catch limits for *Dissostichus* spp. would be revised to include the target species as *D. mawsoni* and for the purpose of CMs 23-04 and 23-07 any *D. eleginoides* caught shall count towards the overall catch limit for *D. mawsoni* and 'by-catch species' are defined as any species other than *Dissostichus* spp.

4.9 The Working Group noted that it was important to remember the history of why particular areas had been closed to fishing, but recalled that this information was provided in Fishery Reports and should form an important part of the preamble in the research plan associated with an exploratory fishery.

4.10 Dr Kasatkina recalled that the CCAMLR regulatory framework was the subject of discussion during the Commission last year (CCAMLR-XXXIV, paragraphs 9.11 to 9.21) and focused on the following proposals that were taken:

(i) China suggested that a glossary of terms that describes the nomenclature and terminology would be beneficial in establishing a common understanding among Members. China also suggested that a mechanism or procedure, utilising the agreed terminology, be established to support the revision and adoption of conservation measures, noting that this would be particularly useful for Members for which English is not their first language (CCAMLR-XXXIV, paragraph 9.14).

(ii) Russia suggested providing a workshop for more detailed consideration of the regulatory framework. The report of this workshop should be presented for consideration by WG-EMM and WG-FSA (CCAMLR-XXXIV, paragraph 9.17).

Dr Kasatkina noted that these proposals were not accomplished.

4.11 The Working Group noted the need for broader consideration of ecosystem effects in research plans for both exploratory and research fisheries, as some of the plans and reports from previous seasons pertain solely to the target species.

4.12 The Working Group recalled that it was important to collect and report information on target and by-catch species, as the requirements of Article II necessitate an understanding of how the wider Antarctic ecosystem (seabirds, marine mammals, pelagic and benthic invertebrates, etc.), or relationships between ecosystem components, may be impacted by harvesting.

Long-distance movement in toothfish

4.13 Upon the request of WG-SAM-16 (Annex 5, paragraphs 4.46 to 4.48), the Secretariat presented WG-FSA-16/25 Rev. 1 on the long-distance movements of tagged *D. eleginoides* and *D. mawsoni*. Some analyses on the movements of toothfish had recently been conducted within Subarea 48.3 (WG-FSA-14/49), within Subareas 88.1 and 88.2 (WG-FSA-15/37) as well as within Division 58.5.2 (WG-FSA-14/43); WG-FSA-16/25 Rev. 1 analysed toothfish tag-recapture data (2006–2016) from across the whole Convention Area to assess long-distance movements and behaviour by species, location and sex with a focus on movements between management areas.

4.14 The results highlighted that in the management areas where most of the tagging occurs (e.g. Subareas 48.3 and 88.1) between 5% and 10% of tagged fish were found to have moved over 200 km from their release location. This is consistent with findings from previous studies looking at movements of *D. eleginoides* in Subarea 48.3 (WG-FSA-14/49). *Dissostichus eleginoides* and *D. mawsoni* that moved long distances showed a strong tendency to move in a counter-clockwise direction. In Subarea 48.4, the majority of long-distance moving *D. eleginoides* moved westerly towards Subarea 48.3 and the majority of tagged fish in Division 58.5.1 moved northwesterly. Meanwhile, *D. mawsoni* in Subarea 88.2 travelled west to northwesterly into Subarea 88.1. Long-distance movements in *D. eleginoides* also tended to be more common in males than females, which was consistent with previous findings (WG-FSA-14/43).

4.15 The Working Group noted that three toothfish were recaptured over 4 000 km from their release points. It further noted that tagging data had recently been received by the Secretariat from Australia and that these data would be migrated into the CCAMLR database so that future analyses could include data from Division 58.5.2.

4.16 The Working Group thanked the Secretariat for the interesting paper, noting that work like this can assist with informing hypotheses on stock structure. It noted that the results generally supported the assumptions made by current stock assessments that most fish are not moving great distances and/or crossing management area boundaries.

4.17 The Working Group agreed that this analysis was useful and should be performed biennially to include the most up-to-date data. Several additional factors that could be considered in future updates of this analysis were suggested, including an examination of the relationship between the long-distance movements and the depth at which fish were released and recaptured; otolith microchemistry; oceanographic patterns; different maturity stages; comparisons with data from PSATs; and long-distance movements recorded outside the Convention Area.

Local biomass estimates of *D. mawsoni* and *D. eleginoides* in research blocks in Subareas 48.6 and 58.4

4.18 In response to the request from WG-SAM, the Secretariat presented WG-FSA-16/27 that provided the documentation of the data extracts, data cleaning and code used to produce the local biomass estimates for research blocks in Subareas 48.6 and 58.4 following the methods that were agreed at WG-SAM-16 (Annex 5, paragraph 2.28). The versions of the code used in the analyses (with the associated documentation and data) presented in WG-FSA-16/27 that have been made available to Members have been archived in the Secretariat under CCAMLR_CPUE_by_seabedarea_biomass_estimation150092016.zip and CCAMLR_Chapman_biomass_estimation15092016.zip and the data extracts and associated metadata have been archived in CCAMLR_csv_data_extract_486_5841_5842_5843a_5844b_2016_08_23.zip.

4.19 The Working Group thanked the Secretariat for undertaking this considerable amount of intersessional work and welcomed the increased level of documentation and transparency that this had brought to the process of providing these biomass estimates. The Working Group agreed that, as the Secretariat is the source of the most up-to date data and now the provider of the standard method for using those data to provide biomass estimates for research blocks, these estimates should be provided by the Secretariat in the future.

4.20 The Working Group agreed that the work presented in WG-FSA-16/27 provided a clear description of the approach to providing local biomass estimates for research blocks and that this should be recommended as the default method, such that any approaches to using other methods for estimating the local biomass in research blocks should be presented in relation to, rather than simply as alternatives to, this default approach.

4.21 The Working Group noted that the agreed methods for producing the point estimates of local biomass in research blocks provided an essential basis from which to consider the uncertainty in those estimates, including through bootstrapping seasonal estimates as well as incorporating multi-year estimates. Such estimates of uncertainty, and how these estimates will be used in setting future catch limits, were identified by WG-SAM and WG-FSA as a high priority for future work in 2017.

4.22 Based on the biomass estimates provided in WG-FSA-16/27, the Working Group generated a table of proposed catch limits (Table 1). In the case of the mark-recapture Chapman biomass estimates, the Working Group agreed that, if there was no estimate in 2016, due to an absence of tagged fish recaptures and/or no fishing, the most recent Chapman biomass estimate should be considered.

4.23 Based on the biomass estimates in Table 1, the proposed catch limits were calculated using the method that had been most recently agreed by WG-FSA of selecting the lower of the two estimates and applying a 4% exploitation rate (SC-CAMLR-XXXIII, Annex 7, paragraph 5.123). The Working Group discussed the use of additional criteria that had been used in calculating catch limits in the past. These criteria included the comparison of the expected and observed numbers of tagged fish recaptures and the catch required to recapture 10 tagged fish.

4.24 The Working Group acknowledged that, even though the comparison of expected and observed numbers of tag recaptures had been used in selecting biomass estimates and setting catch limits in the past, this was a circular argument when the expected numbers of tag recaptures were based on a tag-based biomass estimation method. Additionally, calculating the catch required to recapture 10 tagged fish in the following fishing season had not been a suitable metric for setting catch limits, given that less than 10 tagged fish were being recaptured per fishing season in many of the research blocks.

4.25 The Working Group discussed the difference in the biomass estimates generated using the CPUE by seabed area analogy and the Chapman mark-recapture biomass estimation methods. It was noted that the *D. eleginoides* biomass estimates using the two different methods showed a higher degree of similarity than the *D. mawsoni* estimates. Additionally, the proposed catch limits for *D. eleginoides* were also closer to the current catch limits. The Working Group noted that the *D. mawsoni* local biomass estimates tended to show greater differences than the *D. eleginoides* estimates and discussed the potential explanations for this in relation to difference in the ecology of the two species, how the data were collected in different research blocks and the assumptions of the two biomass estimation methods given the differences in the ecology and data collected/survey methods.

4.26 The Working Group noted that the proposed catch limits in research blocks that were based on the lower of the two *D. mawsoni* local biomass estimates were much lower than the current catch limits. It also noted that most of the current catch limits had in most research blocks been based on biomass estimates generated by WG-FSA-13.

4.27 The Working Group revisited the methods and parameter values that were included in the WG-FSA-13 biomass estimates and compared these with the latest formulas and values agreed to at WG-SAM. A key difference between the most up-to-date biomass estimates and those provided in 2013 was the application of transparent and documented data quality rules in the most recent biomass estimates. Other differences between the biomass estimates provided in 2013 and the current biomass estimates using the CPUE by seabed area analogy methods could be explained by the use of:

(i) different reference areas

(ii) a more recent bathymetry dataset (e.g. Gebco 2014 rather than Gebco 2008)

(iii) the median CPUE of the last three years in which fishing had occurred

(iv) the use of the current spawning stock biomass from the integrated assessments performed in 2015 rather than the vulnerable biomass that was used in 2013

(v) fishable seabed area from all SSRUs in the Ross Sea reference area, rather than only the fishable seabed area from SSRUs that were open to fishing that was used in 2013.

4.28 The key differences between the biomass estimated in 2013 and the current estimates using a mark-recapture method were the use of:

(i) a Petersen method, rather than the Chapman method

(ii) difference in the assumptions regarding the number of tagged fish available for recapture (i.e. the current method used the last three years of tagged fish released assuming the tagged fish are a single- population and the 2013 calculations used a cohort-based approach).

4.29 The Working Group discussed the implications of recommending reduced catch limits, noting that in some cases it may not be possible to continue with existing research programs.

4.30 The Working Group agreed that, when providing advice on research on catch limits to the Scientific Committee where there are alternative options, these should be supported by scientific rationale in order to allow the Scientific Committee to evaluate each option.

4.31 While some participants of the Working Group supported the proposed catch limits based on the lower of the two latest biomass estimates given in Table 1 with the 4% exploitation rate, others did not.

4.32 Dr T. Ichii (Japan) and Mr Somhlaba made the following statement on setting catch limits:

‘In research blocks in Subarea 48.6 and Divisions 58.4.1 and 58.4.2, there are two catch limit (CL) candidates, i.e. one is based on the CPUE by seabed area analogy approach and the other on the Chapman mark-recapture approach. As a process of selecting CL, WG-FSA proposes to use the lower CL.

There are large differences between the two candidates with the CPUE-based CL being lower than the Chapman-based CL in many research blocks. If the lower CL is to be used as suggested by WG-FSA, tag-recapture experiments become very difficult to conduct in many research blocks in the next fishing season because the lower CL tends to be much lower than the current CL.

We consider that the Chapman-based approach should be more appropriate than the CPUE-based approach in research blocks where more than several tags were recaptured. This is because the CPUE-based approach has uncertainty associated with such, as selection of reference area, difference in fishing gear and bottom topography between target and reference areas. The Chapman-based approach also has uncertainty associated with it, such as the number of tagged fish available for recapture, but this can be dealt with by having reasonable scenarios of time at liberty for tagged fish.

Considering that the current CLs are considerably smaller than the Chapman-based CL and that a tag-recapture experiment with the current CL has been assisting the progress of stock assessment without apparent decline in CPUE, we propose a realistic approach, i.e. use of the current CL at least for the next fishing season. Setting such a reduced CL without scientific rationale is not an appropriate way for the development of a stock assessment using tag-recapture experiments.

As high priority work, WG-SAM-17 is supposed to discuss various important issues on both approaches and, subsequently, how to set CLs from the point of view of monitoring of stocks, development of the stock hypothesis and precautionary approach. Appropriate mechanisms for the choice of CLs should be set for research plans in Subareas 48.6 and 58.4 at WG-SAM-17.’

4.33 Mr A. Rigaud (France) made the following statement:

‘I would like to support the points raised by Dr Ichii and Mr Somhlaba about the choice of catch limits. I was thinking that the current catch limit (2016) for the next season is appropriate for Divisions 58.4.3a and 58.4.4b.

Setting a radically low CL without scientific rationale is not an appropriate way for the development of stock assessments using tag-recapture experiments.

Moreover, in the case of Ob and Lena Banks (Division 58.4.4b), the design survey (based on a grid) could explain the lower CPUE observed inside both blocks of the area. Indeed, French and Japanese vessels are fishing in all cells of the grid, even if there is no fish (or less fish) in some cells. So that can explain a lower CPUE, hence and the CPUE-based biomass estimate, in this division.

Finally, I support the idea that the setting of CLs needs to be done by the Scientific Committee.’

Management area research reviews

Dissostichus spp. in Subarea 48.2

Subarea research overview

4.34 WG-FSA-16/41 Rev. 1 provided an overview of the research proposed by Chile, Ukraine and the UK in research proposals for Subarea 48.2. This research aims to work toward regional biomass distribution for *D. mawsoni*, develop stock hypotheses for *Dissostichus* spp., obtain information on biological parameters, describe by-catch species biology and distributions and collect oceanographic and bathymetric data.

4.35 The Chilean and Ukrainian research is in the central and southern areas of Subarea 48.2. The UK research is focused on the east of the subarea and aimed at identifying links between Subareas 48.2 and 48.4. The Working Group thanked Chile, Ukraine and the UK for providing an overview of the proposed research activities in Subarea 48.2 and welcomed the Gantt chart of proposed *Dissostichus* spp. research milestones for each of the proponents. The Working Group recommended the development of species-specific timetables as this research progressed and sufficient information becomes available.

4.36 The Working Group discussed possible stock hypotheses for *Dissostichus* spp. in this subarea and their connection with other areas and agreed that tagging data, including the deployment of PSATs, will be useful to inform stock hypotheses for *Dissostichus* spp. in this subarea.

Chilean survey

4.37 WG-FSA-16/35 presented preliminary results from research activities by Chile in this subarea in 2015/16. The vessel arrived on the fishing grounds late and was only able to complete 11 of the planned 30 stations before leaving the study area to avoid overlapping with planned Ukrainian research in the same area. The report showed that tagging was not completed to the standards agreed in the original survey proposal.

4.38 The Working Group recalled Annex 5, paragraph 4.49, that while the time available to complete the survey in 2015/16 was restricted, there had been no information presented as to why the condition of toothfish was too poor for tagging. The Working Group recalled it requested further information be provided at this meeting so that it could evaluate the likelihood the vessels could provide toothfish in suitable condition for tagging if the research were to proceed successfully. WG-SAM-16 also considered that this inability to provide fish in a condition for tagging should be brought to the attention of the Scientific Committee.

4.39 The Working Group noted that the vessel had used trotlines and discussed the suitability of trotlines to obtain fish in suitable condition for tagging and recalled previous research undertaken by Japan on BANZARE Bank and Ob and Lena Banks. This research found that both trotline and Spanish longline gear could obtain sufficient fish in good condition. It also noted from research surveys by Australia and Japan on BANZARE Bank (Division 58.4.3b) that the catches from autoline and trotline gear had similar species composition in areas where *Dissostichus* spp. co-occur.

4.40 WG-FSA-16/34 presented a plan by Chile to continue the longline research survey for *Dissostichus* spp. in this subarea. The proponents acknowledged the difficulties experienced in tagging last year and advised that this year's survey would be accompanied by an experienced tagging technician and the vessel would be equipped with a reanimation tank to increase the survivability of tagged fish.

4.41 The Working Group noted that the vessel proposed for research activities in 2016/17 was the same vessel that failed to meet tagging requirements in 2015/16 and proponents were not able to satisfy the Working Group of the reason for the failure to meet the tagging requirements in 2015/16.

4.42 The Working Group recalled that WG-SAM-16 (Annex 5, paragraph 4.52) requested an analysis of the spatial distribution of grenadier by-catch be presented to WG-FSA along with any information on species composition. The Working Group noted the analysis of the spatial distribution of by-catch did not include the species composition of *Macrourus* by-catch. Chile informed the Working Group that it was not able to analyse the species composition of *Macrourus* by-catch because macrourids had not been identified to species level. Noting that identifying grenadiers to species can be difficult, the Working Group referred the proponents to training resources provided by the Secretariat to assist with this.

4.43 The Working Group recalled the advice from WG-SAM-16 (Annex 5), particularly paragraph 4.49, which requested further information be provided to WG-FSA-16 to allow evaluation of the likelihood that the vessel would be able to provide toothfish in a condition suitable for tagging if the research were to proceed and to fulfil its research commitments successfully.

4.44 Having considered the proposal, the Working Group, with the exception of the Chilean participants, agreed that the advice from WG-SAM-16 regarding this proposal was clear and that it is the view of WG-FSA-16 that the proponents of this research had not followed this advice in full and, therefore, the majority is unable to support the proposed extension of the Chilean survey in 2016/17.

4.45 Mrs P. Ruiz (Chile) recognised deviations from the original proposal and also understood the Working Group's decision to not support the continuation of research, however, requested that the proposal be revaluated by the Scientific Committee.

4.46 The Working Group encouraged Chile to submit a revised proposal to WG-SAM-17 addressing the advice above and that provided by WG-SAM (Annex 5, paragraph 4.49).

Ukrainian survey

4.47 WG-FSA-16/50 provided preliminary results from the first two years of a three-year longline survey undertaken by Ukraine that aimed at estimating the status of *Dissostichus* spp. in this subarea. The Working Group welcomed the analysis of data that Ukraine has collected over the past two years and observed that in both years *D. eleginoides* were predominately observed in the north, while *D. mawsoni* dominated catches in the south of this subarea.

4.48 The Working Group discussed potential stock hypotheses for *Dissostichus* spp. in this subarea. The stock hypothesis for *D. mawsoni* proposed that large adults move from the

Weddell Sea to the southern part of this subarea to spawn, then moved away. The Working Group suggested that this hypothesis may be validated from both conventional and archival tags and PSATs.

4.49 The Working Group noted that none of the large *D. eleginoides* sampled were in spawning condition, despite some of the largest *D. eleginoides* in the Convention Area being observed here. This situation was similar to *D. eleginoides* in Subarea 48.4, which did not exhibit signs of spawning activity when sampled between March and May. The Working Group noted that many biological reasons could contribute to this, but it was presently unknown why this may occur.

4.50 WG-FSA-16/49 presented a revised plan for the third year of the Ukrainian research in Subarea 48.2. The Working Group noted that in 2015/16 the Chilean vessel had left the research area, leaving 68 of the 75 tonne catch limit available for Ukrainian research in the subarea. The catch limit was not sufficient for Ukraine to complete the research with only 27 of the 43 stations completed, including only 3 of the 18 stations in the northern area. The proponents proposed an increase to the catch limit in this subarea to allow this research to be completed in 2016/17.

4.51 The Working Group noted the difficulties experienced by Ukraine in tagging large toothfish while undertaking this research in 2015/16. The Working Group reminded Ukraine of the request from WG-SAM-16 to discuss the problems in tagging large toothfish and referred the proponents to the tagging guide maintained by the Secretariat. The proponents assured the Working Group that they would tag large toothfish that are in good condition in research planned for 2016/17 in the proportion to which they occur in the catch.

4.52 The Working Group noted that only 3 of the 18 stations in the northern area were completed by Ukraine in 2015/16 and requested that Ukraine structure its research to maximise the likelihood of completing stations in both the northern and southern areas in 2016/17.

4.53 Noting the difficulty to evaluate different methods for setting precautionary catch limits, the Working Group recommended to follow the advice from WG-SAM-16/18 Rev. 1 (Annex 5, paragraphs 2.28 to 2.30) and use the CPUE by seabed area method to determine the level of catch that would be consistent with 4% of exploitation within the proposed survey area. This established upper catch limits of 83 tonnes for the northern area and 264 tonnes for the southern area.

4.54 The Working Group supported the proposal by Ukraine to complete the third and final year of the prospecting phase of its research in Subarea 48.2 in 2016/17. Noting that the catch limits proposed by Ukraine were less than those calculated using the 4% exploitation rate, the Working Group recommended a catch limit of 20 tonnes for the northern area and 90 tonnes for the southern area for Ukraine to undertake this research in 2016/17.

UK survey in the eastern area of Subarea 48.2

4.55 WG-FSA-16/40 Rev. 1 presented a proposal by the UK for a three-year longline survey to determine *Dissostichus* spp. population connectivity between Subareas 48.2 and 48.4, and improve the available data on bathymetry and associated distributions of benthic by-catch species. The proposal stated that survey station locations would be reviewed annually and tag-based biomass estimates provided to the Working Group when sufficient tagged fish are recaptured.

4.56 The Working Group discussed the presentation of preliminary biomass estimates in the prospecting phase of research. The Working Group recalled that it was not a requirement to provide biomass estimates in the prospecting phase of a research plan and that some of the terminology could be confusing. The flow chart provided in WG-SAM-16/18 Rev. 1 could be useful to Members in determining the requirements of a research plan.

4.57 Dr Kasatkina noted that the UK and New Zealand survey and those of Chile and Ukraine (WG-FSA-16/34 and 16/49) are aimed at providing data on *Dissostichus* spp. population structures and highlighted that the vessels used autoline while the Chilean and Ukrainian vessels used trotline. Dr Kasatkina noted that the two gear types have significant differences in hook numbers of individual vessels and requested a standard gear type be used by all research in this subarea. Dr Kasatkina noted that there is some evidence that toothfish catch and by-catch depends on gear type and requested a standard gear type be used by all research in this subarea. She was also concerned the failure to use standardised longline gear would result in additional uncertainty in the species length composition and catch rates.

4.58 Dr Kasatkina expressed concern that there was a discrepancy in how the biomass estimate was obtained using a reference area of the southern part of Subarea 48.4 using *D. mawsoni* and that the research undertaken in Subarea 48.2 involves both *Dissostichus* species.

4.59 Dr Söffker stated that the biomass estimates were calculated using the specified reference area and were provided to demonstrate that the expected catches for this effort-limited survey were conservative. The methods used to estimate the catch limits will be improved as the survey progresses and additional information becomes available.

4.60 Dr Darby clarified for the Working Group that the survey was proposed by the UK, the initial proposal (WG-SAM-16/33) had two UK-flagged vessels undertaking this research, one of these vessels was unavailable and has been replaced with a New Zealand-flagged vessel and that both vessels were autoliners and had previously fished in the adjacent Subarea 48.4.

4.61 The Working Group noted that the main objectives in the UK proposal are different to those in the proposals by Chile and Ukraine, the objectives in the research proposed by the UK are not related to catch rates or by-catch rates, and that there is no spatial overlap with the research being undertaken by Chile and Ukraine. Therefore, the gear type is not relevant and the use of the autoline gear type is not an impediment to this research taking place. The Working Group recalled research undertaken by Australia and Japan on BANZARE Bank that compared species compositions of catches obtained using trotline and autoline gear types and found them to be very similar.

4.62 The Working Group noted that no previous catch data was available for this survey proposal and agreed to calculate biomass using the 4% of the biomass estimated using the seabed analogy method (WG-FSA-16 proposed catch limit method ii). The estimated catch limits from this method were of 235 tonnes in the eastern area of Subarea 48.2 and 271 tonnes in the southern area of Subarea 48.4.

4.63 The Working Group supported the proposal by the UK for a three-year research proposal commencing in 2016/17 to develop stock hypotheses and linkages between Subareas 48.2 and 48.4. Noting that the catch limits proposed by the survey proponents were lower than the catch limit suggested by the seabed analogy method, the Working Group recommended catch limits of 23 tonnes in the eastern area of Subarea 48.2 and 18 tonnes in the southern area of Subarea 48.4 and that these limits were sufficiently precautionary to allow the survey to proceed in 2016/17.

4.64 Based on the stock hypothesis that the established fishery in Subarea 48.4 is likely to be the northern component of a larger stock of *D. mawsoni* distributed across Subareas 48.2 and 48.4, the Working Group recommended that the catch limit for this survey area should be considered separate from the catch limit in the established fishery for *D. mawsoni* in Subarea 48.4.

4.65 The Working Group discussed a variety of methods for setting precautionary catch limits when initiating a survey, before any catch data is available, undertaking research in the subsequent years of the prospecting phase before initiating surveys in research blocks. Four potential methods to calculate precautionary catch limits were discussed; they included:

Potential upper limits to the catch –

(i) 4% of the biomass estimated using the CPUE by seabed area method (Annex 5, paragraphs 2.28 to 2.30)

(ii) 4% of the biomass estimated using the seabed analogy method where (*Bx*) defined as

$$Bx = \frac{Ax}{Ar} * Br$$

where *Ax* and *Ar* were the seabed areas of the spatial boundaries proposed by WG-FSA-16/40 Rev. 1 and the Ross Sea respectively in the depth range of 600−1 800 m using the GEBCO 2014 dataset and *Br* was the current biomass from the most recent assessment of the Ross Sea.

Potential survey total catch limits for surveys where previous catch rate data are available –

(iii) the median catch rate from previous surveys multiplied by the number of proposed stations

(iv) the 75th percentile of catch rates from previous surveys multiplied by the number of proposed stations.

4.66 The Working Group noted that it could not adequately evaluate all of these methods because some of them were developed during this meeting. The Working Group requested that WG-SAM-17 evaluate the potential of all of these methods to calculate precautionary catch limits.

4.67 The Working Group noted that the survey was intended to be effort limited in its initial prospecting phase but that in some cases catch limits have been restrictive and not allowed the surveys to be completed. The Working Group discussed whether increases in the catch limits or reducing the effort, either by reducing the number of hooks set or shortening the line length, are required in such situations.

4.68 The Working Group noted that an effort-limited survey with a spatial separation of survey stations had been suggested by WG-SAM-13 (SC-CAMLR-XXXII, Annex 4, paragraph 2.7, especially (i); SC-CAMLR-XXXII, Figure 1) as an alternative to providing a catch limit for effort-limited surveys undertaken during the prospecting phase of research. An upper catch limit should still be calculated to prevent overexploitation, while at the same time allowing the survey to be completed.

4.69 The Working Group recalled the flow chart describing key aspects of prospecting, biomass estimation and assessment (SC-CAMLR-XXXII, Annex 6, Figure 10). The Working Group recommended that WG-SAM-17 consider the methodology and assumptions underlying this figure and update it as necessary to provide a reference paper that can be used by future survey proponents.

D. mawsoni in Subarea 48.5

4.70 WG-FSA-16/15 Rev. 1 presented a Russian proposal for a three-year longline survey in the eastern region of the Weddell Sea. The survey proposed to collect biological data and undertake tagging to estimate the stock status of *D. mawsoni* in Subarea 48.5.

4.71 The Working Group recalled Annex 5, paragraph 4.71, and noted that it had yet to have the opportunity to review an analysis requested by the Scientific Committee (SC-CAMLR-XXXIII, paragraph 3.232; SC-CAMLR-XXXIV, paragraphs 3.271 and 3.272) on the catch rates in Subarea 48.5 observed in the surveys undertaken by Russia in 2013 and 2014.

4.72 The Working Group recalled that the situation with this survey proposal in Subarea 48.5 has not changed since 2014 (SC-CAMLR-XXXIII, paragraphs 3.230 to 3.233), and WG-FSA was thus still unable to evaluate this research proposal in its current or previous formats. The Working Group referred to the discussions at WG-SAM-15 (SC-CAMLR-XXXIV, Annex 5, paragraph 4.10) recommending that the data concerned remain quarantined until such time that a complete analysis has been undertaken and submitted for consideration by WG-SAM, WG-FSA and the Scientific Committee. No analysis was available for WG-FSA-16 to review.

4.73 Dr Kasatkina recommended that the present proposal should be considered because it would be undertaken by a new vessel and Russia had invited another Member to participate in the survey. Dr Kasatkina further noted that a Ukrainian observer would be on board the Russian vessel for the survey.

4.74 The Working Group noted that this proposal was identical to WG-SAM-16/25 and that it was the conclusion from WG-SAM-16 (Annex 5, paragraph 4.74) that the proposed survey design was not suitable and had been based on quarantined data.

4.75 At the time of adoption, Dr Kasatkina stated that the situation of the quarantined Russian data is the responsibility of SCIC but not of WG-FSA.

4.76 The Working Group noted that the maps provided in WG-FSA-16/15 Rev. 1 showed varied sea conditions and difficult sea-ice conditions in the proposed working areas and their access routes and questioned how likely it was that vessels would be able to return to research locations to recapture tagged fish.

4.77 Dr Kasatkina noted that an analysis of sea-ice conditions was provided in WG-FSA-16/15 Rev. 1. According to this analysis and experience from previous surveys, vessels would be able to carry out the survey with the proposed design.

4.78 The Working Group recalled the advice from WG-SAM-16 to undertake a sea-ice analysis using the method proposed by WG-FSA-14/54 and encouraged Russia to liaise with the Secretariat to undertake such an analysis.

Dissostichus spp. in Subarea 48.6

4.79 The exploratory fishery for *Dissostichus* spp. in Subarea 48.6 operated in accordance with CM 41-04 and associated measures. In 2015/16, the catch limit for *Dissostichus* spp. was 538 tonnes. Fishing was conducted by two vessels using longlines, and the total reported catch up to 14 September 2016 was 240 tonnes. Fishing was carried out in research blocks 486_1 to 486_4 and a total of 40 tagged *D. mawsoni* and four tagged *D. eleginoides* were recaptured. Details of this fishery and the stock assessment are contained in the Fishery Report.

4.80 The Working Group noted that WG-SAM-16 had considered five papers relating to research plans and results of research conducted in Subarea 48.6 and had made a number of recommendations concerning the research proposals for 2016/17 (Annex 5, paragraph 3.40). These included focusing on *D. mawsoni* in research blocks 486_2, _3 and _4 and the use of PSATs to provide data on movement between research blocks to help develop the stock hypothesis. It also recommended further analyses be carried out and a report submitted to WG-SAM-17, including analyses of sea-ice dynamics in the continental shelf region and an analysis of tag movement data to assist with the development of the stock hypothesis.

4.81 The Working Group considered three papers – an updated progress report by Japan and South Africa (WG-FSA-16/56), an updated joint proposal to continue research fishing in Subarea 48.6 submitted by Japan and South Africa (WG-FSA-16/32 Rev. 1) and a proposal for three years of planned research fishing by Uruguay (WG-FSA-16/59).

4.82 WG-FSA-16/56 showed that there had been eight between-season tag recaptures from research block 486_3 and 11 between-season tag recaptures from research block 486_4. The report also summarised the timeline for various activities for the next five years, culminating in a stock assessment in 2020.

4.83 The Working Group welcomed the development of timelines in the research plan. It noted that the research proponents had dropped research block 486_1 as requested by WG-SAM and would now focus on research blocks 486_2, _3 and _4 during 2016/17. Research fishing would now focus primarily on *D. mawsoni* which should be reflected in the conservation measure for this area.

4.84 The Working Group noted that details about PSATs were still being developed, including the number of tags to be released, who would be deploying them and where they would best be deployed. The Working Group recalled discussions at WG-SAM (Annex 5, paragraphs 3.29 and 3.30) where it was considered that deployment in ice-free areas in research blocks 486_2 and _3 might be more useful rather than research block _4 which was often covered in sea-ice.

4.85 The Working Group discussed the timeline for the development of an integrated assessment for this subarea. It noted that there had already been four years of research, and that the plan indicated that a preliminary CASAL model was planned for 2017 and a final model for 2020. The Working Group recalled that the integrated stock assessment of *D. mawsoni* in the Ross Sea had taken about six years from the onset of tagging in 2000 until the acceptance of the model by the Scientific Committee in 2006. The Working Group noted that it may be more difficult here where there is a high degree of variability in sea-ice affecting the ability to release and recover tagged fish that will provide adequate data for an integrated assessment within a specific period of time. The Working Group agreed that it was difficult to forecast the time required to achieve a full stock assessment and that the Scientific Committee and Commission should have a realistic expectation about how long this takes.

4.86 The Working Group noted that the time to develop stock assessments was longer than initially thought, and that this needs to be taken into account when considering uncertainty and setting precautionary catch limits in these areas.

4.87 The revised joint research plan by Japan and South Africa for the 2016/17 fishery (WG-FSA-16/32) included an update of the hypothetical life cycle for *D. mawsoni* in this subarea and the adjacent Divisions 58.4.1 and 58.4.2, biomass estimates for research blocks based on Chapman and CPUE by seabed analogy, and the results of a preliminary stock assessment for *D. mawsoni* in research block 486_2.

4.88 The Working Group agreed that the hypothetical life cycle was very useful and encouraged further work in this area. It noted that most tagged fish in research blocks 486_2 and _3 were recaptured within 1–2 years of liberty, whereas fish on the continental margin in research block 486_4 were still recaptured after four years at liberty. The Working Group also noted that this was similar to the situation in Subarea 88.1, where fish in the north were generally caught within 1–2 years at liberty, while fish on the slope and shelf of the Ross Sea were still recaptured after 10 years at liberty (WG-FSA-15/39).

4.89 The Working Group also discussed progress on the preliminary CASAL assessment model in research block 486_2. The Working Group noted the increasing prevalence of IUU fishing in this subarea in recent years (WG-FSA-16/24) and discussed how to incorporate the uncertainty arising from the unknown IUU catches into the stock assessment models. The Working Group noted that the lack of knowledge over IUU catches had also limited the development of CASAL stock assessments in Divisions 58.4.3a and 58.4.4 (e.g. SC-CAMLR-XXXIV, Annex 7, paragraphs 6.92 and 6.93).

4.90 The Working Group thanked Dr K. Taki (Japan) for the large amount of work that he and his colleagues had done in trying to develop stock assessments of toothfish in Subarea 48.6 and other divisions and acknowledged the difficulties that the lack of information on IUU catches posed. The Working Group also noted that if IUU catches were likely to form a substantial part of the overall catch, then it was necessary to include those IUU catches into a stock assessment so that an estimate of B_0 and hence stock status could be estimated. Estimates of B_0 and stock status are also necessary for projections to be carried out and management advice to be provided in accordance with CCAMLR decision rules. Therefore, there was a need to develop a methodology, at least in the short term, for developing an approach for providing precautionary management advice on toothfish which may not require an estimate of B_0 (SC-CAMLR-XXXIV, Annex 7, paragraph 4.117).

4.91 The Working Group also agreed that, while there might be considerable uncertainty in the estimate of B_0 from the CASAL assessments, the estimates of current biomass arising from the assessments would be less uncertain. It considered that these could potentially be used to provide estimates of recent trends in stock size.

4.92 The Working Group considered that this was a matter which needed to be addressed with some urgency and agreed that this would be a useful focus topic for WG-SAM. It requested WG-SAM consider the following questions:

(i) Can we bound the likely estimates of IUU catches in these locations?
(ii) How can we use recent trends in stock size in management advice?
(iii) How can we formalise uncertainty in IUU into the assessment?
(iv) Is there a precautionary harvest rate that can be used until a formal stock assessment can be carried out?

4.93 The Working Group noted that currently no procedure had been established on how to progress from the estimation of toothfish biomass for a research block to the development of a stock assessment for an entire division or subarea. It also noted that there may be a need to collect additional data to facilitate this procedure and that consideration of these factors could also be included in the recommended focus topic for WG-SAM-17.

4.94 Dr T. Namba (Japan) presented some preliminary options for changes to the research block boundaries in Subarea 48.6. He noted that Japan would like to retain the same catch limit for research block 486_2 but to extend or change its boundaries to better understand the distribution of *D. mawsoni* in this region and to fully utilise the existing catch limits. He presented three options for alternative research blocks which had similar underlying water temperatures at 2 000 m. He also noted that Japan had been unable to conduct fishing in research block 486_5 due to heavy ice conditions and suggested that a new research block be included in a potential spawning area in SSRU 5842A (in the southwest of Division 58.4.2).

4.95 The Working Group noted that the water temperatures in research block 486_2 were based on modelled data and recommended that conductivity temperature depth probe (CTD) data loggers be deployed on the longlines so that the relationship between water temperature and depth and catch rates could be better evaluated. Dr Namba informed the Working Group that Japan was hoping to deploy data loggers in the near future.

4.96 The Working Group noted that at the WG-SAM-16 meeting, Japan had proposed an extension of research block 486_2 to the northeast, which would increase the possibility of the catch limit being taken, but could dilute the fishing effort in the current research block (Annex 5, paragraphs 3.33 to 3.35). In one of the preliminary options presented to the meeting, the western part of research block 486_2 would be replaced by a new research block.

4.97 The Working Group noted that research block 486_5 had not been revisited in the last three years due to ice conditions and agreed that there could be few tagged fish available for recapture. However, it noted that the new proposed research block under consideration in the south was in a different division and questioned whether there were any other regions on the continental shelf/slope within Subarea 48.6 that could be used as an alternate research block. The proponents of the research plan indicated that a proposal to extend research block 486_2 and to develop a new research block on the continental shelf region would be submitted to

WG-SAM-17. The Working Group requested Japan provide information on the resulting changes in the numbers of available tagged fish in the research blocks under the various options.

4.98 The Working Group also considered an updated three-year research plan by Uruguay to conduct fishing in Subarea 48.6 (WG-FSA-16/59). The proposal is based on the joint Japanese/South African research with several additional features, including the deployment of 12 PSATs, otolith microchemistry analysis, the use of cameras to monitor target catch and by-catch species, the tagging of skates in accordance with Year-of-the-Skate protocols and an analysis of differences in skate by-catch between Subareas 48.3/48.4 and 48.6. The proposal considered that it would use up to 50% of the total catch limits currently in place for the subarea.

4.99 The Working Group noted that WG-SAM had requested several revisions to the previous proposal, including clarification of the science objectives, plans for analysis of samples, and other data inputs for stock assessments (Annex 5, paragraphs 3.38 and 3.39). It had also recommended that Uruguay collaborate with Japan and South Africa over both on-water and off-water activities.

4.100 The Working Group noted that the scientific objectives in the revised plan were essentially unchanged from that submitted in the paper to WG-SAM (WG-SAM-16/12). However, the revised plan had included a timetable of the various on-water and off-water activities, including analysis of samples and data analysis continuing out to 2019.

4.101 The Working Group also discussed the level of cooperation that occurred amongst research proponents. It noted that there was evidence of close collaboration between South Africa and Japan in WG-FSA-16/32 Rev. 1 and 16/56, while an independent proposal had been submitted by Uruguay (WG-FSA-16/59). The Working Group noted that the proposal by Uruguay was not available for consideration by the Working Group until 10 days after the paper submission deadline.

4.102 The Working Group noted that the proposal by Uruguay stated that it would work with Japanese and South African scientists to ensure there was no spatial or temporal overlap between the vessels. The Working Group questioned whether this was a useful aspect of the survey design and noted that research designs that allowed for comparisons between different vessels when taking into account spatial and temporal variability could also be considered.

4.103 The Working Group noted that only two skates had been reported as by-catch from this subarea since 2004 (Fishery Report 2016: Exploratory fishery for *Dissostichus* spp. in Subarea 48.6, Table 4). It agreed that it would be useful to collect data from the subarea using another vessel and gear type to better understand the reason for the lack of skate by-catch in this subarea.

4.104 The Working Group examined trends in unstandardised CPUE in each of the research blocks and noted that there had been a decline in CPUE in research block 486_3 over the last three years. Dr Taki noted that this was partly because the *Koryo Maru No. 11* had started fishing in this research block in which it had less experience and a lower CPUE and there had also been fishing on an eastern seamount in the research block which also had a lower CPUE. When the CPUE was recalculated excluding these data, the trend increased and then declined in the final year.

4.105 Dr A. Constable (Australia) considered that if the time series of CPUE is rejected, then the time series of tag data should also be rejected.

4.106 The Working Group noted that the catch limit of 50 tonnes in this research block had been taken in each of the last three years. It also considered that if the research catch was set at 7 tonnes (the lowest value from Table 1) then this was unlikely to provide sufficient tag recaptures to develop an assessment for this research block.

4.107 Dr Ichii noted that in some research blocks there have been sufficient tags recaptured to have reliable Chapman estimates. For example, in research block 486_3, five between-season tagged fish had been recaptured in 2014/15 and eight between-season tagged fish had been recaptured in 2015/16. The median biomass and 95% confidence intervals of the Chapman biomass estimates from this research block were calculated by Dr Taki in WG-FSA-16/32 Rev. 1 for each year of recapture. Even when only the first year of recaptures was considered, the biomass estimate at the lower 95% confidence intervals for each of the past two years equalled 1 256 (2015) and 1 303 (2016) tonnes and suggested a catch limit of 50 to 52 tonnes at an exploitation rate of 4%. He therefore considered that the retention of the existing catch limit of 50 tonnes was sufficiently precautionary.

4.108 The Working Group supported WG-SAM in its desire to progress the development and consideration of variance and associated confidence intervals when using these biomass estimates for providing advice (Annex 5, paragraphs 2.44 and 2.45) and noted that this is important to the development of WG-FSA's advice to the Scientific Committee (paragraph 4.21).

Dissostichus spp. in Divisions 58.4.1 and 58.4.2

4.109 The exploratory fisheries for *Dissostichus* spp. in Divisions 58.4.1 and 58.4.2 operated in accordance with CMs 41-11 and 41-05 respectively, along with associated conservation measures, in 2015/16.

4.110 In 2015/16, the catch limit for *Dissostichus* spp. was 660 tonnes in Division 58.4.1 and 35 tonnes in Division 58.4.2. Fishing in Division 58.4.1 was conducted by three vessels using longlines, with the total reported catch up to 14 September 2016 of 402 tonnes. No fishing had been conducted in Division 58.4.2 to 14 September 2016. Details of these fisheries are contained in the Fishery Reports.

4.111 For 2016/17, a total of five vessels, one each from Australia, France, Japan, the Republic of Korea and Spain, have notified their intention to participate in the exploratory fishery for *Dissostichus* spp. in Divisions 58.4.1 or 58.4.2.

4.112 WG-FSA-16/30 described the recent history of exploratory fishing between 2011/12 and 2015/16 in Divisions 58.4.1 and 58.4.2. Four of the notifying Members have conducted research fishing during this period, Australia (commenced 2015/16), Japan (commenced 2012/13), Korea (commenced 2011/12) and Spain (commenced 2012/13), while France plans to start in 2016/17.

4.113 WG-FSA-16/29 described the coordinated research objectives, milestones and a plan for the allocation of catches in Divisions 58.4.1 and 58.4.2 among the five notifying

Members. This coordinated proposal includes updated research plans of Australia, France, Japan, Korea and Spain, as discussed in WG-SAM-16 (Annex 5, paragraphs 3.12 to 3.14).

4.114 Research fishing has occurred in all research blocks in Division 58.4.1 (i.e. 5841_1 to 5841_5) and research block 5842_1 in Division 58.4.2. Spain has conducted additional sampling outside of research blocks across multiple years within SSRUs 5841C, D, G and H to collect data for the estimation of local biomass using depletion experiments and tagging.

4.115 Research activities in six existing research blocks (5841_1, 5841_2, 5841_3, 5841_4, 5841_5, 5842_1) plus a new proposed research block (5841_6) were proposed for 2016/17. The new proposed research block is to recapture fish tagged by Spain (from 2012 to 2016) and Australia (2016). These locations are expected to contain the highest concentration of previously tagged fish and are likely to be accessible.

4.116 Four research objectives and associated annual milestones were described in WG-FSA-16/29:

(i) collect data required for an assessment of the status and productivity of toothfish stocks in Divisions 58.4.1 and 58.4.2

(ii) collect and utilise environmental data to inform spatial management approaches

(iii) collect data on the spatial and depth distributions of by-catch species

(iv) improve understanding of trophic relationships and ecosystem function.

4.117 WG-FSA-16/29 proposed that notifying Members will confirm whether they intend to pursue research by SC CIRC by 1 January 2017. If any Members are not able to confirm that they will pursue research, their allocation will be evenly redistributed amongst the other notifying Members that have confirmed they will pursue research. If any Members have not commenced research fishing by 28 February 2017, their allocation will also be evenly redistributed amongst the other Members that have commenced research fishing, or in another way agreed by all of these other Members.

4.118 The Working Group recommended that the new proposed research block 5841_6 should be opened on an interim basis, with the results to be reviewed by WG-SAM and WG-FSA in 2017.

4.119 The Working Group welcomed plans for increased coordination between all proponents of research in Divisions 58.4.1 and 58.4.2 to facilitate progress towards stock assessment in these divisions, as requested by WG-SAM-16. The joint, multi-Member research proposal reduced the number of proposals for these divisions from several papers submitted by each proponent to WG-SAM-16, to one paper covering the same research at WG-FSA-16.

4.120 The Working Group agreed that the research plan in WG-FSA-16/29 was appropriate to achieve its objectives.

4.121 WG-FSA-16/06 presented information on the diet composition of *D. mawsoni* in Divisions 58.4.1 and 58.4.2 inferred from fatty acid stable isotope analysis. This study found no significant difference of isotope ratios among sampling area, body size, sex and gonadal maturity groups, indicating the captured fish occupied a similar trophic level.

4.122 WG-FSA-16/07 summarised research by the Republic of Korea concerning the occurrence of perfluorinated compounds in muscle tissues of *D. mawsoni* in Divisions 58.4.1 and 58.4.2. The Working Group requested the Scientific Committee consider a review of bioaccumulation in Antarctic fauna, particularly its potential effects on toothfish reproduction.

4.123 WG-FSA-16/08 summarised the results of a PSAT study on *D. mawsoni* in the Mawson Sea. Information representing the vertical movements from one tagged fish over 366 days was separated into four periods representing different ranges in vertical movements during each period.

4.124 The Working Group discussed whether some of the vertical movements reported in the Korean study might be related to spawning behaviour, such as depth of spawning, because it occurred during late winter when *D. mawsoni* are known to spawn, and further noted that Japan is planning to conduct experiments using PSATs in Subarea 58.4 in the future. The Working Group also noted that behavioural data from PSAT studies could be combined with oceanographic models in the future to evaluate stock hypotheses in these divisions.

4.125 WG-FSA-16/58 presented work on the age and growth of *D. mawsoni* in Division 58.4.1 by Spain from otoliths collected on research fishing in 2012/13, 2013/14 and 2015/16. Preliminary age–length keys have been presented from over 1 000 otoliths collected in the first two seasons. Spain intends to age the otoliths collected in 2015/16 as well as re-read the otoliths from 2013/14 to evaluate inter-reader variation in age estimation. It expects to present the final results to WG-SAM-17.

4.126 The Working Group discussed the merit in having a coordinated and/or centralised ageing program for *D. mawsoni* in the CCAMLR area. It noted that a coordinated and/or centralised ageing program could be particularly important for exploratory fisheries and requested that the Scientific Committee consider mechanisms to facilitate funding and implementing a coordinated and/or centralised ageing program for *D. mawsoni*.

D. eleginoides in Division 58.4.3a

4.127 The exploratory fishery for *D. eleginoides* in Division 58.4.3a operated in accordance with CM 41-06 and associated measures. In 2015/16, the catch limit for *D. eleginoides* was 32 tonnes and no fishing had been conducted to 14 September 2016. Details of this fishery and the stock assessment are contained in the Fishery Report.

4.128 WG-FSA-16/55 presented the research plan for the exploratory longline fishery for *D. eleginoides* in 2016/17 in Division 58.4.3a by France and Japan. The biomass in Division 58.4.3a was estimated at 603 tonnes using the Chapman method with a single-population approach. In response to WG-SAM-16 (Annex 5, paragraph 3.18), WG-FSA-16/55 highlighted plans of France and Japan to develop a procedure to estimate IUU removals in Division 58.4.3a for presentation to WG-SAM-17.

4.129 The Working Group noted that, due to technical issues with the *Saint André,* France does not intend to fish in Division 58.4.3a in the end of the 2015/16 season. France noted that the catch limit for the end of 2015/16 would be available to Japan.

4.130 The Working Group thanked the proponents for their multi-Member research plan and considered that the coordination between proponents will accelerate progress towards the development of robust management advice. The Working Group welcomed plans for an intersessional meeting between France and Japan in January 2017.

4.131 The Working Group noted that the variable timing of fishing in Division 58.4.3a towards the end of the fishing season can create a situation where the vessels fish the catch limits for two fishing seasons back-to-back within the same voyage. The Working Group noted that:

(i) such a seasonal fishing pattern could cause a high fishing mortality on the fish stock within a short period

(ii) this should be considered when making assumptions about the timing of natural mortality and tag recapture within models that utilise tagging data

(iii) tagged fish were unlikely to mix between release in the first fishing season and recapture in the subsequent season.

4.132 The Working Group recommended that a monthly time step be used in tag-recapture models to estimate biomass that can account for variable timing of fishing and that a minimum period of time at liberty between tagging and recapture of a fish should be introduced (such as the six months currently used in the toothfish assessment in Division 58.5.1). The Working Group also recommended that further investigations on the implications of double fishing mortality in fish stocks during a short time be undertaken in the intersessional period, such that the potential for spatial and temporal concentration of fishing mortality can be considered when setting catch limits.

4.133 The Working Group noted that the 4% exploitation rate for research block 5843a_1, based on the Chapman biomass estimate, was 52 tonnes (Table 1).

Management advice

4.134 The Working Group supported the continuation of the proposed research in Division 58.4.3a. The Working Group recommended that the catch limit for this division remain unchanged at 32 tonnes for 2016/17.

D. eleginoides in Divisions 58.4.4a and 58.4.4b

4.135 The Working Group noted one French- and one Japanese-flagged vessel conducted research fishing in Division 58.4.4b in 2015/16 under CM 24-01, with a research catch limit for *D. eleginoides* of 25 tonnes in research block 5844b_1 and 35 tonnes in research block 5844b_2 for 2015/16 (SC-CAMLR-XXXIV, paragraphs 3.265 and 3.267). No research fishing had taken place in this division in 2015/16 by the time of the meeting of WG-FSA-16.

4.136 WG-FSA-16/33 Rev. 1 presented the revised research plan for the 2016/17 toothfish fishery in Division 58.4.4b by Japan and France. Median stock sizes in research blocks 5844b_1 and 5844b_2 were estimated using both the Chapman and seabed analogy methods. Biological data were discussed in the context of toothfish stock hypotheses for this region. WG-FSA-16/33 Rev. 1 also presented data on the spatio–temporal occurrence of whales (mainly killer whales (*Orcinus orca*)) and observed interactions between whales and fishing operations. The proponents intend to continue this research in 2016/17 with the same survey design.

4.137 The Working Group noted that, due to technical issues with the *Saint André*, France does not intend to fish in Division 58.4.4b in the end of the 2015/16 season. France noted that the catch limit for the end of 2015/16 would be available to Japan.

4.138 The Working Group noted that orcas are photographed on an opportunistic basis for the purpose of identification of individuals, and that depredation rates have been considered, however, no recent estimates are currently available. The Working Group also highlighted the need to consider whether depredation would affect availability of tagged fish in this fishery (e.g. if tagged fish are released when killer whales are near the fishing vessel).

4.139 WG-FSA-16/33 Rev. 1 outlined the intention of Japan and France to investigate toothfish movements using PSATs and to provide a tagging plan to WG-SAM-17. The Working Group welcomed plans for ongoing investigation of toothfish movements in this area.

4.140 The Working Group noted that, while providing new knowledge on vertical movement of toothfish, satellite tagging has to date given very little information on the horizontal movements of toothfish due to the difficulty of establishing fish positions. The Working Group recommended intersessional discussion between interested Members about methods to estimate the geographic locations of tagged fish, necessary numbers of satellite tags and the most appropriate tagging regimes.

4.141 The Working Group noted that candidate catch limits for this division for 2016/17 are 14 tonnes in research block 5844b_1 (based on a Chapman biomass estimate) and 20 tonnes in research block 5844b_2 (based on a CPUE by seabed area biomass estimate). These candidate catch limits are based on (i) the approaches to estimating biomass that were agreed at WG-SAM-16, (ii) an exploitation rate of 4%, and (iii) selection of the smaller candidate catch limit (Table 1).

4.142 Mr Rigaud suggested that the current catch limit be carried forward to the forthcoming season (paragraphs 4.32 and 4.33).

4.143 Mr Rigaud noted that the method for determining catch limits should be consistent across research blocks 5844b_1 and 5844b_2.

Management advice

4.144 The Working Group supported the continuation of this research program. Paragraphs 4.18 to 4.34 summarise the discussion across the Working Group regarding research catch limits.

D. mawsoni in Subarea 88.3

4.145 The Scientific Committee agreed to one Korean-flagged vessel conducting research fishing in Subarea 88.3 in 2015/16 under CM 24-01, with a total research catch limit for *D. mawsoni* of 171 tonnes across five research blocks in 2015/16 (SC-CAMLR-XXXIV, paragraph 3.288). Research fishing took place in February and March 2016 with a catch of 106 tonnes of *D. mawsoni* (WG-SAM-16/29).

4.146 WG-SAM-16 reviewed the results from research activities undertaken by the Republic of Korea (WG-SAM-16/29) and the proposal for continuation of this research (WG-SAM-16/11). No issues were identified with these submissions at WG-SAM-16. Therefore, WG-SAM-16/29 and 16/11 were resubmitted to WG-FSA-16.

4.147 The Working Group supported the proposal presented by Korea on the basis that (i) there were no issues identified in the proposal at WG-SAM-16 (Annex 5, paragraph 4.37) and (ii) that no changes have been made to the proposal since WG-SAM-16.

4.148 The Working Group recommended that advice from the Scientific Committee (SC-CAMLR-XXXIV, paragraph 3.290) on this research proposal would remain in place such that the priority for research should be research blocks 883_3 (with a catch limit of 31 tonnes) and 883_4 (52 tonnes) given the previous tagging in those areas. Research block 883_5 (38 tonnes) would be a secondary priority, with research blocks 883_1 (21 tonnes) and 883_2 (29 tonnes) a tertiary priority, should ice conditions allow.

Notothenioids in Subarea 48.1

4.149 The Working Group considered five papers that reported on the results and proposal for a Chilean research survey around Elephant Island and the South Orkney Islands in Subareas 48.1 and 48.2 which included the results of the hydroacoustic survey (WG-FSA-16/21), analysis of bird assemblages (WG-FSA-16/20), analysis of spawning patterns of notothenioids (WG-FSA-16/22), report on cetacean survey (WG-FSA-16/19) and the proposal for the continuation of the research of fish distribution into the second year around Subareas 48.1 and 48.2 (WG-FSA-16/31).

4.150 WG-FSA-16/31 reported on the proposal for the trawl and midwater research plan for the second year around Elephant Island and the South Orkney Islands by Chile. A revised version of this plan was also presented during the meeting where catches that were proposed in the original paper were unchanged from 50 tonnes in Subarea 48.1 and 50 tonnes in Subarea 48.2 and the increase in number of trawls (from 40 to 80) to be sampled around both islands.

4.151 The Working Group recalled the discussion and a recommendation by WG-SAM-16 regarding the plan as presented in WG-FSA-16/31, particularly the difference between what was proposed by Chile in its 2015 research proposal and agreed by the Scientific Committee in 2015 and the outcome from the survey that took place when the research was conducted in 2016 (Annex 5, paragraphs 4.63 to 4.67).

4.152 The Working Group noted the proposed changes made to the proposal during WG-FSA-16. It noted a lack of clarity in rolling over catch limits which were set based on the particular design of the research plan, and the long-term objectives of the research and their relevance to CCAMLR work. It further noted concerns about spatial scale in which the research is to be conducted (Subareas 48.1 and 48.2) where the catchability of both midwater and bottom trawl are to be compared and the Working Group noted that this research could be focused in one subarea. The Working Group recalled previous demersal fish bottom trawl research that has been conducted by Germany and the USA in these areas and that there could be value to CCAMLR if Chile could initiate a similarly designed survey.

4.153 The Working Group thanked Chile for presenting the revised plan and recommended that the revised research plan be presented to WG-SAM-17 and WG-FSA-17 for a full revaluation due to the limited time available to investigate various changes that have been made to the plan.

4.154 The Working Group welcomed, and thanked Chile for presenting, the analysis of the ancillary data (WG-FSA-16/20, 16/22 and 16/19) and it highlighted the importance of recording and analysis of data on various components of the ecosystem when it is possible to do so during the fish surveys. The Working Group further expressed its desire for this kind of work to be shared with other CCAMLR working groups such as WG-EMM and possibly other management organisations such as the International Whaling Commission (IWC).

4.155 The Working Group noted the results of the acoustic and trawl surveys presented by Chile (WG-FSA-16/21). It also noted that there could be a benefit if acoustic data were presented to SG-ASAM and other acoustic surveys previously done be taken into account when *C. gunnari* acoustic survey data are analysed.

Scheme of International Scientific Observation (SISO)

5.1 Data collected by scientific observers on longline and finfish trawl vessels operating in the Convention Area during 2015/16, based on data received up to 19 September 2016 (WG-FSA-16/01), were presented by the Secretariat. The Secretariat noted that this season the French seabird mortality data were analysed in a format consistent with other subareas and divisions, which allowed the seabird mortality tables to be simplified. Overall, it was noted that seabird by-catch figures for this season were slightly higher than in the past few reporting periods, however, they were still at low levels compared with historic data.

5.2 Preliminary results on conversion factor data collection trials voluntarily carried out by South African observers were also presented. While the results were limited due to a low number of comparable processing codes and cut types between vessels, they did show significant variability in conversion factors between a small number of vessels, with the position of the cut on the fish a significant explanatory variable in conversion factor differences. The Working Group thanked the South African observers for the voluntary collection of extra data. The Secretariat noted that more data are required to assess conversion factor variability across the fleet, and invited more Members to participate in the trial in the coming season. Mr Maschette noted that observers on Australian vessels would be willing to assist in further data collection trials.

5.3 The Working Group thanked all Scheme of International Scientific Observation (SISO) observers for their contribution to scientific data collection this season. Collectively, the observers in the Convention Area have collected over 500 000 biometric measurements in 2015/16.

5.4 A new guide for by-catch taxa in the longline and krill trawl fisheries was presented by the Secretariat (WG-FSA-16/17) after development with Members during the last intersessional period. The Working Group thanked the Secretariat for collating various identification guides and commented favourably on the content and format of the new guide. The Secretariat noted that this guide can be developed more if Members desired and requested Members to provide more images and materials to contribute to future editions.

5.5 Dr Söffker presented WG-FSA-16/43 detailing a camera monitoring trial for collection of catch and by-catch data in Subarea 48.3. The system showed advantages for the observer in terms of safety and reducing time spent collecting data during hauling. Comparison between numbers recorded at hauling and numbers seen whilst viewing the video showed very consistent agreement, other than for small organisms with more small taxa noted by observers. It was noted that the use of video analysis software was likely to allow for data analysis automation.

5.6 The Working Group noted that camera monitoring may help reduce variability in proportions of target species to non-target species reported within some fisheries. For example, it noted that a trial of this kind of monitoring may be useful in other areas such as Subarea 88.1 where there appear to be different by-catch rates across gear types and Members (WG-FSA-15/04 Rev. 1). The Working Group noted that any progress towards a trial would require a 'step-wise' approach with regard to implementation.

5.7 Mr Gasco presented an updated tool for observer training in identification of a range of broad taxonomic groups including benthos, fish species, whales and birds (WG-FSA-16/11). The tool allows the observer to train at their own pace and is currently being used by French observers.

5.8 The Working Group noted that this updated tool for training, along with all of the images from the CCAMLR by-catch guide, are available for Members' use from the CCAMLR website.

5.9 The Working Group thanked Mr Gasco for developing and providing this new tool, and noted that Mr Gasco has provided a number of valuable tools to Members at no cost, which have helped standardise the training of, and data collection by, observers across the Convention Area.

5.10 Consideration of additional observer matters in relation to by-catch identification is set out in paragraphs 5.11 to 5.14 and 6.21.

5.11 The Working Group welcomed the continuous effort to improve the quality of data collected by scientific observers. To facilitate this and to validate the data for by-catch species currently being submitted, the Working Group considered that more dedicated efforts to compile a photographic catalogue of fish was of high importance in all fisheries, especially for icefish species in krill trawl fisheries.

5.12 The Working Group encouraged national coordinators to provide SISO observers with cameras that allow close-up photography of fish, so that observers can take photographs of good-quality specimens of each species identified in a trip using the following guidelines:

(i) high-quality specimens of identified by-catch fish species encountered should be photographed in fresh condition

(ii) one or two photographs of each species should be taken on a neutral background and with the CCAMLR tag photo template in view

(iii) additional photographs should be taken of any unknown species, or if specimens are taken outside their known geographic, depth or size range

(iv) verified photos should then be submitted to the CCAMLR Secretariat through the observer's technical coordinator

(v) for national observer programs that are collecting samples of by-catch species for genetic analysis, the Working Group requested that national observers take photographs of fresh specimens prior to their analysis in the laboratory, and these photographs be supplied to the Secretariat along with the verified species identification from the genetic or morphometric analysis.

5.13 The Working Group also noted that many national programs already make use of reference collections, especially for the smaller fish species taken in krill and trawl fisheries. The Working Group encouraged all national programs to maintain such a reference collection to assist with training national and SISO observers.

5.14 The Working Group noted that SISO requirements and issues are relevant to the agendas of a number of working groups. This can result in delays in implementing changes on the forms or the instructions for observers, particularly for SISO discussions undertaken during WG-FSA, as any changes are not able to be circulated in time for the new season. The Working Group recommended the Scientific Committee consider the establishment of a dedicated SISO Working Group that could potentially convene in parallel to the other working groups and report to WG-FSA and the Scientific Committee, similar to the operation of the ad hoc Technical Group for At-Sea Operations (TASO) (SC-CAMLR-XXXIV, Annex 6, paragraph 2.43).

Non-target catch and interactions in CCAMLR fisheries

Fish and invertebrate by-catch

6.1 The Secretariat presented WG-FSA-16/04 that provided an update on the fish by-catch in the krill fishery using data from SISO and commercial data to examine the frequency of occurrence, proportion by mass, length-frequency distribution and geographic provenance of the key fish taxa reported. The estimated total annual mass of fish by-catch in a 300 000 tonne krill fishery would be 370 tonnes, comprising 40% *C. gunnari* and 30% *L. larseni*. The length-frequency distribution of all taxa for which >100 fish were measured had a modal size class of <10 cm. The fish species taken as by-catch in the krill fishery are the same species (and size classes) as those reported in the diet of 'krill-dependent' predators.

6.2 The Working Group noted that the recent data indicated that the structured and systematic data collection on fish by-catch in the krill fishery now provides the opportunity for the quantification of fish by-catch and may enable the population dynamics of those finfish species taken in the krill fishery to be monitored more effectively. The Working Group also noted that there may be some difficulties in scaling up total fish by-catch estimates from observer samples on vessels using the continuous fishing system where the catch reported for the two-hour period when the fish by-catch samples was collected may not actually reflect the catch in that period (Annex 6, paragraphs 2.18 and 2.19).

6.3 The Working Group reiterated the need for correct species identifications, including for the early juvenile stages of species that closely resemble each other (e.g. ocellated icefish (*Chionodraco rastrospinosus*) and crocodile icefish (*C. hamatus*)), for which correct identification remains difficult (paragraph 5.12).

6.4 The Working Group recalled that identification guides to improve the identification of fish species that occur as by-catch in krill fisheries are available, including those compiled by CCAMLR in its SISO (WG-FSA-16/17), and guides produced in Japan and the Republic of Korea. The most comprehensive account describing the early life stages of Antarctic fish is still the work of Kellermann (1989). Modern techniques (e.g. microphotography and genetics) may also allow for improved identification and the Working Group encouraged efforts by Members to continue to refine tools available to vessels and observers to provide accurate identification and quantification of by-catch.

6.5 WG-EMM-16/P09 examined the potential relationships between historic fishing on nototheniid taxa and Antarctic shag (*Phalacrocorax bransfieldensis*) by considering the diet of shag as a method of understanding fish dynamics. Results obtained through this method were consistent with results obtained during the US AMLR Program and the German demersal fish program in the South Shetland Islands that used net sampling for marbled rockcod (*Notothenia rossii*) and humped rockcod (*Gobionotothen gibberifrons*) over a period of almost 30 years. The Working Group suggested that research on tracking recruits of *N. rossii* on their way to the offshore adult population would be augmented through a tagging program.

6.6 WG-FSA-16/02 provided an update of a time series of trammel net catches in Potter Cove (King George Islands). The Working Group noted that interpreting these data was difficult as the causes of the patterns seen are likely to be multifactorial, for example, trajectories may differ considerably between species such as *N. rossii* and *G. gibberifrons*. The current development of the two stocks provides no indication that a fishery on the two stocks could be reopened and, therefore, the Working Group agreed with the conclusions of the paper that the current conservation measures preventing targeting of these stocks should remain in place.

6.7 Three species of skate, Eaton's skate (*Bathyraja eatonii*), Kerguelen sandpaper skate (*B. irrasa*) and Murray's skate (*B. murrayi*), are commonly taken as incidental by-catch in fisheries for *D. eleginoides* and *C. gunnari* on the Kerguelen Plateau in the southern Indian Ocean (WG-FSA-16/P03). Data from fishery observations from 1997 to 2014 show that the three skates were distributed widely across the Kerguelen Plateau, showing different spatial distributions, linked mainly with depth. The catch rates of skates from the trawl fisheries in the Australian EEZ surrounding Heard Island and McDonald Islands (HIMI) have shown little evidence of depletion on the main trawl fishing grounds. There was evidence of a decrease in the average total length of *B. eatonii* and further studies of this are required. The paper concluded that the marine reserves and the conservation measures employed by CCAMLR in the HIMI fisheries appear to provide effective protection for skates.

6.8 WG-FSA-16/12 summarised information on the species composition, spatial and vertical distributions, size composition and abundance of morids in the Southern Ocean. The main goal of this work was to contribute to the conservation of these species and minimise the risk from causing adverse effects in stocks of these vulnerable and little-studied species that are a regular by-catch in fisheries for *Dissostichus* spp. The Working Group thanked the authors for providing valuable information to better understand the biology and demography of morid fishes.

6.9 Dr Hanchet gave a presentation on the implementation of the New Zealand data collection plan discussed by WG-FSA in 2015 (SC-CAMLR-XXXIV, Annex 7, paragraph 4.69). He noted that the approach had been successful for icefish (*Chionobathyscus dewitti*) in 2015/16, but required additional focused data collection from other vessels to achieve the target coefficients of variation (CVs) for the other species.

6.10 In addition to the accuracy of species identification, the Working Group noted that the collection of data by three-letter codes could also result in typographical errors. The current CCAMLR data forms do not have appropriate validation at the data inputting stage and any future developments of data forms could usefully incorporate routine data checks (e.g. validation of unusual species, specimens outside known length range; see also paragraphs 7.10 and 7.11).

6.11 CM 33-03 describes the limits for by-catch taken in new and exploratory fisheries. This conservation measure provides catch limits for non-target fish (excluding individuals released alive), currently defined for skates (5% of the catch limit of *Dissostichus* spp., or 50 tonnes, whichever is larger), *Macrourus* spp. (16% of the catch limit of *Dissostichus* spp., or 20 tonnes, whichever is larger) and 'all other species combined' (20 tonnes).

6.12 The Working Group noted that the catch limits for *Dissostichus* spp. are applied at varying spatial scales, depending on the different management areas applied. However, the catch limits for by-catch in CM 33-03 are not applied at the same spatial scales as the catch limits for *Dissostichus* spp. This can result in a lack of clarity on the actual by-catch limit for a research block, as well as catch limits for by-catch actually being higher than the target species in some areas, without any formal assessments supporting these limits.

6.13 The Working Group also noted that CM 33-03 includes additional by-catch mitigation measures (by-catch move on rules, release of live skates and catch limits on *Macrourus* spp.) that aim to minimise by-catch. Consequently, while there are management areas where catch limits for by-catch species are set higher than for target species, these catch limits are unlikely to be attained.

6.14 The Working Group considered that there should be consideration of removing the absolute limits and applying percentage thresholds, including extending the 16% catch limit in place for *Macrourus* spp. to the category 'all other species combined', so that by-catch limits are:

(i) skates and rays: 5% of the catch limit of *Dissostichus* spp.

(ii) *Macrourus* spp.: 16% of the catch limit for *Dissostichus* spp.
(iii) all other species combined: 16% of the catch limit for *Dissostichus* spp.

The Working Group recognised that other consequential changes, including to move-on rules, would need to be introduced into CM 33-03.

6.15 The Secretariat provided details on the catches of *Dissostichus* spp. and associated by-catch in new and exploratory fisheries (Table 2) that indicated that the percentage by-catch limits alone should be a sufficient measure to avoid large by-catch in most SSRUs and research blocks.

6.16 It was noted that 'all other species combined' may also include Somniosidae (sleeper sharks). Whilst these large-bodied sharks are caught very infrequently and accidental catch should 'as far as possible, be released alive' (CM 32-18), there is a potential for the retention of dead specimens to trigger a by-catch limit, if taken in a management area with a low catch limit for *Dissostichus* spp. The Working Group requested that the Secretariat separately report on the by-catch of sleeper sharks in compiling Fishery Reports to enable monitoring of this issue.

6.17 The Working Group considered that the utility of the catch limit CPUE by seabed area method (developed for toothfish) could usefully be explored for by-catch species in the future. Furthermore, analyses of reported by-catch in relation to target catch could usefully be explored to better understand the factors (e.g. depth, location, gear type) that influence by-catch rates. It also recalled that stock assessments had informed catch limits, e.g. the Ross Sea slope and Division 58.5.2 *Macrourus* spp. limits, and encouraged further evaluation of by-catch limits in other areas.

6.18 The Working Group recalled that by-catch reporting is a requirement of the Flag State per CMs 23-01 to 23-07 (SC-CAMLR-XXXIV, paragraph 3.165; SC-CAMLR-XXXIV, Annex 7, paragraph 8.8). However, there are often arrangements between the vessel operators and scientific observers to facilitate identification of by-catch species.

6.19 It was also noted that there was a variety of methods that could be used to fulfil the requirements for reporting the catch weight and number of fish by species on a haul-by-haul basis. Examples of these methods could range from weighing and counting the entire catch of each species in the case of small catches, to the estimation of total catch based on scaling up from the total number of fish counted by the mean weight of a subsample of fish. In order to further understand the reported data on by-catch used for CCAMLR management and regulation, it is requested that Contracting Parties document the procedures used by vessels to satisfy the requirements of CM 23-04 and other measures, such as CM 33-03, which rely on accurate reporting of target and by-catch species.

6.20 The Working Group also noted that CM 23-04 states 'The catch of all target and by-catch species must be reported by species'. Catches of some taxa are, however, often reported at genus or family level. Consequently, there should be consideration of modifying this requirement which also applies to related measures (e.g. 'The catch of all target and by-catch species must be reported by species, or to the lowest taxonomic level possible (e.g. species or genus)').

6.21 The Working Group discussed current CCAMLR data collection methods and protocols (paragraph 7.10) and how they may be improved with the implementation of the new CCAMLR data management systems (SC-CAMLR-XXXV/BG/25), including for recording by-catch. The Working Group agreed that the current Excel-based data forms provide minimal data validation during entry and recommended that in-built validation tools to minimise input and other potential errors at source should be developed in the new forms to improve data quality. The Working Group requested that the Secretariat discuss changes to all CCAMLR data collection forms using an e-group that includes national technical coordinators and representatives from those Members that submit commercial fishing data to the Secretariat.

Bottom fishing activities and vulnerable marine ecosystems (VMEs)

6.22 The Working Group noted that there was one notification of a vulnerable marine ecosystem (VME) risk area in Subarea 88.1 during 2015/16, which brings the total number of VME risk areas to 76 in Subareas 88.1 and 88.2. The VME registry can be found at www.ccamlr.org/node/85695.

6.23 Mr Maschette informed the Working Group that Australia will be investigating seafloor communities and potential VMEs with underwater cameras mounted on longlines in 2016/17. Deployments will be made in toothfish research blocks and exploratory fisheries in Subareas 88.1 and 88.2 and Divisions 58.4.1 and 58.4.2. The Working Group further noted that camera deployments without associated fishing gear may be a valuable method to confirm the presence of VMEs in areas currently closed as a VME risk area under CM 22-07.

6.24 Dr Darby informed the Working Group that UK vessels will be deploying cameras on longlines in Subarea 48.3 to collect information on seafloor communities.

6.25 Dr Jones informed the Working Group that the BBC Blue Planet series will be undertaking 28 days of manned submersible deployments to film several CCAMLR-registered VMEs along the Antarctic Peninsula in December 2016 for an upcoming series on the deep sea.

6.26 Dr Welsford informed the Working Group that an Australian vessel undertook a multi-beam survey in the HIMI region in 2015/16 to explore volcanic activity and detected deep-sea hydrothermal vents (which are considered VMEs) in the region. He further noted that these vents occur in the area protected within the HIMI Marine Reserve.

Marine mammal and seabird by-catch

Marine mammal depredation

6.27 WG-FSA-16/09 presented a data collection framework suitable across different fisheries interacting with odontocetes. The paper provided basic guidelines for observer programs that are new to depredation data collection or wish to expand their observation efforts and data collection, based on 10 years of experience around Kerguelen and Crozet Islands. The Working Group thanked Mr Gasco for the development of this guide, which not only provided a useful guide on data collection but also contributed to standardising data collection across fisheries. The Working Group asked the Secretariat to provide this guide as a reference on the CCAMLR website.

6.28 WG-FSA-16/10 presented an update of depredation estimates in the fisheries around Kerguelen and Crozet Islands, to address a request by SC-CAMLR-XXXIV (paragraph 3.318). This method built on previous work on the CPUE method, including a small-scale spatial cell grid to consider spatial variation in depredation rates. While a large dataset allows to almost always have both true presence and absence observations within a grid cell, when data availability decreases, the CPUE method becomes increasingly difficult to be applied as true presence and absence observations may not both occur within the same grid cell. To achieve annual estimates of depredation, this method calculated the overall catch losses per grid cell and the overall catch losses without the given year per grid cell. The difference provided an estimate of catch loss in a given year.

6.29 The Working Group noted that this novel approach allowed the estimation of a catch loss time series in these fisheries for the first time and would prove useful for other fisheries in the future too.

6.30 The authors clarified that in the case of the Kerguelen and Crozet Islands, the method given here captured the spatial variation better than the GLM CPUE method estimation, due to high spatial variability in the data. However, this would be different for each fishery with different characteristics. The updated time-series estimations were included in the integrated assessments for these fisheries (paragraphs 3.132 to 3.140).

6.31 The Working Group noted that there is an apparent decrease in losses due to depredation around Crozet Islands, which may be tied to the introduction of mitigation measures such as short lines, faster hauling times and strict move-on rules. The Working Group suggested that the data could be examined for correlations between changes in depredation and introduction of mitigation measures, which would also prove useful in evaluating which management measures are most effective. This could also inform management strategies in other fisheries.

6.32 WG-FSA-16/42 summarised the first depredation workshop held by the Coalition of Legal Toothfish Operators (COLTO). The workshop brought together researchers, fishers and industry representatives from Southern Ocean toothfish fisheries and the Alaskan sablefish fishery with experience in depredation from odontocetes.

6.33 The workshop included discussion on longline fisheries mitigation methods, data collection and effects on stock assessments, and concluded with several action points that are further given in SC-CAMLR-XXXV/BG/23. Key outcomes included the establishment of a COLTO-funded postdoctoral fellowship to study depredation and mitigation worldwide, guidance documents on mitigation methods for stakeholders (see WG-FSA-16/09 as an example), and a framework for experimentally testing and scientifically evaluating mitigation methods, in collaboration between fishers and researchers.

6.34 The Working Group welcomed work being progressed in this area, and recalled the similar approach used by the Working Group on Incidental Mortality Associated with Fishing (WG-IMAF) to mitigate seabird by-catch by including fishers, scientific experts and managers together in discussions.

6.35 The Working Group encouraged continuing engagement in the CCAMLR Depredation e-group as a means to exchange information and collaboration. It noted that Dr Söffker created a mailing list for marine mammal depredation (mm-depredation@jiscmail.ac.uk) which also allows non-CCAMLR researchers to exchange information.

Seabird by-catch and mitigation

Hook marking scheme

6.36 WG-FSA-16/03 was a response by the Secretariat to a request from CCAMLR-XXXIV on the requirements of vessel-specific hook markings as a means to identify the origin of recovered offal containing hooks, or hooks found in seabird colonies (CCAMLR-XXXIV, Annex 6, paragraph 223; SC-CAMLR-XXXIV, paragraphs 3.86 and 3.87). The Secretariat discussed these issues with fishing industry representatives, those with experience in hook-marking schemes and gear manufacturers, and presented the conclusions for consideration by the Working Group (WG-FSA-16/03, paragraph 14). Overall, the Secretariat concluded that the administrative, financial (burden on vessels) and implementation burden would be substantial while the issues of offal discarding and hooks in seabird colonies may remain unresolved.

6.37 The Working Group noted that if there are issues with offal discharge as a compliance issue, then this would need to be addressed, however, hooks found in toothfish stomachs may not be definitively indicative of offal discharge. Toothfish are apparently capable of 'grazing' off the longline, ripping hooks and bait off and thus ingesting hooks, and similarly, marine mammals may ingest hooks through depredation. Furthermore, hooks as part of clearly identified offal discharge have been observed on a few occasions only.

6.38 The Working Group noted that feedback from scientific observers deployed in fisheries with hook-marking schemes suggested that hook-marking had a distinct positive effect on the behaviour of the crew and the attitude towards offal management.

Season extensions

6.39 At CCAMLR-XXXIV, a further pre- and post-season extension trial in the longline fishery in Division 58.5.2 was endorsed. This trial is in addition to an existing pre- and post-season trial. WG-FSA-16/28 Rev. 1 summarised information on fishing effort and seabird interactions in the periods 1–14 November 2015, 1–14 April 2016 and 15–30 April 2016. Overall, there was one white-chinned petrel (*Procellaria aequinoctialis*) caught during the new extension trial period (1–14 April 2016), and one grey-headed albatross (*Thalassarche chrysostoma*) was entangled in the streamer line during the trial period 15–30 April 2016. The Working Group recommended that the trial be extended for another season and an update be provided to WG-FSA-17.

Seabird by-catch

6.40 The Working Group noted the table prepared by the Secretariat on the fishery-specific total for the extrapolated seabird by-catch in longline fisheries throughout the Convention Area (Table 3).

6.41 Dr Darby noted that the extrapolated numbers of seabird deaths shown in Table 3 for Subarea 48.3 did not reflect the actual bird by-catch numbers for this subarea, as the vessels operating here report actual bird by-catch. Therefore, the additional scaling by percentage of hooks observed inflates the number of seabird by-catch reported by CCAMLR for Subarea 48.3.

6.42 The Secretariat clarified that the method to estimate total seabird by-catch was developed by WG-IMAF and used the number of seabird deaths reported by observers and the percentage of hooks observed, to extrapolate the total number of seabird by-catch.

6.43 The Working Group acknowledged that application of this method was consistent throughout the time series, and acknowledged that how seabird by-catch is reported to CCAMLR may vary geographically. It noted that in the case of Subarea 48.3, incidental mortality of seabirds was observed on six hauls from two vessels in April 2016.

Net monitoring cable mitigation

6.44 WG-FSA-16/38 introduced a new design for the use of a net monitoring cable in the trawl fishery. Net monitoring cable systems have been prohibited in CCAMLR trawl fisheries since 1994 to minimise bird strikes. The proposed layout of the net monitoring cable in this paper should reduce the aerial extent of the cable by submerging the cable below the surface close to the stern of the vessel through the use of a snatch block. The paper noted that this method follows ACAP's best-practice advice, where no practicable method for avoiding using a third line is available, with the exception of requiring streamer lines.

6.45 The Working Group recalled that when the initial prohibition was declared in 1994, there was no advantage between cable or wireless in terms of the transmitted signal. ACAP had, at the time, been consulted on best practice. Technology has developed significantly since, however, and today the information transmitted through a cable is of better quality and quantity than the use of wireless, which is dependent on e.g. weather or krill density deflecting the signal. Use of a net-monitoring cable allows much finer control over the fishing gear, and for increasingly sophisticated net monitoring activities. The Working Group also recalled that the krill fishery in the CCAMLR area usually trawls at slow speeds, which in itself already reduces the risk of warp strikes.

6.46 The Working Group 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 this trial be reported to WG-EMM, WG-FSA and ACAP to further evaluate the safety of the use of this cable. It noted that the usefulness and conditions of such trials needs to be evaluated on a case-by-case basis. The slower speed of krill vessels, as opposed to finfish vessels, was considered lowering the risk of interaction with the third cable during this trial.

6.47 The Working Group recommended the following requirements for the season trial, in order to monitor and mitigate potential interactions with seabirds and marine mammals effectively:

(i) 100% observer coverage for the trial vessel(s)

(ii) the use of a camera monitoring system that records the full aerial length of the cable and the seaward entry point

(iii) during trawling operations, the mandatory use of two streamer lines as per the specifications set out in CM 25-02, Annex 25-02/A

(iv) the observer(s) conduct IMAF observations on the net monitoring cable twice daily, following the current standard warp strike observer protocols outlined in the SISO krill logbook instructions

(v) the 'snatch block' (WG-FSA-16/38) should be set so that the distance from the stern of the vessel to the point where the net monitoring cable enters the water is less than 2 m

(vi) if there are more than three (3) 'heavy' bird strikes (www.ccamlr.org/node/74769) on the net monitoring cable, recorded during the warp strike protocol observations, then the vessel will remove the cable, this number of birds being consistent with the mitigation measures given in CMs 41-03 to 41-11.

6.48 The Working Group also recommended that the observers provide details of the system and effectiveness of protocols, including safety implications, in their cruise reports and this information be provided to WG-FSA. While the standardised protocols outlined are to be applied at the beginning of the trial, the Working Group considered that observers should have the ability to adapt protocols, if required, to ensure effective data collection and safety are not compromised.

6.49 WG-FSA-16/38 also noted that net monitoring cable systems allowed for the 'continuous flow of information from trawl sonars and cameras' for both commercial operations (e.g. gear performance) and research (e.g. interactions between marine life and the gear). More details on the latter could usefully be provided in the observer report.

Other issues

6.50 The Working Group noted that some national programs collect additional data on marine mammal sightings and encouraged the continuation of these programs. It noted that without a specific scientific question regarding marine mammals and seabirds, it was not appropriate to implement additional data collection protocols as their design could not be adequately assessed. The Working Group encouraged the development of specific data collection protocols for collecting data on the presence of marine mammals and seabirds by observers in trawl fisheries.

6.51 The Working Group noted that the issue of marine mammal and seabird by-catch and interactions spans the terms of reference of several working groups. It further noted discussions in Agenda Item 5 (paragraph 5.14) to establish a WG-SISO, which would be a suitable place to recommend the design and implementation of data collection protocols for marine mammals and seabirds.

Future work

Secretariat's data management systems

7.1 The Working Group noted the key achievements to date, and the proposed work plan, for the redevelopment of the Secretariat's data management systems (SC-CAMLR-XXXV/BG/25). The work plan for the next two years includes the advice of the Scientific Committee and its working groups on data traceability, system testing and evaluation, user training, data extracts with corresponding metadata and establishing a data management group. Data users can expect improvements in data quality assurance, database documentation and ease of use as the new system is progressively rolled out, and prototype data extracts and associated metadata will be available to WG-FSA for evaluation in 2017.

7.2 The Secretariat acknowledged that in the current data management system there were inconsistencies in naming standards and the level of data quality assurance processes and the move to the new system would introduce common standards and increased rule-based rigour in data quality assurance processes. The Secretariat noted that much of the development that has been undertaken to date was essential foundational work with limited impact on current data users.

7.3 The Working Group discussed the implications of this redevelopment on the data extracts provided by the Secretariat for the work of WG-FSA, recalling that the Working Group will be conducting biennial assessments in 2017. The Working Group noted that:

(i) Data extracts based on the current system will continue to be produced in 2017, and that prototype new extracts and associated metadata will be made available to data users for review prior to WG-FSA-17. These extracts would not be adequately tested with enough lead time to support the 2017 assessments for toothfish fisheries.

(ii) New data extracts will be developed in consultation with users and will require changes in the way users use the data in their analyses. This will require a plan for the transition to extracts from new databases with different data quality and naming rules in order to ensure that unexpected differences in assessments do not arise as an artefact of changes in the data management system.

(iii) Metadata will accompany data extracts and provide users with information on data structure (data dictionary), processing (data quality rules) and change history from previous extracts of the same data (data change log).

7.4 The Working Group noted the importance of having metadata that was searchable to make external users aware of what data are available (and also what are not available) from CCAMLR. The discoverability of this metadata is also important in increasing transparency and understanding of the work of CCAMLR.

7.5 The Working Group noted that the proposed Data Management Group (Annex 5, paragraph 2.20 and Annex 6, paragraph 6.21) could provide a mechanism for data providers and data users to contribute to the design and testing of the new data management systems, priority setting and reviews of progress with achieving project outcomes. However, in order to achieve this remit it would be essential for the Data Management Group to have access to the project plan for the Secretariat data management system redevelopment.

7.6 The Working Group thanked the Secretariat for the update on the considerable amount of work that has been undertaken and recognised the challenges faced in redeveloping the entire Secretariat data management systems. The Working Group recognised that the implementation of the work was taking longer than desirable but expressed concern that there was little information available on an expected completion date.

7.7 The Working Group agreed that high-quality data are crucial to all aspects of the work of the Scientific Committee and noted the discussion of issues related to data management this year at WG-SAM (Annex 5, paragraphs 2.15 to 2.20, 2.51 to 2.54, 5.7, 5.14, 5.15 and 6.8) and WG-EMM (Annex 6, paragraphs 6.18 to 6.21) and encouraged the presentation of a timeline for the proposed work plan to the Scientific Committee, in order that Members may better understand the project milestones and contribute to setting priorities and implementing relevant elements of the work.

7.8 Noting the increased length of time that it was taking to implement the project to the stage where data users, such as those involved with WG-FSA, could expect to benefit from the new systems and processes, the Working Group discussed the level of Secretariat resources allocated to the redevelopment. The Secretariat noted that since 2015, the project has benefitted from additional funding from the Korean Contribution Fund and that this fund was sufficient to support planned project activities for at least another 18 months.

7.9 The Working Group agreed that the data management systems redevelopment work outlined by the Secretariat was central to the role and function of the Secretariat and if the allocation of additional resources to the project would assist in a more timely completion of the work, then a means to facilitate this should be considered by the Scientific Committee.

7.10 The Working Group reviewed the revised in-season catch and effort reporting form that will be used in CCAMLR fisheries in 2016/17, including daily reporting in exploratory fisheries for toothfish (refer CMs 23-01, 23-02, 23-03 and 23-07). The Working Group noted the improvements that will be implemented with the new form, particularly the development of validation rules applied in the automated data load procedure that will improve data quality.

7.11 The Working Group also noted that currently the instructions for the completion and submission of commercial catch and effort forms were limited in their description and utility and recommended:

(i) the further development of all the commercial and observer data forms applying analogous data validation and formatting improvements outlined in the daily catch and effort form

(ii) the development of comprehensive instructions for the commercial forms that include a glossary of CCAMLR definitions of fishing terminology, to ensure standardised recordings of times and positions across vessels for fishing events

(iii) the formation of an e-group to review the new commercial forms and instructions as they are developed and to identify further data validation rules (e.g. for species, catch and effort data) that may be applied, noting that the role of this e-group may change depending on the terms of reference of the proposed Data Management Group.

Organisation of intersessional activities

7.12 Mrs Large noted that the CCAMLR e-groups provide a very useful platform to discuss and develop ideas associated with an issue being considered by the Working Group. She also noted that, while the e-groups are open to all Members, it is not always possible for this involvement to take place and, therefore, non-involvement in an e-group should not automatically confer consensus of the material being considered. She suggested that any material that is required to be considered by all Members be submitted in a scientific paper to the Working Group for review.

Notification of scientific research

7.13 The Working Group noted the proposal by the UK for a randomised stratified trawl survey in Subarea 48.3 during January/February 2017 that had been distributed as SC CIRC 16/60.

7.14 Dr P. Ziegler (Australia) indicated that Australia also intended to conduct its annual randomised stratified trawl survey in Division 58.5.2 in 2017.

Other business

8.1 At its annual meeting in 2016, WG-EMM recalled its obligation to review and advise on CM 51-07, which is due to lapse at the end of the 2015/16 fishing season, and presented its discussions on this subject in paragraphs 2.201 to 2.244 of its Working Group report (Annex 6). WG-EMM recommended that work be undertaken to further develop a risk assessment approach (WG-EMM-16/69) to spatially subdivide the trigger level through the Conservation Measure 51-07 WG-EMM review e-group and to deliver these outputs to the Scientific Committee (Annex 6, paragraphs 2.230 to 2.244). These outputs would first be provided to WG-FSA for review, which in turn should pass these with a commentary on to the Scientific Committee to support the review and advice on CM 51-07 to the Commission.

8.2 Discussions at WG-EMM included consideration of WG-EMM-16/69. An updated version of the approach is presented in WG-FSA-16/47 Rev. 1 and 16/48 Rev. 1 which also includes advice from the intersessional e-group.

8.3 Drs Constable and Söffker presented WG-FSA-16/47 Rev. 1 and 16/48 Rev. 1 on behalf of the intersessional e-group. The risk assessment approach presented in WG-FSA-16/47 Rev. 1 and 16/48 Rev. 1 aims to minimise the risk of predator populations, in particular land-based predators, being inadvertently or disproportionally affected by the krill fishery (see CM 51-07, first preambular paragraph). It assesses the localised risk of such effects, according to the requirements in the preamble of CM 51-07, and is based on the best available science. This risk assessment is then combined with an expected, or desired, fishing pattern to distribute the catch in such a way that the risks will also be spread. The overall risk of localised effects on predators is also calculated for the fishing pattern. It can be used to compare alternative fishing patterns in order to help minimise risk.

8.4 The Working Group agreed that a brief description of the risk assessment method along with the summary of information requested by WG-EMM in paragraph 2.239 of its 2016 report (Annex 6) would be provided to the Scientific Committee in a background paper.

8.5 The Working Group noted that comparisons with the risks associated with a baseline distribution of the trigger level would provide a means of assessing how much the risks of a scenario may deviate from an ideal distribution of catch that spreads the risks. The baseline scenario is determined by the relative abundance of krill driving the location of the fishery, combined with the calculated risk based on predation pressure and proportion of juvenile krill (see Figures 3 to 6). The desirability of areas by the fishery is not included in the baseline calculation, i.e. all areas are equally desirable. The results of the baseline scenario are given in Table 4.

8.6 The emphasis of this approach lies in evaluating scenarios and determining where risks are increased or decreased relative to other scenarios and can be ranked. This will enable the Scientific Committee to evaluate the direction of change in regional risk using a data-limited approach. It can then be used to provide management advice on whether scenarios may be less or more precautionary than the baseline scenario.

8.7 Tables 5 and 6 present several scenarios of risk associated with different historical catch patterns (Table 5), and variations of patterns based on CM 51-07 as well as adjusted catch for keeping the relative risk for different scenarios similar to the calculated baseline risk (Table 6). The Working Group noted that the baseline risk is calculated at 0.387, and that all other scenarios have a higher risk than the baseline risk. It further noted that increases in regional risk can be offset spatially or temporally.

8.8 Table 5 shows risk associated with changes in historical fishing patterns throughout several scenarios, with some having higher regional risks than others. It summarises patterns observed in the past, and considers the risk of a possible pattern where the fishery is solely concentrated in Bransfield Strait. The table also presents catches adjusted to maintain the regional risk level at the baseline level ((1/relative risk)*catch allocation).

8.9 Table 6 shows several scenarios based on the existing CM 51-07, with different allocations of the proportional regional catch to subareas. The table shows that certain scenarios have a higher regional risk because of catch being concentrated in areas where there are higher concentrations of krill predators and juvenile krill. The adjusted catches to maintain regional risk at the baseline level means that accumulation of risk from catches in the high-risk areas is offset by catches in lower risk subareas that would then have little or no krill fishing. The table provides catch limits for each scenario for the area and subareas that would keep the overall regional risk in line with the baseline risk.

8.10 The Working Group noted that as Subarea 48.4 has had no recent fishery, in the scenarios looking at current catch distributions, the catch for Subarea 48.4 was distributed according to the relative size of its SSMUs.

8.11 The Working Group also considered how the local risks of each scenario have changed from the local risks of the baseline scenario, i.e. whether the local risks have increased or decreased in their contributions to the regional risk. The contribution of local areas (local catch-weighted risk) to the regional risk (regional catch-weighted risk) in the baseline scenario is given in Table 4. The relative changes in these local catch-weighted risks for the different scenarios are given in Table 7.

8.12 The Working Group thanked those involved in the development of the risk model framework and the calculation of different scenarios, noting that this was an important step forward and that it would provide a useful additional tool to help decision-making in regard to CM 51-07. The Working Group recalled that this process of using best-available science to create management options in data-limited fisheries follows approaches from other regional fishery management organisations (RFMOs) around the globe. The Working Group noted that the method would improve as knowledge about the local ecosystems improves.

8.13 The Working Group discussed the results presented, and agreed that the risk assessment allows to identify and focus on areas of concern. The Working Group considered that the presented scenarios were informative and agreed that as the fishery patterns are relatively flexible, the use of the most recent three years of fishery operations in the provision of advice was sensible.

8.14 The Working Group noted that at present it is difficult to establish whether there are direct effects of the fishery on predators because of a lack of data at appropriate spatial and temporal scales. The Working Group noted that krill-dependent predators have been observed on the same grounds as krill vessels, but at the moment there are very few systematic observations of those feeding close to, or in the same, krill aggregation being fished by the krill fishing vessels.

8.15 The Working Group discussed the use of buffers as a scenario to offset potential increasing fishing pressure in Subarea 48.1, and noted that at present, the spatial scale of land-based predator habitat use is only at SSMU level. Thus, the inclusion of a buffer zone would not change the risk level in these calculations unless the fishing pressure were to be shifted into another SSMU entirely. It recommended that buffer zones should be investigated as a means to offset increasing regional risk once better spatial data for habitat use of land-based predators are available.

8.16 The Working Group noted that such buffer zones could be valuable for reducing risk during particular times of year, for example during the penguin breeding season. It also noted, however, that the value of buffer zones would differ for different predator species. Species which forage coastally would receive benefit to a greater extent than other species which spend time foraging further offshore.

8.17 Some Members noted that the risk assessment model could be used for directly providing krill catch distribution in case of other equal conditions, such as equal krill density and space distribution and prevailing conditions for fishing.

8.18 The Working Group noted that the risk analysis should be updated periodically as more data become available, and that this update does not require a full reassessment. The update can be partial or complete depending on data improvements. The Working Group also noted that once an integrated assessment for krill is developed, a method for spatially distributing catch limits will still be needed so the two approaches are complementary.

8.19 The Working Group discussed the data contributing to the model, in particular data on krill density distribution, and agreed that, while currently the model uses best available science, this can be reviewed periodically and data updated. The Working Group recommended that a standard way by which data be accepted or rejected in future revisions be established, and that the standard datasets used in the assessment should be made available to Members once agreed as input to the risk model.

Advice

8.20 The Working Group recalled that there needs to be consideration by the Scientific Committee and Commission of this work to support their decisions in the evolution of CM 51-07 this year.

8.21 The Working Group endorsed the risk assessment framework as presented in WG-FSA-16/47 Rev. 1 and 16/48 Rev. 1 for use as a tool for providing advice to the Scientific Committee in regard to CM 51-07.

8.22 The Working Group wished to draw the attention of the Scientific Committee to its consideration of the risks associated with historical fishing patterns as well as those that may be associated with plausible subdivisions of the trigger level and recommended that the Scientific Committee consider, inter alia, the results of the scenarios presented in Tables 4 to 7 as well as Figures 3 to 7 in providing advice to the Commission for its review of CM 51-07. The Working Group requested that the Scientific Committee consider the contents of the background paper on this topic to be provided by the Working Group (SC-CAMLR-XXXV/BG/37).

8.23 In addition, it recommended that the model be further developed within the Scientific Committee working groups and that a standard way to include or reject data be part of that development.

8.24 The Working Group noted that a number of factors will be important to consider in revising CM 51-07, in particular for distributing the trigger level, including factors influencing the krill fishery, such as the spatial distribution of krill, conditions affecting the krill fishery, and the amount of the catch limit being taken.

Future work

8.25 The Working Group made several recommendations for future work to update the risk assessment model:

(i) krill density distribution could be evaluated in relation to local biomass of land-based krill predators

(ii) inclusion of a measure of temporal variability in krill density, such as through confidence intervals associated with data from surveys, should be progressed

(iii) the risk analysis should look at including a layer for data gaps, for example lack of monitoring effort near the fishery, or lack of data regarding pelagic predators in winter months

(iv) inclusion of historical fishing patterns in the calculation of regional risk was suggested

(v) the role of buffer zones for off-setting increased catches in high-risk areas should be investigated as better spatial data becomes available

(vi) a sensitivity analysis should be conducted on the baseline risk level

(vii) identify strategies for obtaining data that could improve the risk assessment, such as updating estimates of abundance of krill

(viii) how to include as a component of risk, the ability to manage spatial dynamics of the fishery.

Species profiles

8.26 The Working Group discussed a proposal to develop a detailed description of target and by-catch species which are, or have been, subject to exploitation in the Southern Ocean (WG-FSA-16/51). The Working Group recalled that species profiles are currently available for *C. gunnari* (Kock and Everson, 2003), *D. eleginoides* (Collins et al., 2010), *D. mawsoni* (Hanchet, 2010) and Antarctic krill (*Euphausia superba*) (Miller, 2003); however, only one of these profiles (*D. eleginoides*) has been published, and the other three profiles are CCAMLR meeting documents. The Working Group agreed that such species profiles, when published, would provide an authoritative source of information for use by the CCAMLR community as well as other groups such as the Scientific Committee on Antarctic Research (SCAR), the Committee for Environmental Protection (CEP), the Food and Agriculture Organization of the United Nations (FAO), FishBase and the public (e.g. Wikipedia). The profiles and related fishery reports will also provide comprehensive and up-to-date information on fishery species in the Convention Area.

8.27 The project will be coordinated by Dr Kock and would take four years to complete, with an annual budget of approximately A$9 000 to support the project coordinator's attendance at the meeting of WG-FSA. Additional funding would be required if the profiles were translated to CCAMLR languages (costed at 10–20 pages per profile).

8.28 The Working Group encouraged the development of the species profiles, however, it noted that the budget to support the project would need to be considered in the context of other priorities. It also discussed publication options and the need to use an appropriate medium for each target audience. The material developed for each profile will need to be tailored to the intended audience and this may require various approaches such as CCAMLR publication, contributions to the Antarctic Environments Portal (www.environments.aq) or a wikibomb event (https://en.wikipedia.org/wiki/Wikipedia:Meetup/SCAR_2016).

8.29 The Working Group agreed to establish an e-group to develop this proposal intersessionally and:

(i) identify the target audiences and appropriate publication media

(ii) define the publication mechanism and peer-review process

(iii) develop a list of species and a work plan, and identify potential contributors

(iv) develop a generic table of contents for the species profiles, including taxonomy, vertical and horizontal distribution, age and growth, reproduction and diet

(v) develop species profiles for *N. rossii* and *C. dewitti* – these species were chosen because the available information on these two species is representative of many of the species for which profiles will be developed.

8.30 The Working Group agreed to review progress at WG-FSA-17.

8.31 The Working Group noted that the species profiles could also be developed for species such as krill-dependent species, and VME taxa, and these possible inclusions were referred to WG-EMM for consideration.

Parasites and lipid metabolism features of *D. mawsoni*

8.32 The Working Group noted a study on parasites of *D. mawsoni* from the exploratory longline fisheries in Subareas 88.1 and 88.2 (WG-FSA-16/P01). The study identified 14 species of parasites using standard parasitological methods and genetic analysis, and the results contributed to baseline data on the parasitofauna of *D. mawsoni*. The authors noted that an earlier study of the parasites of *D. eleginoides* reported that the parasitofauna of that species from Heard Island, Macquarie Island and the Prince Edward Islands were the most similar, while the parasitofauna from the Ross Sea was the most dissimilar. The Working Group noted that the genetic and tagging studies apparently provided better discrimination of stock structure in toothfish than parasites.

8.33 The Working Group also noted a study on the lipid metabolism features of *D. mawsoni* from Subareas 88.1 and 88.2 (WG-FSA-16/P02). Samples were studied for the content of total lipids and lipid composition, products of lipid peroxidation and level of antioxidant protection. The authors noted that future research will evaluate changes in the physiological state of toothfish that may arise as a result of pollution and other forms of anthropogenic impact.

8.34 The Working Group thanked the authors of these papers and agreed that these publications raised the profile of science based on datasets collected in CCAMLR in the broader scientific community.

Marine debris

8.35 The Working Group noted the Secretariat's report on the CCAMLR marine debris monitoring program (WG-FSA-16/18). Overall, the occurrence of plastic debris on beaches and in seabird colonies remains an issue in the CAMLR Convention Area. The global issue of plastic pollution in the world's oceans, in particular the prevalence of plastics in seabirds, receives increasing attention in the popular and scientific literature and monitoring of additional sites, including those where marine debris/plastics have not previously been recorded, would add to the ability of CCAMLR to contribute to global monitoring of marine pollution.

8.36 The Working Group noted the increased recent global attention on plastic pollution in the marine environment, and the UN Environment Programme (UNEP)-led Global Partnership on Marine Litter (GPML). The Working Group also noted that CCAMLR is now a partner in the GPML. The Secretariat recently contributed to GPML's review on global marine plastic debris and the CCAMLR marine debris monitoring program will continue to contribute information on the occurrence of macro plastics in the Southern Ocean. The CCAMLR program has also recently contributed information on marine mammal entanglements to the Commonwealth Scientific and Industrial Research Organisation (CSIRO) (Australia) for their work on the Global Ghost Gear Project, which is developing a global picture of fishing gear loss with an ultimate aim of reducing ghost fishing in the marine environment.

8.37 The Working Group noted that the CCAMLR program of marine debris monitoring is land-based, and that fishing vessels and scientific observers also record fishing gear lost at sea. However, there was no at-sea monitoring of marine debris in the Convention Area.

8.38 The Working Group encouraged Members to further develop collaborative programs for monitoring plastics in the marine environment, including collaboration with other groups (e.g. CEP, SCAR or the International Association of Antarctica Tour Operators (IAATO)), in order to collect data which may be used to evaluate the likely impact of plastics on the growth and reproductive success of marine living resources in the Convention Area. The Working Group recommended that this matter be referred to the Scientific Committee for further consideration.

Advice to the Scientific Committee and its working groups

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.

9.2 The Working Group provided advice on the following topics:

(i) 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 3.22)

(c) catch limit for *D. eleginoides* in Division 58.5.1 (paragraphs 3.135 and 3.136)

(d) catch limit for *D. eleginoides* in Subarea 58.6 (Crozet Islands) (paragraphs 3.139 and 3.140)

(e) catch limit for *D. eleginoides* in Subarea 48.3 (paragraph 3.24)

(f) catch limits for *D. eleginoides* and *D. mawsoni* in Subarea 48.4 (paragraphs 3.26 and 3.33)

(g) catch limits for *D. mawsoni* in Subarea 88.1 (paragraphs 3.44 and 3.45)

(h) research plan and tagging rates for *D. mawsoni* in Subarea 88.2 (paragraphs 3.130 and 3.131)

(i) monitoring fishing capacity (paragraph 3.37).

(ii) Research fishing in data-poor fisheries for *Dissostichus* spp. –

(a) setting species-specific catch limits (paragraphs 4.8 and 4.83)

(b) research on catch limits (paragraph 4.30)

(c) assessment focus topic for WG-SAM (paragraphs 4.92 and 4.93)

(d) setting catch limits in research blocks (paragraph 4.104)

(e) coordinated and centralised ageing program for *D. mawsoni* (paragraph 4.126)

(f) research in a new, proposed research block 5841_6 (paragraph 4.118)

(g) research fishing in Divisions 58.4.1 and 58.4.2 (paragraph 4.120)

(h) research fishing in Division 58.4.3a (paragraphs 4.132 and 4.134).

(iii) Research fishing on *Dissostichus* spp. in other areas –

(a) setting research catch limits (paragraphs 4.66 and 4.69)

(b) research fishing in Subareas 48.2 and 48.4 (paragraphs 4.54, 4.63 and 4.64)

(c) research fishing in Division 58.4.4b (paragraph 4.144)

(d) research fishing in Subarea 88.3 (paragraphs 4.147 and 4.148).

(iv) Scheme of International Scientific Observation –

(a) establishing a dedicated SISO Working Group (paragraph 5.14).

(v) By-catch –

(a) by-catch limits in new and exploratory fisheries in CM 33-03 (paragraph 6.14)

(b) reporting of catch by species, or to the lowest taxonomic level possible in CM 23-04 and related measures (paragraph 6.20)

(c) pre- and post-season extension trial in the longline fishery in Division 58.5.2 (paragraph 6.39)

(d) trial use of net monitoring cables during krill fishing (paragraphs 6.46 to 6.48).

(vi) Data –

(a) reporting on vessel freezing capacity and fish processing rates in fishery notifications (paragraph 3.48)

(b) redevelopment of the Secretariat's data management systems (paragraphs 7.5 to 7.7 and 7.9).

(vii) Spatial subdivision of the trigger level for *E. superba* in Subareas 48.1 to 48.4 –

(a) revision of CM 51-07 (paragraphs 8.20 to 8.24).

(viii) Marine debris –

(a) collaborative programs for monitoring plastics in the marine environment (paragraph 8.38).

(ix) Meeting report –

(a) attributed statements (paragraph 10.2).

Adoption of the report

10.1 The report of the meeting was adopted.

Attributed statements

10.2 At the time of report adoption the Working Group noted that there were a large number of attributed statements in the report that raised points that had not been raised during the plenary session and often contained errors of fact. The Working Group noted that this practice was counter to the purpose of having a meeting to discuss the issues, counter to the spirit of seeking Working Group consensus, counter to the need to keep our reports concise and creates a public view of CCAMLR that is confusing, repetitive and contradictory. The Working Group also noted that the accommodation of such large numbers of attributed statements requires significant time within the Working Group to organise and respond to. It requested that the Scientific Committee consider providing advice to its working groups on approaches to manage this issue.

Close of the meeting

11.1 In closing the meeting, Dr Welsford thanked all the participants for their hard work that had enabled the Working Group to complete its work in the shorter time that was available this year. He also thanked the rapporteurs and the Secretariat for their support to the work of WG-FSA-16.

11.2 On behalf of the Working Group, Dr Belchier thanked Dr Welsford for his humour and zeal that had made a huge contribution to leading his first meeting as Convener to a successful conclusion.

References

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Kellermann, A. 1989. Catalogue of early life stages of Antarctic notothenioid fishes. *Ber. Polarforsch.*, 67: 45–136; *BIOMASS Sci. Ser.*, 10: 44−136.

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Table 1: Table of the biomass estimates based on the methods agreed to at WG-SAM-16 (Annex 5, paragraph 28) and presented in WG-FSA-16/27, catch limits for the current season, catch that has been taken in the past three years and the proposed catch limits based on the two biomass estimates provided in this table with the 4% exploitation rate applied.

Research block	Species	CPUE by seabed area estimated biomass – three year median CPUE (tonnes)	Chapman estimated biomass most recent (tonnes)	Catch limit current 2016 season (tonnes)	Catch 2014 (tonnes)	Catch 2015 (tonnes)	Catch 2016 (tonnes)	CPUE by seabed area catch limit (4%)	Chapman catch limit (4%)
486_2	TOA	600	9369	170	95.22	82.20	83.16	24	375
486_3	TOA	182	4456	50	49.92	48.86	49.74	7	178
486_4	TOA	870	5147	100	0	56.45	99.18	35	206
486_5	TOA	2039	n/a	190	0	0	0	82	n/a
5841_1	TOA	911	831	80	0	0	79.68	36	33
5841_2	TOA	841	6909	81	54.15	15.40	42.57	34	276
5841_3	TOA	1052	5285	233	0	71.33	65.81	42	211
5841_4	TOA	149	n/a	13	0	9.95	12.10	6	n/a
5841_5	TOA	286	404	35	0	25.70	34.91	11	16
5841_6 (proposed)	TOA	3675	n/a	90	24.34	0	84.23	147	n/a
5842_1	TOA	291	n/a	35	0	9.62	0	12	n/a
5843a_1	TOP	1740	1310	32	32.08	15.19	0	70	52
5844b_1	TOP	481	351	26	12.00	18.22	0	19	14
5844b_2	TOP	509	765	35	14.94	16.33	0	20	31

Table 2: Catch of by-catch taxa by small-scale research unit (SSRU) and research block in exploratory fisheries and research fishing for toothfish in 2015/16 (Source: in-season catch and effort reports). Instances where the reported by-catch levels would have exceeded the relevant percentage of target catch are highlighted. MA – management area; RB – research block. Note: Divisions 58.4.2 and 58.4.3a are not included as no fishing has occurred this season.

Season	Subarea/ division	Region/ MA	RB	2016 catch limit for toothfish	Reported catch of			By-catch percentage	
					Skates	Macrourids	Other species	Macrourids (%)	Other species (%)
2015/16	48.2	482		75		0.4	0.0	0.53	0.00
2015/16	48.6	AG	486_1	28		0.8	0.2	2.86	0.71
2015/16	48.6	AG	486_2	170		2.6	0.3	1.53	0.18
2015/16	48.6	D	486_3	50		1.6	0.1	3.20	0.20
2015/16	48.6	E	486_4	100		4.8	0.6	4.80	0.60
2015/16	58.4.1	C	5841_1	80		0.4	0.0	0.50	0.00
2015/16	58.4.1	C	5841_2	170		0.7	0.1	0.41	0.06
2015/16	58.4.1	E	5841_3	50		8.2	0.5	**16.40**	1.00
2015/16	58.4.1	E	5841_4	13		5.0	0.1	**38.46**	0.77
2015/16	58.4.1	G	5841_5	35		0.7	0.0	2.00	0.00
2015/16	88.1	BCG	B	360		0.7	0.4	0.19	0.11
2015/16	88.1	HIK	H	2 050	5.9	81.7	19.2	3.99	0.94
2015/16	88.1	JL	J	320	0.6	6.3	1.0	1.97	0.31
2015/16	88.2	CDEFG	882_2	200	0.0	2.0	0.2	1.00	0.10
2015/16	88.2	CDEFG	882_3	200	0.3	46.0	1.4	**23.00**	0.70
2015/16	88.2	CDEFG	882_4	200	0.0	2.1	0.2	1.05	0.10
2015/16	88.2	H	H	200		2.0	0.8	1.00	0.40
2015/16	88.3	883_1	883_1	21		0.5	0.1	2.38	0.48
2015/16	88.3	883_3	883_3	31	0.0	0.5	0.1	1.61	0.32
2015/16	88.3	883_4	883_4	52	0.1	1.8	0.5	3.46	0.96
2015/16	88.3	883_5	883_5	38		0.6	0.3	1.58	0.79

Table 3: Summary of extrapolated seabird mortality (where the mortality rate is in birds/1 000 hooks) figures for the past five seasons across the CAMLR Convention Area. This table should be considered in relation to the discussions contained in this report (paragraphs 6.40 to 6.43).

Area	Mortality	2012	2013	2014	2015	2016
48.3	Extrapolated	6	3	123	3	98
	Mortality rate	0.0006	0.0003	0.013	0.0007	0.012
58.6, 58.7 (South Africa)	Extrapolated	0	3	0	0	6
	Mortality rate	0	0.009	0	0	0.008
58.6 (France)	Extrapolated	68	55	24	41	20
	Mortality rate	0.022	0.019	0.009	0.012	0.005
88.1, 88.2	Extrapolated	0	0	2	0	0
	Mortality rate	0	0	0.0002	0	0
58.4.1, 58.4.2, 58.4.3a, 58.4.3b	Extrapolated	0	0	0	0	0
	Mortality rate	0	0	0	0	0
58.5.1 (France)	Extrapolated	190	102	24	49	64
	Mortality rate	0.012	0.004	0.001	0.004	0.005
58.5.2	Extrapolated	0	0	2	2	4
	Mortality rate	0	0	<0.001	0.0002	0.007
Total		222	163	175	95	192

Table 4: Baseline distribution of the trigger level based on density of krill and risk of effects on predators and krill in small-scale management units (SSMUs). Regional risk (R_risk) is the accumulated risk across Area 48 of localised effects on predators and krill. Relative risk (R_relative) is the regional risk relative to the baseline regional risk. For Subarea 48.1, Bransfield includes Bransfield SSMUs, Drake includes Drake Passage plus Elephant Island SSMUs, Pelagic is the pelagic SSMU, and E_W includes the East and West SSMUs.

Scenario		Regional risk		Distribution in Subarea 48.1				Subareas				Total catch
#	Name	R_risk	R_relative	Bransfield	Drake	Pelagic	E_W	48.1	48.2	48.3	48.4	
1	Baseline Alpha			0.001	0.002	0.044	0.002	0.049	0.456	0.434	0.061	
	Catches			1	1	28	1	31	283	269	38	620
	Local catch-weighted risk	0.387	1	000.1	000.1	0.018	0.002	0.022	0.168	0.184	0.013	

Table 5: Distribution of the trigger level for scenarios based on historical catch distributions plus a scenario for all catch to be taken from Bransfield Strait. Catches (thousand tonnes) are calculated as the alpha level multiplied by the trigger level of 620 000 tonnes. The adjusted catches (thousand tonnes) for a scenario give catches for each area that would result in the regional risk of the scenario being equal to the baseline regional risk (calculated by pro-rating the alphas for a scenario in order to achieve a regional risk equal to the baseline). The total catch indicates what the total catch for Subareas 48.1, 48.2, 48.3 and 48.4 that would correspond to the regional risk indicated. See Table 4 for definitions.

Scenario		Regional risk		Distribution in Subarea 48.1				Subareas				Total catch
#	Name	R_risk	R_relative	Bransfield	Drake	Pelagic	E_W	48.1	48.2	48.3	48.4	
	Alpha											
2	Catch 2013–2016	0.650		0.430	0.057	0	0.075	0.562	0.205	0.233	0	
3	Catch 2010–2013	0.625		0.362	0.114	0.001	0.054	0.531	0.26	0.21	0	
4	Catch 2000–2010	0.48		0.076	0.202	0.002	0.006	0.286	0.429	0.285	0	
5	Catch 1990–2000	0.679		0.01	0.595	0.017	0.011	0.633	0.147	0.221	0	
6	Catch 1980–1990	0.823		0.001	0.763	0.055	0.005	0.824	0.176	0	0	
7	Bransfield only	0.942		1	0	0	0	1	0	0	0	
	Catches											
2	Catch 2013–2016	0.65	1.68	266	35	0	47	349	127	145	0	620
3	Catch 2010–2013	0.625	1.61	224	70	1	34	329	161	130	0	620
4	Catch 2000–2010	0.48	1.24	47	125	1	4	178	266	177	0	620
5	Catch 1990–2000	0.679	1.75	6	369	10	7	392	91	137	0	620
6	Catch 1980–1990	0.823	2.13	1	473	34	3	511	109	0	0	620
7	Bransfield only	0.942	2.43	620	0	0	0	620	0	0	0	620
	Adjusted catches											
2	Catch 2013–2016	0.387	1	159	21	0	28	208	76	86	0	369
3	Catch 2010–2013	0.387	1	139	44	0	21	204	100	81	0	384
4	Catch 2000–2010	0.387	1	38	101	1	3	143	214	142	0	500
5	Catch 1990–2000	0.387	1	3	210	6	4	224	52	78	0	353
6	Catch 1980–1990	0.387	1	0	222	16	2	240	51	0	0	292
7	Bransfield only	0.387	1	255	0	0	0	255	0	0	0	255

Table 6: Distribution of the trigger level for scenarios based on Conservation Measure (CM) 51-07, along with the resulting catches from the trigger level of 620 000 tonnes. Adjusted catches for a scenario give catches for each area that would result in the regional risk of the scenario being equal to the baseline regional risk. The scenarios relate to the following: 'CM_' indicates the scenario based on CM 51-07. '_25' or '_35' indicate scenarios where Subarea 48.1 has 25% or 35% of the trigger level with the remaining subareas divided according to the relative proportions in other subareas according to the existing conservation measure. Catches between seasons and between small-scale management units (SSMUs) in groups of SSMUs (either subareas or, in Subarea 48.1, within subarea groups) for Subareas 48.1, 48.2 and 48.3 are divided according to the catch distributions of the most recent period in the fishery. Subarea 48.4 is divided between pelagic and island SSMUs according to the proportion of the subarea in each SSMU. 'even481' relates to having one third of the catch in each of Drake Passage SSMUs (including Elephant Island), Bransfield Strait SSMUs and the Pelagic Area, with no catch in the other SSMUs in Subarea 48.1. 'current481' indicates distribution amongst SSMUs according to the most recent fishing period. 'D&B' is where half the catch from Subarea 48.1 is taken from the Drake Passage SSMUs and half from the Bransfield Strait SSMUs. See Table 4 for definitions.

Scenario		Regional risk		Distribution in Subarea 48.1				Subareas				Total catch
#	Name	R_risk	R_relative	Bransfield	Drake	Pelagic	E_W	48.1	48.2	48.3	48.4	
	Alpha											
8	CM_even481_25	0.467		0.083	0.083	0.083	0	0.25	0.32	0.32	0.11	
9	CM_current481_25	0.457		0.191	0.025	0	0.034	0.25	0.32	0.32	0.11	
10	CM_D&B_481_25	0.466		0.125	0.125	0	0	0.25	0.32	0.32	0.11	
11	CM_even481_35	0.532		0.117	0.117	0.117	0	0.35	0.28	0.28	0.09	
12	CM_current481_35	0.518		0.267	0.035	0	0.047	0.35	0.28	0.28	0.09	
13	CM_D&B_481_35	0.53		0.175	0.175	0	0	0.35	0.28	0.28	0.09	
	Catches											
8	CM_even481_25	0.467	1.21	52	52	52	0	155	198	198	68	620
9	CM_current481_25	0.457	1.18	118	16	0	21	155	198	198	68	620
10	CM_D&B_481_25	0.466	1.20	78	78	0	0	155	198	198	68	620
11	CM_even481_35	0.532	1.37	72	72	72	0	217	174	174	56	620
12	CM_current481_35	0.518	1.33	166	22	0	29	217	174	174	56	620
13	CM_D&B_481_35	0.53	1.37	109	109	0	0	217	174	174	56	620
	Adjusted catches											
8	CM_even481_25	0.387	1	43	43	43	0	129	165	165	57	514
9	CM_current481_25	0.387	1	100	13	0	18	131	168	168	58	525
10	CM_D&B_481_25	0.387	1	64	64	0	0	129	165	165	57	515
11	CM_even481_35	0.387	1	53	53	53	0	158	126	126	41	451
12	CM_current481_35	0.387	1	124	16	0	22	162	130	130	42	463
13	CM_D&B_481_35	0.387	1	79	79	0	0	158	127	127	41	452

Table 7: Local relative catch-weighted risks for groups of small-scale management units (SSMUs) in Subarea 48.1 and for Subareas 48.1, 48.2, 48.3, and 48.4 for each scenario shown in Table 5 and Table 6. These local relative catch-weighted risks are the local catch-weighted risks divided by the local catch-weighted risk for that area in the baseline scenario (Table 4). See Table 4 for definitions.

Scenario		Local relative risk within Subarea 48.1				Local relative risk by subarea				Relative regional risk
#	Name	Bransfield	Drake	Pelagic	E_W	48.1	48.2	48.3	48.4	
2	Catch 2013–2016	392	56	0	33.5	23.41	0.32	0.44	0	1.68
3	Catch 2010–2013	340	93	0.06	24.5	21.91	0.39	0.42	0	1.61
4	Catch 2000–2010	67	161	0.06	2.5	10.64	0.64	0.76	0	1.24
5	Catch 1990–2000	9	513	0.78	5	24.82	0.23	0.52	0	1.75
6	Catch 1980–1990	1	710	2.89	2.5	34.95	0.32	0	0	2.13
7	Bransfield only	942	0	0	0	42.82	0	0	0	2.43
8	CM_even481_25	76	82	4.44	0	10.82	0.51	0.6	2.54	1.21
9	CM_current481_25	174	25	0	15	10.41	0.51	0.6	2.54	1.18
10	CM_D&B_481_25	114	124	0	0	10.82	0.51	0.6	2.54	1.20
11	CM_even481_35	106	115	6.22	0	15.18	0.44	0.53	2.08	1.37
12	CM_current481_35	244	35	0	21	14.55	0.44	0.53	2.08	1.33
13	CM_D&B_481_35	159	173	0	0	15.14	0.44	0.53	2.08	1.37

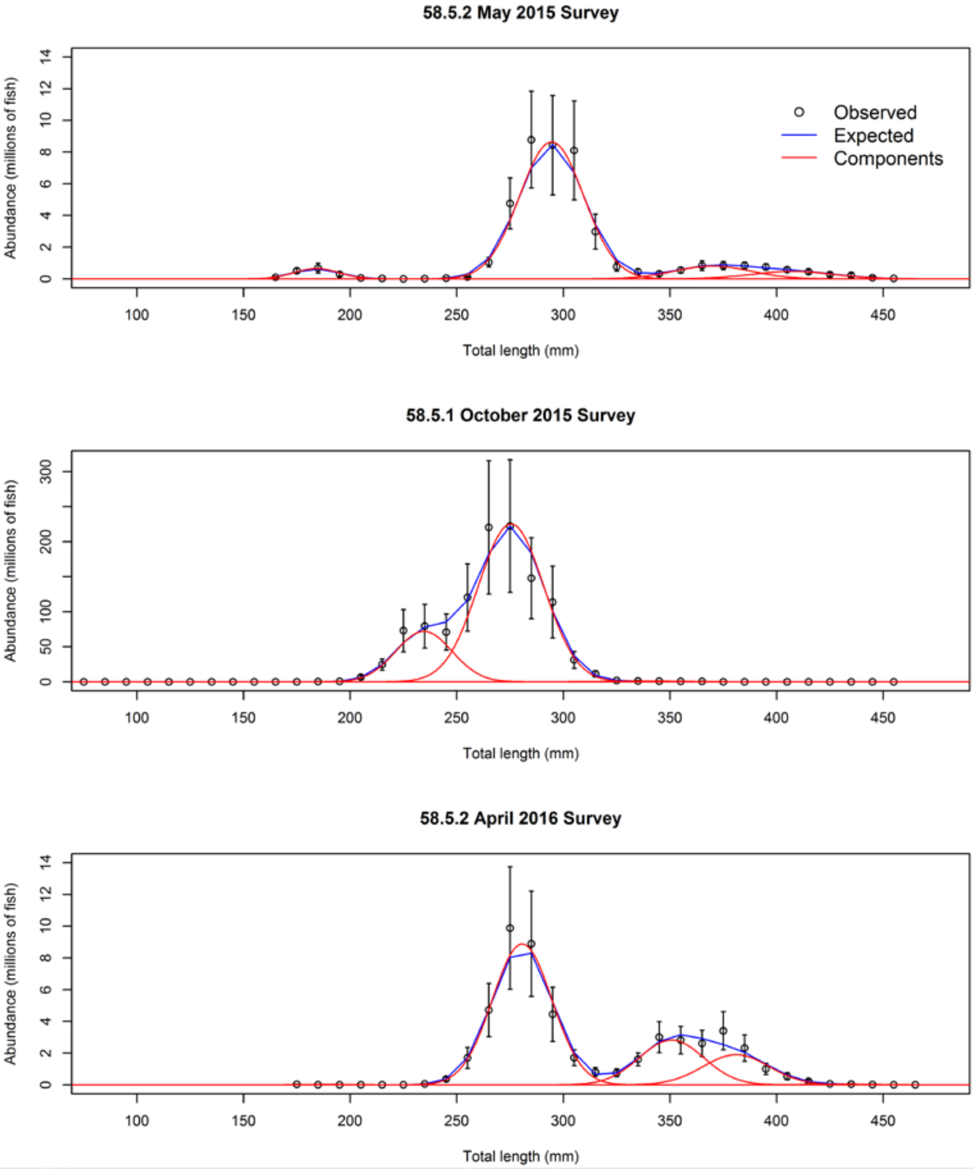


Figure 1: Fit to length-density data from the 2015 and 2016 surveys conducted within Divisions 58.5.1 (WG-FSA-16/53) and 58.5.2 (WG-FSA-16/26) using CMIX. Points are mean (+SE) abundance at length, the blue line is the expected length distribution arising from the best fit and the red lines are the abundances at length of the different components.

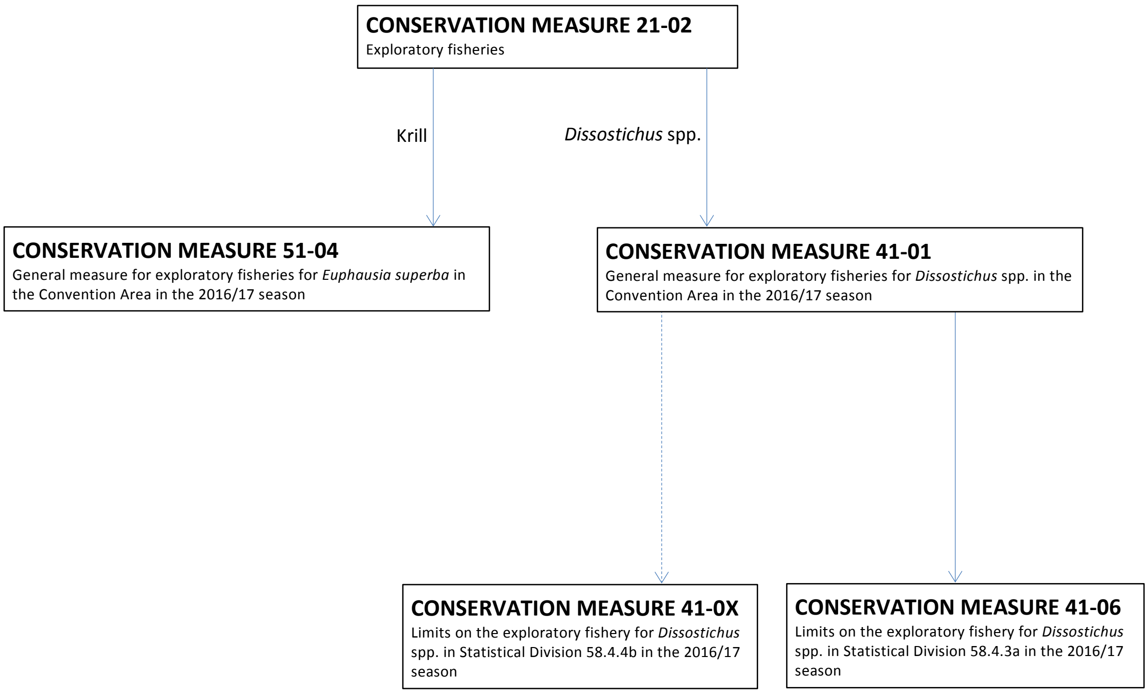


Figure 2: Hierarchy of conservation measures relating to exploratory fisheries.

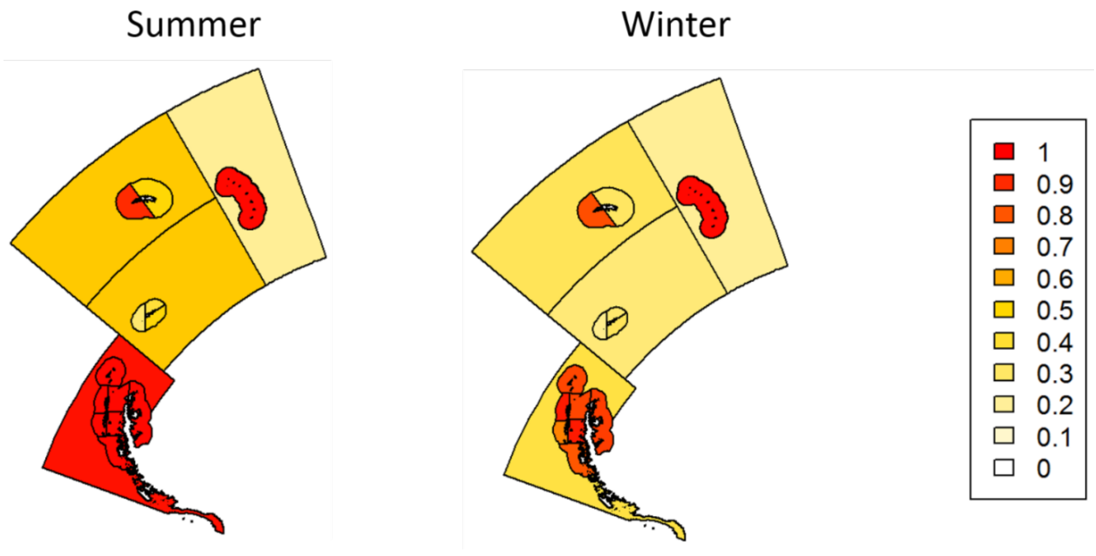


Figure 3: Baseline risk based on distribution of juvenile krill and land-based and pelagic predators in Area 48.

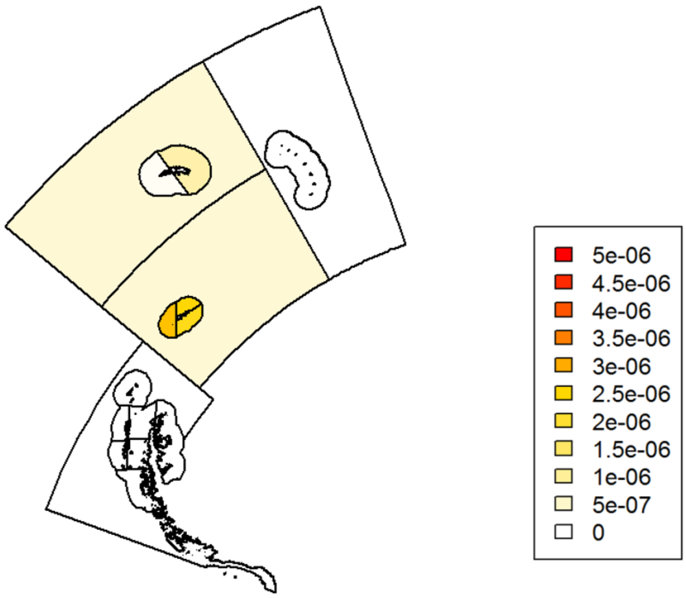
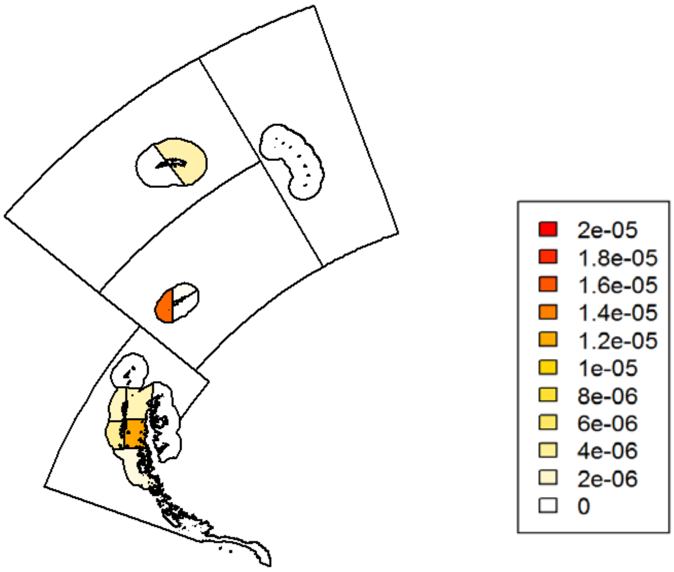


Figure 4: Baseline alpha and regional risk (0.39) for Area 48 and its subareas calculated based on the risk shown in Figure 3.

Scenario 2: Catches 2013–2016 (R_Risk = 0.65)

Figure 5: Proportions of the trigger level calculated for each SSMU (plotted as a density) in Scenarios 2–6 in Table 5. Regional Risks (R_risk) are given for scenarios. (continued)

Scenario 3: Catches 2010–2013 (R_Risk = 0.62)



Scenario 4: Catches 2000–2010 (R_Risk = 0.48)

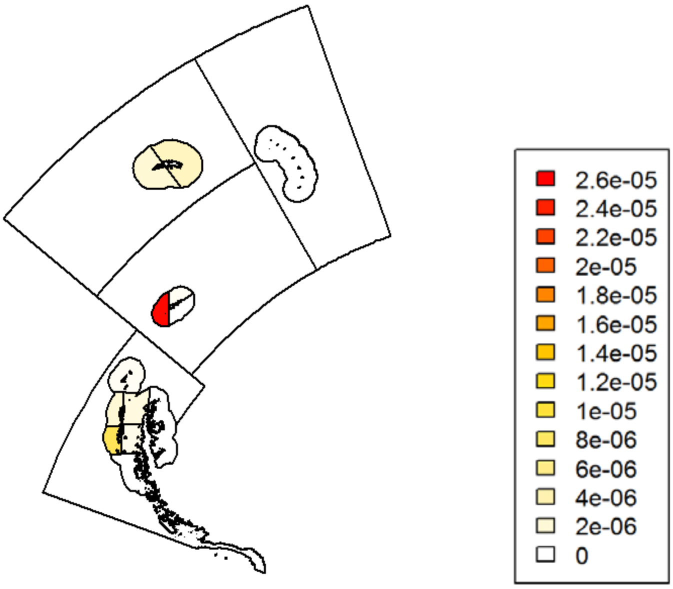
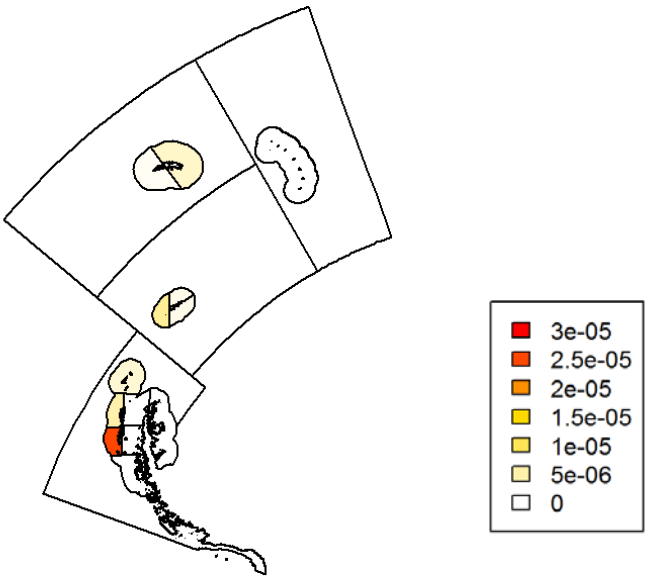


Figure 5 (continued)

Scenario 5: Catches 1990–2000 (R_Risk = 0.68)



Scenario 6: Catches 1980–1990 (R_Risk = 0.82)

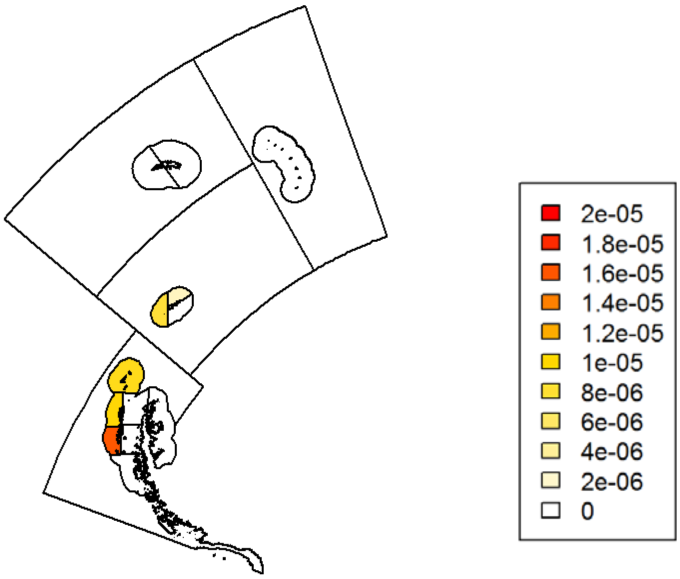


Figure 5 (continued)

Scenario 7: Catches Bransfield Strait (R_Risk = 0.94)

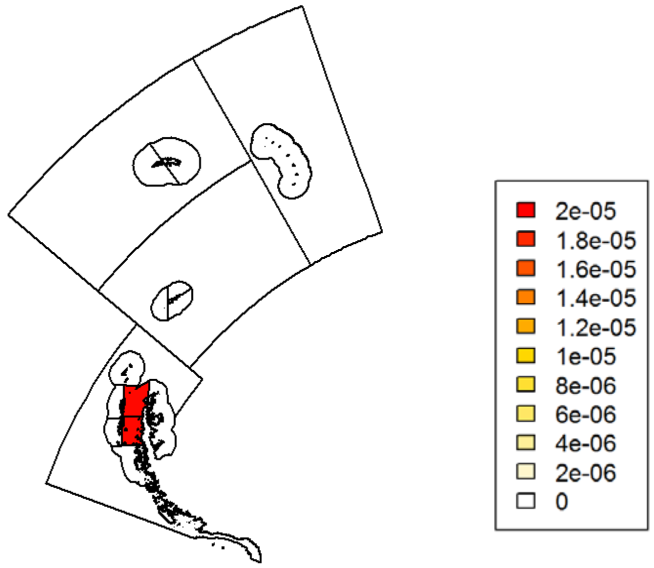


Figure 5 (continued)

Scenario 8: CM_even481_25 (R_Risk = 0.47)

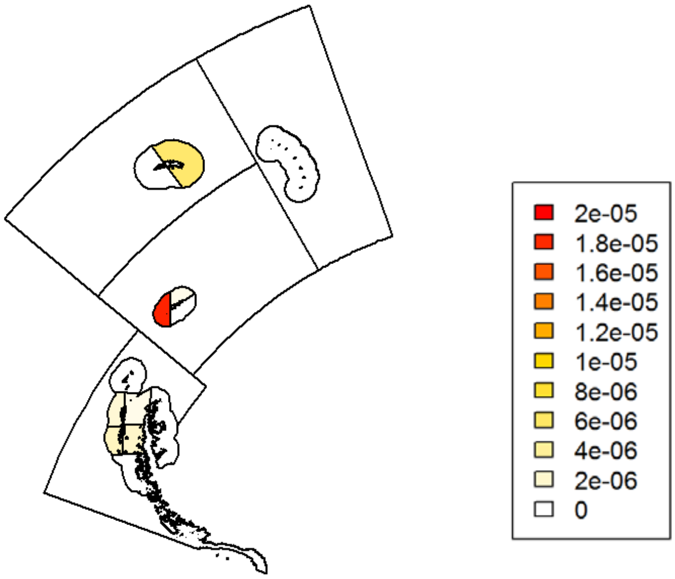
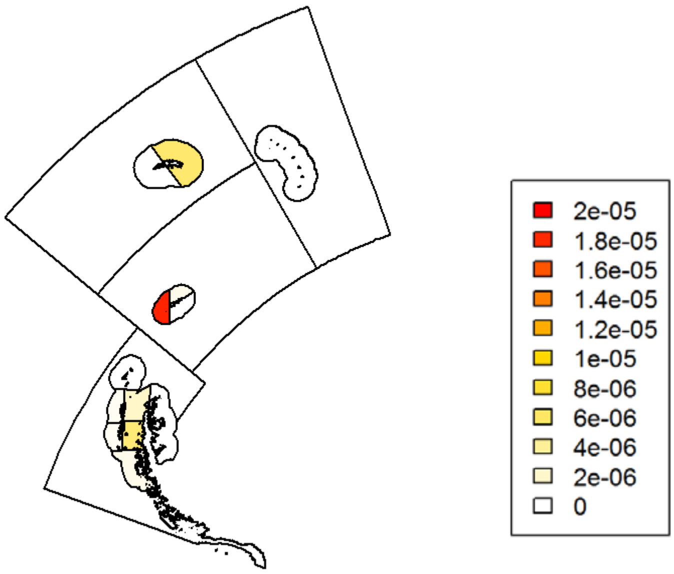


Figure 6: Proportions of the trigger level calculated for each SSMU (plotted as a density) in Scenarios 8–13 in Table 6. Regional Risks (R_risk) are given for scenarios. (continued)

Scenario 9: CM_current481_25 (R_Risk = 0.46)



Scenario 10: CM_D&B_481_25 (R_Risk = 0.47)

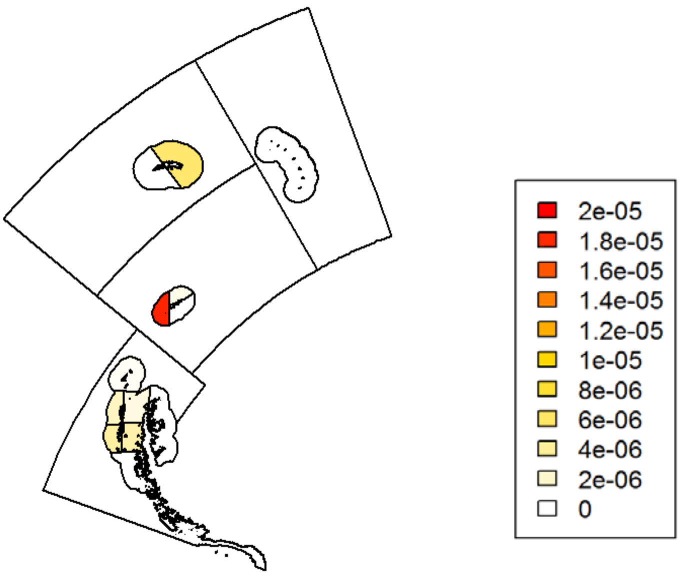
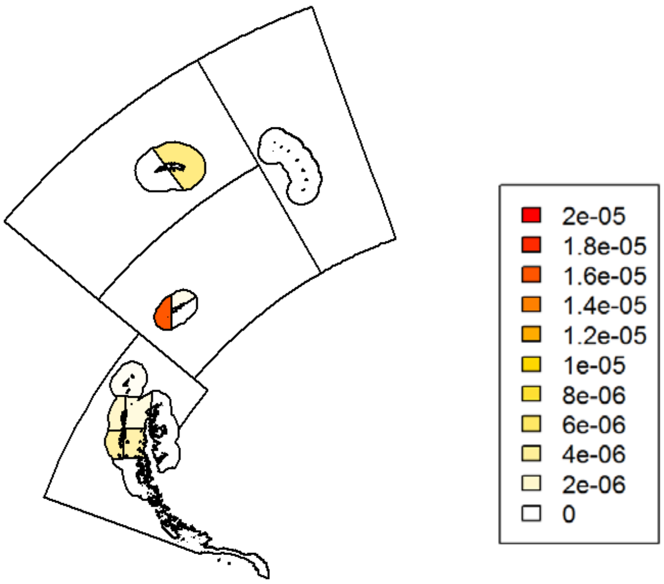


Figure 6 (continued)

Scenario 11: CM_even481_35 (R_Risk = 0.53)



Scenario 12: CM_current481_35 (R_Risk = 0.52)

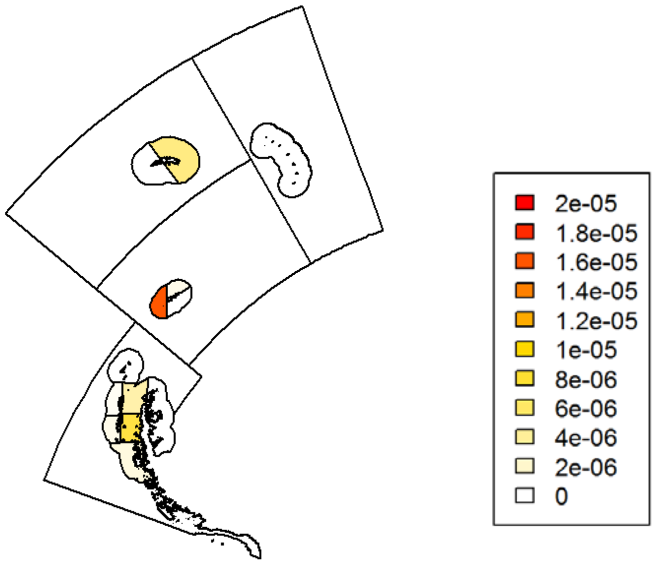


Figure 6 (continued)

Scenario 13: CM_D&B_481_35 (R_Risk = 0.53)

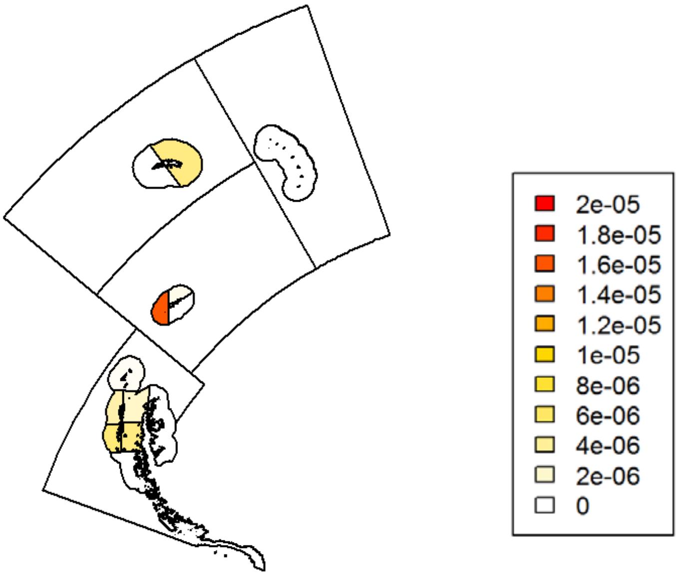


Figure 6 (continued)

List of Participants

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(Hobart, Australia, 3 to 12 October 2016)

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Appendix B

Agenda

Working Group on Fish Stock Assessment
(Hobart, Australia, 3 to 12 October 2016)

1. Opening of the meeting

2. Organisation of the meeting and adoption of the agenda

    2.1 Organisation of the meeting
    2.2 Subgroup organisation and coordination

3. Review of available information (all fisheries)

    3.1 *Champsocephalus gunnari* in Subarea 48.3 and Divisions 58.5.1 and 58.5.2

        3.1.1 Champsocephalus gunnari Subarea 48.3
            3.1.1.1 Review of available information
            3.1.1.2 Review of stock assessment
            3.1.1.3 Management advice and revisions to fishery reports

        3.1.2 *Champsocephalus gunnari* Division 58.5.1
            3.1.2.1 Review of available information
            3.1.2.2 Review of stock assessment
            3.1.2.3 Management advice and revisions to fishery reports

        3.1.3 *Champsocephalus gunnari* Division 58.5.2
            3.1.3.1 Review of available information
            3.1.3.2 Review of stock assessment
            3.1.3.3 Management advice and revisions to fishery reports

    3.2 *Dissostichus* spp. in Subareas 48.4, 88.1 and 88.2

        3.2.1 *Dissostichus* spp. in Subarea 48.4
            3.2.1.1 Review of available information
            3.2.1.2 Review of stock assessment
            3.2.1.3 Management advice and revisions to fishery reports

        3.2.2 *Dissostichus* spp. in Subarea 88.1
            3.2.2.1 Review of research proposals
                3.2.2.1.1 88.1 Shelf
                3.2.2.1.2 88.2 AB North
                3.2.2.1.3 88.2 AB South

            3.2.2.2 Management advice and revisions to fishery reports

3.2.3 *Dissostichus* spp. in Subarea 88.2

3.2.3.1 Review of available information
3.2.3.2 Review of stock assessment
3.2.3.3 Management advice and revisions to fishery reports

3.2.4 *Dissostichus eleginoides* in Subarea 58.6 and Division 58.5.1

3.2.4.1 Review of available information
3.2.4.2 Review of stock assessment
3.2.4.3 Management advice and revisions to fishery reports

4. Research to inform current or future assessments in 'data-poor' fisheries (e.g. closed areas, areas with zero catch limits and Subareas 48.6 and 58.4) notified under Conservation Measures 21-02 and 24-01

4.1 Generic issues
4.2 Management area research reviews

4.2.1 *Dissostichus* spp. Subarea 48.2

4.2.1.1 Review of available information and data quality
4.2.1.2 Review of progress towards a stock assessment and research proposals
4.2.1.3 Management advice and revisions to fishery reports

4.2.2 *Dissostichus eleginoides* Subarea 48.5

4.2.2.1 Review of available information and data quality
4.2.2.2 Review of progress towards a stock assessment and research proposals
4.2.2.3 Management advice and revisions to fishery reports

4.2.3 *Dissostichus* spp. Subarea 48.6

4.2.3.1 Review of available information and data quality
4.2.3.2 Review of progress towards a stock assessment and research proposals
4.2.3.3 Management advice and revisions to fishery reports

4.2.4 *Dissostichus* spp. Division 58.4.1

4.2.4.1 Review of available information and data quality
4.2.4.2 Review of progress towards a stock assessment and research proposals
4.2.4.3 Management advice and revisions to fishery reports

4.2.5 *Dissostichus* spp. Division 58.4.2

4.2.5.1 Review of available information and data quality
4.2.5.2 Review of progress towards a stock assessment and research proposals
4.2.5.3 Management advice and revisions to fishery reports

4.2.6 *Dissostichus* spp. Division 58.4.3a
4.2.6.1 Review of available information and data quality
4.2.6.2 Review of progress towards a stock assessment and research proposals
4.2.6.3 Management advice and revisions to fishery reports

4.2.7 *Dissostichus* spp. Division 58.4.4a and b
4.2.7.1 Review of available information and data quality
4.2.7.2 Review of progress towards a stock assessment and research proposals
4.2.7.3 Management advice and revisions to fishery reports

4.2.8 *Dissostichus* spp. Subarea 88.3
4.2.8.1 Review of available information and data quality
4.2.8.2 Review of progress towards a stock assessment and research proposals
4.2.8.3 Management advice and revisions to fishery reports

4.2.9 Notothenioid spp. Subarea 48.1
4.2.9.1 Review of available information and data quality
4.2.9.2 Review of progress towards a stock assessment and research proposals
4.2.9.3 Management advice and revisions to fishery reports

5. Scheme of International Scientific Observation

6. Non-target catch and interactions in CCAMLR fisheries

6.1 Fish and invertebrate by-catch
6.2 Marine mammal and seabird by-catch
6.3 Bottom fishing activities and vulnerable marine ecosystems (VMEs)

7. Future work

7.1 Organisation of intersessional activities
7.2 Intersessional meetings
7.3 Notification of 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, 3 to 12 October 2016)

WG-FSA-16/01	Summary of scientific observer data collected in finfish fisheries in the CAMLR Convention Area during 2016 CCAMLR Secretariat
WG-FSA-16/02	Updated status of *Notothenia rossii*, *Gobionotothen gibberifrons* and *Notothenia coriiceps* in inshore sites of the South Shetland Islands: results of a long-term monitoring program (1983–2016) at Potter Cove E. Barrera-Oro, E. Marschoff and D. Ainley
WG-FSA-16/03	Consideration of requirements for a CCAMLR hook-marking scheme CCAMLR Secretariat
WG-FSA-16/04	Fish by-catch in the krill fishery: 2016 update CCAMLR Secretariat
WG-FSA-16/05	Measurement of capacity in CCAMLR exploratory fisheries in Subareas 88.1 and 88.2: Secretariat update 2016 CCAMLR Secretariat
WG-FSA-16/06	Diet composition of Antarctic toothfish Delegation of the Republic of Korea
WG-FSA-16/07	Perfluorinated compounds in muscle tissues of Antarctic toothfish in Division 58.4.1 and 58.4.2 of Antarctic Sea Delegation of the Republic of Korea
WG-FSA-16/08	Preliminary results of pop-up satellite tag study on Antarctic toothfish in the Mawson Sea Delegation of the Republic of Korea
WG-FSA-16/09	Whale depredation data collection guidelines N. Gasco, P. Tixier, M. Söffker and C. Guinet
WG-FSA-16/10	Update on Patagonian toothfish (*Dissostichus eleginoides*) losses in the bottom longline fishery due to the depredation by killer whales and sperm whales off the Kerguelen and Crozet Islands N. Gasco, P. Tixier, G. Duhamel and C. Guinet

WG-FSA-16/11	Identification self training N. Gasco and A. Martin
WG-FSA-16/12	By-catch of morid cods (Gadiformes: Moridae) in the CCAMLR area and adjacent areas during commercial fishing and research surveys A. Orlov and I. Gordeev
WG-FSA-16/13 Rev. 1	Integrated analysis of the by-catch data in the Ross Sea toothfish fishery S. Kasatkina
WG-FSA-16/14	Analysis of the longline fishery data in the Ross Sea (SSRUs 881B, C and G) S. Kasatkina
WG-FSA-16/15 Rev. 1	Plan of research program of the Russian Federation in Subarea 48.5 Delegation of the Russian Federation
WG-FSA-16/16 Rev. 1	Research program on resource potential and life cycle of *Dissostichus* species from the Subarea 88.2 A in 2016–2019 Delegation of the Russian Federation
WG-FSA-16/17	A by-catch guide for commonly caught species in CCAMLR longline and trawl fisheries CCAMLR Secretariat
WG-FSA-16/18	Report on the CCAMLR marine debris monitoring program CCAMLR Secretariat
WG-FSA-16/19	Report on an Antarctic cetacean survey on board a Chilean fishing vessel in February 2016 S. Viquerat, H. Herr, K.-H. Kock and P. Arana
WG-FSA-16/20	Part 1. Seabird assemblages during trawling operations J.A. Arata
WG-FSA-16/21	Hidroacustics survey around Elephant Island (Subarea 48.1) and South Orkney Islands (Subarea 48.2), austral summer 2016 N.A. Landeros and P.M. Arana
WG-FSA-16/22	Spawning pattern and type of fecundity in notothenioids collected around the Elephant and South Orkney Islands G. Plaza, P.M. Arana, F. Becker, A. Zavatteri and V.H. Castillo

WG-FSA-16/23	The random stratified trawl survey to estimate the abundance of *Dissostichus eleginoides* and *Champsocephalus gunnari* in the waters of Heard Island (Division 58.5.2) for 2016 G.B. Nowara, T.D. Lamb and D.C. Welsford
WG-FSA-16/24	IUU summaries for inclusion in Fishery Reports CCAMLR Secretariat
WG-FSA-16/25 Rev. 1	Long-distance movements of tagged Patagonian (*Dissostichus eleginoides*) and Antarctic toothfish (*D. mawsoni*) CCAMLR Secretariat
WG-FSA-16/26	A preliminary assessment of mackerel icefish (*Champsocephalus gunnari*) in Division 58.5.2, based on results from the 2016 random stratified trawl survey D. Maschette and D. Welsford
WG-FSA-16/27	Local biomass estimates for Antarctic (*Dissostichus mawsoni*) and Patagonian (*Dissostichus eleginoides*) toothfish in research blocks in Subareas 48.6 and 58.4 CCAMLR Secretariat
WG-FSA-16/28 Rev. 1	Report on season extension trials in the Patagonian toothfish longline fishery in CCAMLR Statistical Division 58.5.2 T. Lamb
WG-FSA-16/29	Joint research proposal for the *Dissostichus* spp. exploratory fishery in East Antarctica (Divisions 58.4.1 and 58.4.2) by Australia, France, Japan, Republic of Korea and Spain Delegations of Australia, France, Japan, Republic of Korea and Spain
WG-FSA-16/30	Joint report on exploratory fishing in Divisions 58.4.1 and 58.4.2 between the 2011/12 and 2015/16 fishing seasons Delegations of Australia, France, Japan, Republic of Korea and Spain
WG-FSA-16/31	Finfish distribution and abundance in Subareas 48.1 and 48.2, 2016–2018. Research proposal for the second year Delegation of Chile
WG-FSA-16/32 Rev. 1	Revised research plan for the 2016/17 exploratory longline fishery of *Dissostichus* spp. in Subarea 48.6 by South Africa and Japan Delegations of Japan and South Africa

WG-FSA-16/33 Rev. 1	Revised research plan for the 2016/17 toothfish fishery in Division 58.4.4b by Japan and France Delegations of Japan and France
WG-FSA-16/34	Revised research longline fishing proposal for *Dissostichus* spp. in Subarea 48.2. Second Season 2017 Delegation of Chile
WG-FSA-16/35	Final report on the survey for *Dissostichus* spp. in Subarea 48.2 (Phase one 2016) A. Zuleta, S. Hopf and P. Ruiz
WG-FSA-16/36	Fishing for structure; can we describe normal patterns in toothfish fishing operations using catch and effort data? J.M. Fenaughty and K. Large
WG-FSA-16/37	Results of the first winter longline survey to the northern Ross Sea region to investigate toothfish reproductive life history D. Stevens, D. Di Blasi and S. Parker
WG-FSA-16/38	Proposal to allow the use of net monitoring cable in CCAMLR krill trawl fisheries Delegation of Norway
WG-FSA-16/39	Preliminary tag-recapture based population assessment of Antarctic toothfish in Subarea 48.4 S. Wright, N. Walker, M. Söffker and T. Earl
WG-FSA-16/40	Proposal for a longline survey to determine toothfish population connectivity between Subareas 48.2 and 48.4 Delegation of the United Kingdom
WG-FSA-16/41	Subarea 48.2 research proposals – overview M. Söffker, C. Cardenas, L. Pshenichnov, D. Marichev, A. Zuleta, S. Ajiumerov and C. Darby
WG-FSA-16/42	Report on the 1st COLTO depredation workshop in Punta Arenas, Chile M. Söffker and D. Welsford
WG-FSA-16/43	The use of an electronic monitoring camera system for the toothfish fishery in CCAMLR Subarea 48.3: A study case to help CCAMLR scientific observers R. Benedet, D. Barnes and M. Collins

WG-FSA-16/44	Progress towards an assessment of Antarctic toothfish (*Dissostichus mawsoni*) in Subarea 88.2 SSRUs 882C–H for the years 2002–03 to 2015–16 using a two-area model S. Mormede, K. Large and S. Hanchet
WG-FSA-16/45	A characterisation of the toothfish fishery and tagging programme in the Amundsen Sea region (SSRUs 882C–H) through 2015–16 K. Large, S. Parker and S. Hanchet
WG-FSA-16/46	A multivariate approach to examining patterns in research fishing activities using the SSRUs 882A–B North survey as an example S. Mormede, A. Dunn, S.J. Parker, T. Earl, C. Darby, M. Söffker and O.R. Godø
WG-FSA-16/47 Rev. 1	Scientific contribution to the 2016 review of Conservation Measure 51-07: Part 1 – rationale, method and data for a risk assessment framework for distributing the krill trigger level A. Constable (on behalf of the e-group on CM 51-07 WG-EMM review)
WG-FSA-16/48 Rev. 1	Scientific contribution to the 2016 review of Conservation Measure 51-07: Part 2 – outcomes from the application of the risk assessment framework for distributing the krill trigger level in Area 48 A. Constable (on behalf of the e-group on CM 51-07 WG-EMM review)
WG-FSA-16/49	Revised plan of research program of the Ukraine in Subarea 48.2 in 2017 (third season) Delegation of Ukraine
WG-FSA-16/50	The report on the survey in Subarea 48.2 in 2016 (second season) Delegation of Ukraine
WG-FSA-16/51	Species profiles: Target species and common by-catch species K.-H. Kock, C.D. Jones and D. Welsford
WG-FSA-16/52	Updated assessment of Patagonian toothfish (*Dissostichus eleginoides*) in the vicinity of Crozet Islands (Subarea 58.6) R. Sinegre and G. Duhamel
WG-FSA-16/53	Stock assessment of mackerel icefish (*Champsocephalus gunnari*) in the vicinity of Kerguelen Islands (Division 58.5.1) after the 2015 Icefish Biomass survey R. Sinegre and G. Duhamel

WG-FSA-16/54	Updated stock assessment of Patagonian toothfish (*Dissostichus eleginoides*) in the vicinity of Kerguelen Islands (Division 58.5.1) R. Sinegre and G. Duhamel
WG-FSA-16/55	Research plan for the exploratory longline fishery for *Dissostichus* spp. in 2016/17 in Division 58.4.3a by France and Japan Delegation of France and Japan
WG-FSA-16/56	Revised progress report for the fourth year of the research fishery for *Dissostichus* spp. in Subarea 48.6 being jointly undertaken by Japan and South Africa S. Somhlaba, R. Leslie, K. Taki, T. Ichii and T. Namba
WG-FSA-16/57	Pop-off satellite tagging in the Ross Sea region in 2016 C.D. Jones, S.J. Parker, A. Dunn, D. Di Blasi and D. Stevens
WG-FSA-16/58	Update of ongoing work on age and growth of Antarctic toothfish (*Dissostichus mawsoni*) (2013/14 season) from Division 58.4.1 by Spain L.J. López-Abellán, M.T.G. Santamaría, R. Sarralde and S. Barreiro
WG-FSA-16/59	Proposal for research fishing in CCAMLR Subarea 48.6 during the three-year period 2016/17–2018/19 Delegation of Uruguay

Other documents

WG-FSA-16/P01	Parasites of the Antarctic toothfish (*Dissostichus mawsoni* Norman, 1937) (Perciformes, Nototheniidae) in the Pacific sector of the Antarctic I.I. Gordeev and S.G. Sokolov *Polar Res*., 35 (2016): 29364, http://dx.doi.org/10.3402/polar.v35.29364
WG-FSA-16/P02	Lipid metabolism features of Antarctic toothfish *Dissostichus mawsoni* (Nototheniidae) I.I. Gordeev, D.V. Mikryakov, N.I. Silkina and A.S. Sokolova *Issues of pathology, immunology and health protection of fishes and other hydrobionts*. Extended materials of the IV International Congress, Borok, 24–27 September 2015: 280–286 (in Russian)

WG-FSA-16/P03	Distribution and abundance of skates (*Bathyraja* spp.) on the Kerguelen Plateau through the lens of the toothfish fisheries G.B. Nowara, P. Burch, N. Gasco, D.C. Welsford, T.D. Lamb, C. Chazeau, G. Duhamel, P. Pruvost, S. Wotherspoon and S.G. Candy *Fish. Res.*, 186 (2017): 65–81, http://dx.doi.org/10.1016/j.fishres.2016.07.022
WG-SAM-16/11	Korean research plan in Subarea 88.3 in 2016/17 Delegation of the Republic of Korea
WG-SAM-16/14	Results of the fifth Ross Sea shelf survey to monitor abundance of sub-adult Antarctic toothfish in the southern Ross Sea, February 2016, and notification for continuation in 2017 A. Dunn, C. Jones, S. Mormede and S. Parker
WG-SAM-16/15	Proposal for a second longline survey of toothfish in the northern Ross Sea region (SSRUs 882A and B) S.J. Parker, R.J.C. Currey, M. Söffker, C. Darby, D. Welsford and O.R. Godø
WG-SAM-16/29	Progress report on the Korean research fishing by longline fishery for *Dissostichus* spp. in Subarea 88.3 in 2015/16 Delegation of the Republic of Korea
WG-EMM-16/P09	Linking population trends of Antarctic shag (*Phalacrocorax bransfieldensis*) and fish at Nelson Island, South Shetland Islands (Antarctica) R. Casaux and E. Barrera-Oro *Polar Biol.*, (2015), doi: 10.1007/s00300-015-1850-5
CCAMLR-XXXV/14	A proposal to make activities targeting toothfish consistent with CCAMLR's regulatory framework Secretariat
CCAMLR-XXXV/BG/05 Rev. 1	Fishery notifications 2016/17 Secretariat
CCAMLR-XXXV/BG/09	Proposal to revise conservation measures related to activities targeting toothfish consistent with CCAMLR's regulatory framework Secretariat
SC-CAMLR-XXXV/BG/01	Catches of target species in the Convention Area CCAMLR Secretariat
SC-CAMLR-XXXV/BG/25	Developing the Secretariat's data management systems CCAMLR Secretariat

The CCAMLR Scientific Scholarship Scheme
Terms and conditions

The CCAMLR Scientific Scholarship Scheme
Terms and conditions

Purpose

1. CCAMLR recognises that to develop the best available science to support the work of the Scientific Committee and the Commission, from time to time active investment in science capacity will be required. The activities that contribute towards science capacity may include increasing participation and awareness of CCAMLR science, mechanisms to resource and deliver scientific activities and improving information flow within the CCAMLR scientific community (SC-CAMLR-XXVIII, paragraph 10.23).

2. In 2010, as part of this program of interrelated activities, the Scientific Committee created the CCAMLR Scientific Scholarship Scheme (SC-CAMLR-XXIX, paragraph 15.11 and Annex 9).

Objective

3. CCAMLR awards scholarships to assist early career scientists to participate in the work of the Scientific Committee and its working groups. Scholarships may be awarded annually or only occasionally, dependent upon the scientific priorities. CCAMLR may award more than one scholarship in any year.

4. The objective of the scholarship scheme is to contribute to capacity building within the CCAMLR scientific community, so as to generate a sound basis of scientific expertise able to support the requirements of CCAMLR in the long term. It will be expected to contribute to:

(i) consistent and high attendance and participation by scientists from all Members, so that scientific advice has wide understanding and acceptance by Members

(ii) consistent and high-quality scientific advice being provided by the Scientific Committee

(iii) advice for robust decision-making being available to the Commission.

Scope

5. Scholarships of up to A$30 000 are available to cover travel, accommodation and subsistence at CCAMLR Scientific Committee workshops or working group meetings and relevant preparatory meetings and, exceptionally, meetings of the Scientific Committee, over a period of two years. Applications for partial support for the above items are encouraged. Relevant preparatory meetings may include meetings and short periods of preparatory collaborative work with mentor scientists in their home institutions, or travel to/from mentor scientist research cruises.

6. Exceptionally, and on review of the activities of the scholarship recipient over the two-year period, the Scientific Committee may extend the scholarship for one additional year.

Publicity

7. Opportunities for scholarships will be advertised on the CCAMLR website and social media, including in conjunction with the Scientific Committee on Antarctic Research (SCAR) and the Council of Managers of National Antarctic Programs (COMNAP) fellowships.

8. Additional publicity by individual Members, particularly in Member scientific institutions, and by CCAMLR Observers at international meetings, as well as Observers to CCAMLR, will be strongly encouraged.

Eligibility

9. Scholarships are open to scientists from CCAMLR Members. Preference will be given to early career scientists (for example, but not limited to, PhD students or early post-doctoral scientists) who have not previously, or routinely, participated in CCAMLR working groups and are actively seeking to participate in CCAMLR science.

10. Although candidates are sought from all Members, particular preference will be given to early career scientists from developing countries and those from Members having received low numbers of scholarships in past years.

11. Scholarships are not intended to cover salary or similar costs; candidates must have sources of additional funding to cover these aspects of their requirements.

Requirements

12. Proposals for candidates must be made by the Scientific Committee Representative of the relevant Member providing the following:

(i) the name, address and affiliation of the candidate scientist

(ii) the language ability of the scientist. Ideally, this will include proof of at least intermediate-level proficiency in English, which is the working language of the working groups

(iii) the area of the Scientific Committee's work to which the scientist would contribute, considering particularly topics of special and current interest of the Scientific Committee

(iv) the scientific contribution that would be made by the scientist to CCAMLR arising from his/her intersessional work during the period of the scholarship

(v) confirmation of participation from at least one established scientist with significant experience of attendance in relevant CCAMLR working groups, who may be from the applicant's country or from another CCAMLR Member, who has agreed to mentor the successful candidate

(vi) the working groups and workshops that the scientist would participate in

(vii) any additional travel to preparatory meetings, for instance with the mentoring scientist and his/her institution

(viii) justification of the need to apply for scholarship money

(ix) a preliminary budget, based on assumptions about the future disposition and length of Scientific Committee working group meetings

(x) evidence that other funds are available to support the work of the scientist during the proposed period of tenure of the scholarship

(xi) a commitment that the Member will facilitate participation by the recipient in the work of the Scientific Committee for the duration of the scholarship

(xii) references from the scientist's home institution and the Member's Scientific Committee Representative.

Reporting

13. Scholarship recipients will be required to provide at least one paper for CCAMLR over a two-year period and this paper should be highlighted as being a product of the work supported by the scholarship in order that this can also be reviewed by the Scientific Scholarship Review Panel. They will, further, be encouraged to publicise their activities, whilst a recipient of the scholarship, within the scientific community.

14. The Chair of the Scientific Scholarship Review Panel will report to the Scientific Committee each year on the disbursement of funds and the associated activities of the recipients.

Application procedure

15. The Secretariat will annually publish widely a call for scholarship proposals amongst all Members. This call shall include details of the Scientific Committee's priority topics and work plan.

16. The deadline for proposals shall be one month prior to the start of the annual Scientific Committee meeting.

17. Application shall be by application form which is available from the Secretariat.

Scientific Scholarship Review Panel

18. A Scientific Scholarship Review Panel will be convened at the Scientific Committee meeting, chaired by the Senior Vice-Chair of the Scientific Committee and comprising the CCAMLR Secretariat's Science Manager, the conveners of the Scientific Committee working groups and the other Vice-Chair of the Scientific Committee. Two other members of the scientific community with expertise relevant to the applications will be appointed by the Senior Vice-Chair.

Evaluation

19. The Scientific Scholarship Review Panel will be convened at each Scientific Committee meeting. This panel will annually provide a written report to the Scientific Committee that, inter alia:

(i) reviews existing scholarships, approves the annual expenditure and forecast expenditure

(ii) reviews scholarship proposals received by the deadline against the following set of criteria:

(a) scientific and other qualifications of the candidate

(b) relevance to the work priorities and work plan of the Scientific Committee

(c) the extent to which it will strengthen the scientific capacity and engagement in the work of the Scientific Committee of the applying Member

(d) strength of the linkages made with mentor scientist(s) and the new scientist

(e) justification for the budget requested

(iii) provides a shortlist of candidates based on the review

(iv) considers the funds available to the scholarship scheme, and propose any adjustments necessary to the budgets proposed by candidates

(v) recommends to the Scientific Committee the scholarship recipient(s) and the budget requirements for the scholarship scheme in the upcoming year.

20. Applicants will be advised of the outcome of their application.

Funding and disbursement

21. The CCAMLR Secretariat will administer the scholarship scheme. The Secretariat will pay actual costs of all budgeted items on presentation of receipts. Airfares will be reimbursed at economy travel rates only. Living and accommodation while attending approved meetings

etc. will be reimbursed at the relevant United Nations Daily Subsistence Allowance rates for country and city of meeting(s). A Daily Subsistence Allowance may also be payable for travel to and from meeting(s) depending on the time and distance travelled by scholarship holders. This will be decided on an application by application basis. All other travel expenses are payable by the scholarship holder or sponsoring country.

22. In situations where a scholarship recipient is unable to attend a meeting that forms part of the funded scholarship, then the reasons for this should be reported to the Scientific Scholarship Review Panel in order that the panel can make an evaluation of whether any modifications to the schedule of funding of the scholarship is required.

Breach of terms and conditions

23. In the event that a scholarship recipient fails to comply with any of the requirements in these terms and conditions, CCAMLR may, in its absolute discretion, require the recipient to repay, in part or in total, monies paid under this scholarship.

Acceptance of these terms and conditions

24. Information on how to apply for the CCAMLR Scientific Scholarship Scheme on the CCAMLR website (www.ccamlr.org/node/77769) forms part of these terms and conditions. Submission of an application for the scheme is deemed acceptance of these terms and conditions.

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
WWW	World Wide Web
XBT	Expendable Bathythermograph
XML	Extensible Mark-up Language
Y2K	Year 2000
YCS	Year-class Strength(s)