**SC-CAMLR-XXXIV**

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

# REPORT OF THE THIRTY-FOURTH MEETING OF THE SCIENTIFIC COMMITTEE

HOBART, AUSTRALIA
19–23 OCTOBER 2015

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Chair of the Scientific Committee
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**Abstract**

This document presents the adopted report of the Thirty-fourth Meeting of the Scientific Committee for the Conservation of Antarctic Marine Living Resources held in Hobart, Australia, from 19 to 23 October 2015. 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

## Contents

**Report of the Thirty-fourth**
**Meeting of the Scientific Committee**
(Hobart, Australia, 19 to 23 October 2015)

## Opening of the meeting

1.1 The Scientific Committee for the Conservation of Antarctic Marine Living Resources met from 19 to 23 October 2015 at the CCAMLR Headquarters in Hobart, Tasmania, Australia. The meeting was chaired by Dr C. Jones (USA).

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. An apology was received from Brazil.

1.3 The Chair also welcomed to the meeting Observers from Finland and the Netherlands (Acceding States), along with Observers from intergovernmental organisations ACAP, CCSBT, CEP, IUCN, IWC, SCAR (including SCOR), 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 and welcomed Oceanites Inc. to its first meeting of the Scientific Committee.

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

1.5 The Scientific Committee's report was prepared using a web-based system 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.

1.6 The report of the Scientific Committee was prepared by A. Constable (Australia), J. Clark (EU), R. Currey (New Zealand), C. Darby (UK), I. Foster (Secretariat), O.R. Godø (Norway), S. Hanchet (New Zealand), K.-H. Kock (Germany), R. Leslie (South Africa), J. Melbourne-Thomas (Australia), S. Parker (New Zealand), D. Ramm, K. Reid and L. Robinson (Secretariat), C. Reiss (USA), M. Söffker and P. Trathan (UK), G. Watters (USA), D. Welsford and P. Ziegler (Australia).

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

1.8 The Scientific Committee noted the passing of Dr Konstantin Shust (Russia) in August 2015, and paused to reflect on his long-standing contribution to the work of the Scientific Committee and the Commission. Dr Shust had authored a total of 34 meeting papers and had participated in CCAMLR meetings from 1988 to 2010.

Adoption of agenda

1.9 The Scientific Committee discussed the Provisional Agenda which had been circulated prior to the meeting (4 September 2015) and the agenda was adopted without change (Annex 3). The Scientific Committee agreed to consider Item 13.1 early in its meeting in order to allow sufficient time to develop the elements and priorities for its work.

Chair's report

1.10 Dr Jones reflected on the Scientific Committee's work in the 2014/15 intersessional period. The following meetings had taken place:

(i) the Subgroup on Acoustic Survey and Analysis Methods (SG-ASAM) met in Busan, Republic of Korea, from 9 to 13 March 2015 (Annex 4) and was convened by Dr X. Zhao (China); 18 participants from six Members participated, three meeting papers were tabled

(ii) the Working Group on Statistics, Assessments and Modelling (WG-SAM) met in Warsaw, Poland, from 29 June to 3 July 2015 (Annex 5) and was convened by Dr Parker; 39 participants from 15 Members participated and 53 meeting papers were tabled

(iii) the Working Group on Ecosystem Monitoring and Management (WG-EMM) met in Warsaw, Poland, from 6 to 17 July 2015 (Annex 6) and was convened by Dr S. Kawaguchi (Australia); 50 participants from 16 Members participated and 70 meeting papers were tabled

(iv) the Working Group on Fish Stock Assessment (WG-FSA) met in Hobart, Australia, from 5 to 16 October 2015 (Annex 7) and was convened by Dr M. Belchier (UK); 38 participants from 14 Members participated and 90 meeting papers were tabled.

1.11 Dr Jones, on behalf of the Scientific Committee, thanked the conveners of SG-ASAM, WG-SAM, WG-EMM and WG-FSA, and Korea and Poland for hosting the intersessional meetings in 2015. He also thanked participants for developing the Scientific Committee's work in 2014/15 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) a review of progress towards updated integrated assessments
(ii) review of stock assessment methods

(iii) evaluation of research plans from Members notifying to fish in exploratory fisheries in Subareas 48.6 and 58.4 under Conservation Measure (CM) 21-02 and research proposals for other areas submitted under CM 24-01.

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 within the WG-FSA report (Annex 7).

2.3 The Scientific Committee noted advice from WG-SAM regarding input data and progress on updated CASAL stock assessments for toothfish (*Dissostichus* spp.) fisheries in several management areas. It reviewed:

(i) the developing CASAL model for toothfish in Divisions 58.4.3 (Elan Bank) and 58.4.4 (Ob and Lena Banks) and made recommendations for further work (Annex 5, paragraphs 2.1 to 2.9)

(ii) stock structure and methodology to estimate catchability and discussed stock structure and linkages between toothfish in Divisions 58.5.1 and 58.5.2 (Annex 5, paragraphs 2.10 to 2.17)

(iii) progress towards developing a two-area model in small-scale research units (SSRUs) 882C–H (Annex 5, paragraphs 2.18 to 2.21).

2.4 The Scientific Committee endorsed the advice from WG-SAM regarding several generic aspects of integrated stock assessments, including:

(i) advice to develop and use stock-specific life-history and productivity parameters where available (Annex 5, paragraph 2.22)

(ii) advice on documenting the rationale for the choice of priors (Annex 5, paragraph 2.23)

(iii) encouraging work using simulations or power analysis to evaluate the quantity and quality of data needed to develop robust assessments (Annex 5, paragraph 2.24).

2.5 The Scientific Committee noted that WG-SAM examined by-catch to target catch ratios reported by observers and vessels. It noted that WG-SAM noted inconsistencies and had requested the Secretariat to collect information on how Members provide guidance to observers and vessels in recording catch (Annex 5, paragraphs 2.25 to 2.32).

2.6 The Scientific Committee recalled that a number of issues related to differences in the reporting of observer data have already been highlighted in the CCAMLR Scheme of International Scientific Observation (SISO) review in 2013 and in discussion of the rationale for the CCAMLR Observer Training Program Accreditation Scheme (COTPAS). The Scientific Committee endorsed the recommendation of WG-SAM for a review of the training and instructions provided to observers on by-catch reporting (Annex 5, paragraph 2.31). The Scientific Committee agreed that it was important to distinguish between differences in by-catch reporting by Members and through SISO, noting that these are issues for the Commission.

2.7 The Scientific Committee endorsed the advice from WG-SAM regarding stock assessment methodologies used in providing management advice (Annex 5, paragraphs 2.33 to 2.55), including, inter alia:

(i) development of model diagnostics to assist in interpreting assessment results (Annex 5, paragraphs 2.33 to 2.39)

(ii) recommendations for how to structure updates to integrated assessment reports (Annex 5, paragraphs 2.40 to 2.43)

(iii) the redevelopment of the CCAMLR database system (Annex 5, paragraphs 2.49 to 2.51)

(iv) updated bathymetric data for the Southern Ocean (Annex 5, paragraphs 2.53 to 2.55)

(v) the emerging importance of marine mammal depredation, including developing a plan to address this issue in collaboration with a science working group of COLTO (Annex 5, paragraphs 2.56 to 2.61)

(vi) developing management strategy evaluations to evaluate the robustness of CCAMLR's management systems (Annex 5, paragraphs 2.62 to 2.64).

2.8 The Scientific Committee noted that WG-SAM reviewed research plans submitted by Australia, France, Japan, Republic of Korea, South Africa and Spain as part of their notifications to fish in exploratory fisheries in Subareas 48.6 and 58.4 under CM 21-02 (Annex 5, paragraphs 3.1 to 3.25). Under this topic, WG-SAM:

(i) encouraged the development of a stock assessment for research block 486_2 and further encouraged a focus on toothfish recapture in other research blocks in the subarea (Annex 5, paragraphs 3.2 to 3.5)

(ii) reviewed five research plans in Divisions 58.4.1 and 58.4.2 with similar overall objectives of developing biomass estimates, noting the importance of research coordination to prevent one Member's research interfering with the ability of others to meet their objectives (Annex 5, paragraphs 3.6 to 3.18)

(iii) reviewed the research plan and developing stock assessment for Division 58.4.3a and again recommended coordination between Members (Annex 5, paragraphs 3.20 to 3.23).

2.9 The Scientific Committee recalled its long-standing recommendation for Members to coordinate research plans with other Members fishing in the same areas in order to ensure such research plans achieve their objectives.

2.10 The Scientific Committee noted that WG-SAM reviewed scientific research proposals submitted by Chile, France, Japan, Republic of Korea, New Zealand, Russia and Ukraine notified under CM 24-01 (closed areas, areas with zero catch limits and Subareas 88.1, 88.2 and 88.3) (Annex 5, paragraphs 4.1 to 4.42). Under this topic, WG-SAM:

(i) reviewed the first year of results from the Subarea 48.2 longline survey by Ukraine and its proposal to continue the research, along with a proposal from Chile to conduct a similar survey in the same area, recommending that these Members coordinate their proposals for review by WG-FSA (Annex 5, paragraphs 4.1 to 4.6)

(ii) noted the renotification of a previous research proposal by Chile to conduct a trawl survey in Subarea 48.1 (Annex 5, paragraph 4.7)

(iii) noted the analysis of catch data from the Weddell Sea in 2012/13 but did not complete the evaluation because the Scientific Committee had requested analysis of all *Yantar 35* data from Subarea 48.5 from 2012 to 2014 (Annex 5, paragraphs 4.8 to 4.16)

(iv) recommended further collaboration between France and Japan on work regarding the depredation issue in Division 58.4.4 (Annex 5, paragraphs 4.17 to 4.19)

(v) reviewed a proposal by the Republic of Korea to begin a new research plan in Subarea 88.3 and made recommendations to prioritise the areas chosen for research (Annex 5, paragraphs 4.20 and 4.21)

(vi) reviewed two survey proposals from New Zealand for the Ross Sea: the Ross Sea shelf survey focusing on inclusion of the survey age data in the stock assessment model (Annex 5, paragraphs 4.22 to 4.26) and a proposal for a winter survey in 2016 (Annex 5, paragraphs 4.27 to 4.29)

(vii) reviewed the progress of a multi-Member two-year survey in the northern region of SSRUs 882A–B (Annex 5, paragraphs 4.30 to 4.36)

(viii) reviewed a proposal for a Russian survey in the southern region of SSRU 882A (Annex 5, paragraphs 4.37 to 4.42).

2.11 The Scientific Committee recommended that contingency plans be developed for research survey proposals to enable alternative vessels with appropriate gear configurations to be substituted to ensure necessary data collection and continuity of CCAMLR-sponsored research survey programs.

2.12 The Scientific Committee noted that WG-SAM concluded that it was unable to complete the review of the investigation of the *Yantar 35* data from 2012/13 and 2013/14 (Annex 5, paragraph 4.10). WG-SAM agreed that the review needs to be complete and approved by the Scientific Committee prior to that vessel being considered for any further surveys in the CCAMLR area.

2.13 The Scientific Committee was informed by Russia that the *Yantar 35* has been withdrawn from all future activities within the Convention Area.

2.14 The Scientific Committee noted that WG-SAM considered other issues (Annex 5, paragraphs 5.1 to 5.5), including, inter alia:

(i) papers (WG-SAM-15/19, 15/20 and 15/51) submitted outside the remit of WG-SAM that were referred to the Scientific Committee (Annex 5, paragraphs 5.1 and 5.2)

(ii) recommendations for how to progress work of *CCAMLR Science* (Annex 5, paragraphs 5.3 to 5.5).

2.15 The Scientific Committee noted that WG-SAM discussed the process for review of research plans, the likelihood of success of research plans in meeting their objectives and the workload associated with annual review (Annex 5, paragraphs 6.1 to 6.10).

2.16 The Scientific Committee agreed that the requirements of the notification process were not consistent with the desire to have multiyear multi-Member research proposals that do not necessarily require an annual presentation and review. The Scientific Committee also recognised that there were several occasions during the WG-SAM meeting that highlighted an apparent lack of clarity in the process of notifications for research conducted under CMs 21-02, 24-01 and 41-10, Annex 41-10/A.

2.17 The Scientific Committee noted that WG-SAM developed an outline of the key types of information needed to enable review of progress towards an assessment and suggested that much of the available data could be compiled by the Secretariat for WG-FSA. The Scientific Committee noted that the results of that discussion formed the basis of WG-FSA-15/14 which was considered by WG-FSA (see Item 13).

### Acoustic survey and analysis methods

2.18 The Scientific Committee reviewed the progress and recommendation made by SG-ASAM (Annex 4) which covered three main areas:

(i) proof of concept
(ii) protocol for data collection and analysis
(iii) analysis of data collected during fishing operations.

2.19 The Scientific Committee noted the progress of SG-ASAM and its further validation of the proof of concept which is now documented through a scientific paper in a special issue of *Fisheries Research* that deals with collecting data from fishing vessels (Annex 4, paragraph 2.1).

2.20 The Scientific Committee welcomed the fact that data has already been collected and partly analysed by the Subgroup. The experience from this effort has supported the development of protocols for data collection and analyses that are now incorporated in an instruction manual for collecting acoustic data from fishing operations. This is found in an appendix in the SG-ASAM report (Annex 4, Appendix D). The Subgroup recommended this manual should be developed as a stand-alone document and posted on the CCAMLR website.

2.21 The Scientific Committee endorsed this suggestion and advised that this manual is actively used by the Member countries collecting acoustic data. The translation of this manual into languages used by the krill fishing companies was encouraged in accordance with the recommendations of SG-ASAM.

2.22 The Scientific Committee noted that the first analysis of acoustic data from fishing vessels was already completed, demonstrating favourable results but also highlighting some challenges such as acoustic recording being contaminated by noise. Standard routines for noise removal will be required and instructions for using such routines should be developed.

2.23 The Scientific Committee recognised that training people in the collection and analysis of acoustic data is an essential requirement for the implementation of using such data in the feedback management (FBM) approach. It was agreed that training the scientific observers in the collection and handling of acoustic data could be an appropriate step forward. This issue should be brought to the attention of the Commission during the discussion of scientific observation in the krill fishing fleet.

2.24 The Scientific Committee also recommended that SG-ASAM discuss what could reasonably be expected of observers with respect to collection of acoustic data. Further tasks for SG-ASAM's next meeting identified in Annex 4, paragraph 5.2, are:

(i) analysis to generate validated acoustic data suitable for further analyses
(ii) analysis to produce specific products from that validated acoustic data.

2.25 It was noted that China, Republic of Korea and Norway have agreed to collect data during 2015/16, which will bring more experience to the next SG-ASAM meeting. Vessels will be calibrated and data will be collected along transects as instructed in the SG-ASAM manual. Korea underlined the importance of using the on-board observers to ensure the data quality and also confirmed that such data collection over one month in 2016 is planned under the supervision of scientists on a Korean vessel.

2.26 The EU supported the development of this initiative but also inquired who was going to handle and analyse the enormous amount of data that would be collected. It also wondered whether observers could be trained sufficiently to handle technically difficult issues, such as standard calibration of the instruments.

2.27 It was clarified that specific routines for standardised processing of data is an important subject for the upcoming SG-ASAM meeting in March 2016. It was also clarified that technically challenging tasks like instrument calibration have been discussed and that CCAMLR has agreed to support the purchase of three calibration kits that will be located at research stations in the three subareas presently exploited by the fleet. This resource will support the participating vessels' need to routinely calibrate their equipment. The Secretariat confirmed that this is work in progress and funds are being sought to ensure implementation. The SG-ASAM Convener confirmed that the manual will be developed further to include calibration and data collection and processing procedures.

2.28 Given the importance of the work for WG-EMM and the FBM, the Scientific Committee Chair inquired about a possible hosting country and institution for the next SG-ASAM meeting. The USA, through the Southwest Fisheries Science Center in La Jolla, California, kindly offered to take on this duty during the week starting 21 March 2016.

## Harvested resources

Krill resources

3.1 The Scientific Committee noted that the krill fishery in Subarea 48.1 was closed on 28 May 2015 when the catch was 153 946 tonnes. This closure was 11 days later than in 2014/15, but continues the recent early season closures in this subarea. The total catch at the time of the Scientific Committee meeting for Subareas 48.1 to 48.4 was 221 048 tonnes (SC-CAMLR-XXXIV/BG/01).

3.2 The Scientific Committee further noted the continued concentration of fishing effort in Bransfield Strait throughout most of the season because of ice-free conditions. The Scientific Committee agreed that trends in sea-ice extent on the krill fishing grounds should be included in the Krill Fishery Report, especially given the climatic change in this region and the influence of sea-ice on fishing operations.

3.3 The Scientific Committee thanked the Secretariat for developing the structure and content of the draft Krill Fishery Report, and noted the utility of having these data summaries available to Members in a single place. It noted that the inclusion of maps of catch and spatial shifts in fishing areas in fishery reports was extremely helpful and supported the publication of such maps in the Krill Fishery Report, pending a decision by the Commission on the spatial resolution of data published in these maps. Proposed options for the spatial resolution of the maps were:

(i) 10° × 10° blocks aggregated at 10-year timescales

(ii) small-scale management units (SSMUs) for Area 48 and then 5° × 5° blocks elsewhere, aggregated at 10-year timescales

(iii) 5° × 5° blocks for all areas and divisions aggregated at 10-year timescales

(iv) the current fine-scale view presented in the Krill Fishery Report (column A of Figure 3), that is 0.5° (latitude) × 1° (longitude) blocks, aggregated at 10-year timescales.

3.4 The Scientific Committee suggested that maps of fish by-catch in the krill fishery might be a useful addition to the Krill Fishery Report (paragraphs 3.161 to 3.166). The Secretariat confirmed that it would be presenting a full analysis of by-catch data to WG-EMM and WG-FSA in 2016.

3.5 The Scientific Committee reiterated its advice to the Commission that the reporting of fish by-catch in the C1 data was a vessel responsibility and recalled the previous discussion in SC-CAMLR-XXXIII, paragraph 3.145.

Fishery notifications, green weight estimation and gear library

3.6 The Secretariat informed the Scientific Committee that the notified total catch for krill fisheries in 2015/16 is 574 000 tonnes with 18 vessels participating. The Scientific Committee noted that all vessels had notified for fishing in Subarea 48.1, and most vessels had also notified for fishing in Subareas 48.2 and 48.3. In addition, two vessels had notified for fishing in Subarea 48.4.

3.7 The Scientific Committee noted the continued discussions in WG-EMM on green weight estimation, given its importance to estimating total removals of krill in the fishery.

3.8 The Scientific Committee agreed that:

(i) the expected level of catch provided in the notifications was of limited use to its work, and recommended that, instead, Members notify each vessel's daily processing capacity (Annex 6, paragraph 2.22)

(ii) the net information listed in Annex 6, paragraphs 2.23(i) to (vii), was essential in developing estimates of stock assessment parameters

(iii) the notification pro forma in CM 21-03, Annex 21-03/A, be revised and that the parameters listed in the net configuration table be replaced with the parameters above (Annex 6, paragraph 2.24)

(iv) information on fishing gears and exclusion devices was important in developing estimates of total removals from krill fisheries and estimating stock assessment parameters (Annex 6, paragraph 2.25).

Krill biology, ecology and management

3.9 The Scientific Committee noted the continued effort to understand krill biology, ecology and management by Members through a variety of activities. The Scientific Committee also noted recent studies in the Antarctic Peninsula region that have shown that krill biomass is highly concentrated in Bransfield Strait during winter, an area that is becoming ice-free more frequently, increasing their availability to autumn and winter krill fisheries. The Scientific Committee agreed that these environmental changes highlight the importance of considering climate change in providing advice to the Commission on the future spatial distribution of the fishery.

3.10 The Scientific Committee further noted other ecosystem studies, including opportunistic cruises, to undertake ecosystem monitoring and research (Annex 6, paragraphs 2.62 and 2.63). The Scientific Committee welcomed the acoustic survey for krill biomass conducted around the Balleny Islands during the 2015 austral summer (WG-EMM-15/17).

3.11 The Scientific Committee agreed that it was not easy to understand and implement the current protocol for acoustic data analysis because different elements are distributed in different reports and publications over a series of years. In addition, there were published papers that are no longer consistent with the present protocol that are still frequently cited. The Scientific Committee, therefore, agreed that, to facilitate the implementation and citation of the current acoustic protocol, SG-ASAM be requested to document the full protocol together with associated code in one single publication (Annex 6, paragraphs 2.53 to 2.59).

3.12 In relation to the effect of climate change, the Scientific Committee agreed that future warming may affect the susceptibility of krill to infection by disease agents which require specific temperatures for survival, and recommended that this type of work should be progressed (Annex 6, paragraph 2.66).

3.13 The Scientific Committee agreed that recent reanalyses of the krill biomass index in Area 48 based on KrillBase data and local acoustic surveys show no evidence of a systematic change in krill biomass since 2000 (Annex 6, paragraph 2.70). The Scientific Committee further noted that as the trigger level is less than 2% of krill biomass estimated in any year between 2000 to 2011, the current trigger level is appropriate for achieving the objectives of Article II of the Convention for the krill stock at the area scale (see Annex 6, paragraph 2.101), but is not intended to manage localised fishery impacts on krill predators.

3.14 The Scientific Committee discussed how to estimate change given the high level of variability that exists in these time series of krill biomass estimates. Such challenges would also indicate difficulty in attributing changes in biomass or abundance to fishing or the environment. Developing FBM advice would then be more complicated. The Scientific Committee agreed that the question of statistical power in these types of analyses should be reviewed by WG-EMM and WG-SAM.

3.15 The Scientific Committee agreed that these time series of krill biomass estimates are invaluable and would grow in importance with increased length of the time series. It also agreed that maintenance of these time series is critical to its work.

3.16 The Scientific Committee agreed that:

(i) if catches at the subarea trigger level were to be taken in a few SSMUs, then the objectives of Article II of the Convention may not be achieved. Management of the krill fishery at the SSMU scale is likely to be required to ensure precautionary management in extreme years (Annex 6, paragraph 2.72)

(ii) current levels of catch are not observed to cause a trend in krill biomass and comparison of catch and catch limits to krill biomass indices is useful for providing advice. Early detection of systematic changes to krill abundance may be difficult, but the probability of reliable detection will increase with the length of the time series, especially if the spatial replication is maintained (Annex 6, paragraph 2.74).

3.17 The Scientific Committee noted that climate change has the potential to not only impact krill and upper trophic levels directly but could also impact all components of marine ecosystems, including in the planktonic community, and some of these are likely to drive changes in krill and dependent and related species (Annex 6, paragraphs 2.77 and 2.78).

3.18 The Scientific Committee noted the review of WG-EMM-15/40 by WG-EMM. This paper proposed that catch percentages be modified for all subareas, including an increase in Subarea 48.1 to 50% with re-examination of the catch limit once every two years.

3.19 The Scientific Committee endorsed the advice from WG-EMM that there was no scientific basis provided by the authors to support the changes to the conservation measure.

The ultimate determination of catch limits or allocations is an item for the Commission to decide, and the Scientific Committee therefore referred the paper to the Commission (Annex 6, paragraph 2.83).

3.20 The Scientific Committee also considered CCAMLR-XXXIV/BG/35 from Ukraine that examined changes to the interim distribution of the trigger level in the fishery for Antarctic krill (*Euphausia superba*) in Subareas 48.1, 48.2, 48.3 and 48.4. The authors argue that given the current state of the krill fishery in Area 48, and the recent closures of the fishery in Subarea 48.1 during late May and June, well before the end of the fishing season, changes to CM 51-07 may be in order. They argue to redistribute the trigger level of catch of 620 000 tonnes between subareas in Area 48 in new percentage limits and to encourage vessels to produce food for human 'direct' consumption from krill. This revision will still enable the precautionary conservation principles of the Convention to be followed and at the same time will not inflict economic damage to the krill fishery.

3.21 A number of Members noted that there was little scientific rationale for the reallocation schema presented in CCAMLR-XXXIV/BG/35. Members noted that a scientific basis must be presented for the reallocation and that allocations of catch were an issue for the Commission. The authors noted their willingness to continue the development of these arguments.

3.22 The Scientific Committee agreed that further scientific results on this issue should be provided to WG-EMM for consideration.

### Current state of the krill-based ecosystem and the fishery

3.23 With regard to the state of the krill-based food web, the Scientific Committee agreed that:

(i) there is currently no evidence for a systematic change in krill biomass, density or abundance in Subareas 48.1 to 48.3 (Annex 6, paragraph 2.133)

(ii) subarea-scale catch limits established in CM 51-07 may risk failure to achieve the Commission's objectives at the SSMU scale (Annex 6, paragraph 2.134), and in this regard:

   (a) results from surveys conducted by the US AMLR Program demonstrate that, at the SSMU scale, interannual differences in krill biomass within Subareas 48.1 can span two orders of magnitude, and annual biomass estimates in the Bransfield Strait and north of the South Shetland Islands have periodically been less than the subarea-scale catch limit established for Subarea 48.1 in CM 51-07 (WG-EMM-11/26)

   (b) fishing activity has become more concentrated in some SSMUs, with particular focus on the Bransfield Strait in Subarea 48.1 (WG-EMM-14/11)

   (c) given points (a) and (b) above and catch limits that are only resolved to the subarea-scale, it is not possible to rule out SSMU-scale harvesting impacts that would result in failure to achieve management objectives. In some years, SSMU-scale harvest rates may inadvertently be higher than would be expected from application of the krill decision rules at the SSMU scale.

3.24 The Scientific Committee agreed that:

(i) Catch is currently at about 48% of the trigger level and 5% of the precautionary catch limit; catches are currently less than 0.5% of biomass estimate from the CCAMLR-2000 Survey.

(ii) Interannual trends in SSMU-scale biomass are not evident (with only limited information on seasonal or monthly cycles of SSMU-scale biomass). However, given the observed variation described in Annex 6, paragraph 2.134(i), it is not possible to rule out small-scale harvesting impacts because fishing activity has become more concentrated in some SSMU-scale areas and local harvest rates in some years may be higher than expected by gamma.

(iii) A consideration in interpreting CCAMLR Ecosystem Monitoring Program (CEMP) data is that the different CEMP parameters integrate across different time and space scales. For example, foraging trip duration may be affected by conditions in the foraging area at the time of foraging, while breeding success and fledging weight integrate conditions in the foraging areas over several months during the breeding season. Breeding population size integrates conditions at the scale of years. Thus, CEMP and subsequent analyses need to be organised in such a way that they detect the spatial and temporal effects intended to be observed. Within-season effects of fishing will need to be detected using parameters that indicate conditions at locations and times where there is coincidence between foraging and fishing area and the months of fishing.

3.25 The Scientific Committee endorsed the advice of WG-EMM (Annex 6, paragraph 2.137) on the following points:

(i) Krill biomass is not homogeneously distributed within the subareas. Consequently, an increase in catch may be possible if the catch for a subarea is subdivided into smaller spatial units that take account of predator needs, or other safeguards to predators are put in place.

(ii) The fishery has become concentrated in some SSMU-scale areas in recent years (WG-EMM-15/30, Appendix 3, Table 3).

(iii) There is a need to avoid harvesting impacts upon the ecosystem at the SSMU scale.

(iv) During certain time periods, particularly during the breeding season, krill beyond a critical distance from land are not accessible to land-based predators. Similarly, the fishery also preferentially targets krill in some locations. The krill readily available to breeding land-based predators is likely to be the main focus of the fishery, although the degree of overlap will depend on, inter alia:

(a) the time of year

(b) the individual constraints on foraging of the breeding and non-breeding parts of the predator populations at that time

(c) the aggregation/distribution of krill.

(v) Fishing in areas distant from land may not affect land-based predators but could affect pelagic predators such as whales, pack-ice seals, fish and other predators foraging in those areas.

(vi) Full implementation (i.e. stage 4) of FBM requires that CCAMLR is able to estimate the ecosystem effects of fishing; CEMP currently only includes land-based predators, making these the best opportunity for detecting such effects at present. Detecting effects in pelagic areas may need monitoring of krill predators utilising those areas, such as cetaceans, ice seals and fish.

(vii) The trigger level (CM 51-01) was based on the highest aggregate catch in the historical time series. No information is available on whether that catch had an effect on the ecosystem or whether sustained catches at that level would or would not have an effect. Kinzey et al. (2013) concluded that better information is required about krill recruitment variability and natural mortality before increasing catches much beyond the trigger level. Watters et al. (2013) also indicated in simulations that sustained catches at the trigger level would increase the risks of CCAMLR not meeting the objectives of Article II, including by failing to facilitate the restoration of depleted predator populations.

(viii) Krill consumption by predators within different SSMUs could be used as a basis for distributing catch limits. An approach for undertaking these calculations is available in Everson and de la Mare (1996). Estimates are also available in Hill et al. (2007).

(ix) If the existing spatial distribution of the trigger level (CM 51-07) was removed, precautionary management would still be required. This is because more concentrated fishing might then occur in subareas or SSMU-scale areas, and CCAMLR would only be able to detect the effects of fishing if the fishing occurred in areas where monitoring exists.

3.26 The Scientific Committee agreed that a future revision of CM 51-07 should consider how the fishery is arranged within subareas in order to avoid impacts on predators within some SSMU-scale areas (Annex 6, paragraph 2.138).

3.27 The Scientific Committee agreed that consideration should be given as to whether it is more precautionary for the subareas in Area 48 to be managed separately. A list of tasks to address this issue is described in Annex 6, paragraphs 2.140(i) to (v).

3.28 The Scientific Committee agreed on the importance of facilitating fisheries research that contributes towards development of FBM (Annex 6, paragraph 2.141).

3.29 The Scientific Committee agreed that the spatial distribution of the trigger level in CM 51-07 should be continued to avoid further harvesting concentration and does not impact adversely on predators, and CM 51-07 should ultimately be revised to reflect stage 2 (Annex 6, paragraph 2.136).

3.30 The Scientific Committee agreed on the utility of fishery acoustics to help monitoring seasonal and monthly cycles in SSMU-scale biomass. The Scientific Committee further agreed that this includes the necessity of trialling some acoustic transects for a year to look at data and then determine how it might be scaled up (paragraph 2.25).

3.31 The Scientific Committee noted a number of points on using CEMP indices and encouraged further development of CEMP for FBM, the usefulness of developing indicators of the fishery performance and the use of SISO to collect data for FBM other than krill data.

3.32 The Scientific Committee noted the following points in relation to the use of CEMP data in FBM:

(i) Although there is a desire to use predator data and CEMP data, in particular in the FBM strategies, it would be important to ensure that functional relationships between CEMP indices and krill density have been demonstrated. It should be noted that the functional relationships are available in Subarea 48.3, which is not a target region for FBM.

(ii) Although direct functional relationships between krill and their predators are desired, the relationships are often more complicated and much of the benefit of CEMP is in the use of multiple indices. Additionally, we should not just be relying on existing time series of CEMP indices, but developing new ones or bringing other CEMP data that could be used in FBM. The development of CEMP and the use of ecosystem monitoring data is a hallmark of CCAMLR's approach.

(iii) The utility of CEMP data increases when combined with other data, such as acoustic data for krill, as this can help provide better understanding of the relationships between predators, their prey and the krill fishery.

(iv) CEMP data are important for inclusion in the FBM approach, however, the challenge will be how to include uncertainty regarding functional relationships into the FBM approaches and incorporating uncertainty directly into the framework will allow progress to be made quickly. Functional relationships may change in space and in time, and some relationships may change over time.

(v) Dr Constable noted that the issue in (iv) is accommodated in the FBM approach detailed in WG-EMM-15/36. He further suggested that as far back as the 2003 CEMP review (SC-CAMLR-XXXII, Annex 4), there was difficulty in attributing changes in CEMP indices to changes in fishing or in krill abundance and that an FBM approach will need to take account of the possibility that the effects of fishing may not easily be disentangled from the effects of natural variability and change.

3.33 The Scientific Committee requested that WG-EMM address the following questions as part of its consideration of FBM:

(i) 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? On what basis could that agreement occur?

(ii) What is the magnitude of effect of fishing that could be agreed to have occurred using the current sampling regime?

(iii) What is the magnitude of change in krill and the krill-based food web that needs to occur in order for it to be detected, noting that each FBM proposal will have different levels of capacity to detect and reflect change?

3.34 Dr Godø reiterated the need to see functional responses between prey and predators, as they must exist even if the ability to discern them is limited. Thus, at present, there may be limited abilities to discuss these data but technologies and approaches need to be developed that can help elucidate relationships necessary to progress to stage 2 of FBM.

3.35 Dr S. Kasatkina (Russia) supported the questions raised and indicated similar difficulties in discussing changes in catch-per-unit-effort (CPUE) because of high variability in CPUE, and increasing CPUE over the last several years that could be linked as easily to climate variability as to changes in fishing.

3.36 Prof. B. Fernholm (Sweden) noted that in situations where relationships are complicated or the potential to see relationships was low, then the management strategies must become more precautionary. Additionally, there should be a program to ensure that existing CEMP work be maintained and expanded among Members.

3.37 The Scientific Committee noted that the CEMP Fund has facilitated the broadening of participation by Members in CEMP activities. This has led to the deployment of camera systems across a greater number of sites, and in some cases has increased the temporal coverage at existing sites. These cooperative programs among Members are likely to continue and should help to develop the CEMP indices usefully to provide advice regarding FBM.

3.38 The Scientific Committee suggested that while declines in predators may be important to inform FBM, gentoo penguins (*Pygoscelis papua*) have been expanding their range southward and drastically increasing in number in Subarea 48.1. Yet under current FBM arguments, it is likely that the fishery might still be asked to limit its activities.

3.39 The Scientific Committee noted that although some species may be increasing, others are declining; it noted that given ongoing changes in the environment related to climate, the varying rates of recovery of previously depleted stocks of marine mammals and fish, and changes in other components of the Antarctic food web, precautionary measures may be needed to ensure that Article II of the Convention was met.

3.40 The Scientific Committee further commented that these are important and challenging questions that will need to be discussed and explored at WG-EMM. Comparisons of ecosystem change in areas where fishing is occurring and elsewhere can assist in understanding the trajectory of the system. Ecosystem models will also inform the development of FBM approaches in this context. An international conference that will be held in Hobart in 2018 is aimed at assessing change in Southern Ocean ecosystems and will help to address these questions (SC-CAMLR-XXXIV/BG/22).

3.41 Dr Godø noted that these questions are similar to the broad approach taken during scoping work at the Census of Marine Life (some questions are unknowable). Given that 0.5% of the krill catch limit are taken and a dramatic change with climate change is occurring, a dynamic that has never been seen before, programs need to be developed to collect data to predict or understand the likely consequences, as most of this is missing. Therefore, it would be important for WG-EMM to consider the whole range of inputs that are needed to understand the risk spectrum without spending effort on things that are unknowable.

### Feedback management

3.42 The Scientific Committee agreed that the three approaches to FBM submitted to WG-EMM-15 had a number of common elements and similar data requirements, but also agreed that different parts of the CAMLR Convention Area may need different approaches.

3.43 The Scientific Committee highlighted progress with FBM made by WG-EMM-15 to the Commission.

3.44 The Scientific Committee agreed that work to address the approaches and evaluate candidate decision rules could be advanced by holding a workshop in 2016, perhaps associated with WG-EMM (Annex 6, paragraph 2.128).

3.45 The Scientific Committee discussed that developments, approaches and decision rules applied in FBM need to be understood by policy-makers and stakeholders. The Scientific Committee agreed that plain English summaries could be provided to policymakers, the general public and other interested parties, by placing these summaries in a dedicated area of the CCAMLR website.

3.46 The Scientific Committee agreed that a submission of further approaches needed to be accompanied by suitable documentation to understand the basis and implementation of the approach as well as how it would result in conservation measures, and that the pro forma adopted in SC-CAMLR-XXXIII needs to be amended accordingly (Annex 6, paragraph 2.129).

3.47 The Scientific Committee agreed that implementation of all stage 2 approaches would need to be reviewed after a trial period. If the approaches are not successful, the risks to achieving the objectives in Article II could be minimised by maintaining the subarea catch limits currently established in CM 51-07, and that implementing an FBM approach in one subarea might have broader implications for management of the krill fishery in other subareas (Annex 6, paragraphs 2.130 to 2.132).

3.48 The Scientific Committee considered SC-CAMLR-XXXIV/11 submitted by Russia concerning the development of procedures for managing the krill fishery in the CAMLR Convention Area. This paper examined the development of an FBM strategy for the krill fishery and argued that an integral part of developing an FBM strategy should be studying the risks of impacts that methods under development (for spatially distributing the catch) will have on the fleet's performance parameters. The paper further discussed that with the growing interest in the krill fishery, there are concerns surrounding the lack of sufficient information to research these risks, and above all, adequate information in respect of the spatial and temporal variability in krill distribution, and assessment of competition between the fishery and krill-dependent predators.

3.49 Dr Kasatkina highlighted that an integral part of developing an FBM strategy should be studying the risks of impact that methods under development for spatially distributing the catch will have on the fleet's performance parameters. With the growing interest in the krill fishery, there are concerns surrounding the lack of sufficient information to research these risks, and above all, adequate information in respect of the spatial and temporal variability in krill distribution, and assessment of competition between the fishery and krill-dependent predators (SC-CAMLR-XXXIV/11).

3.50 Dr Kasatkina noted that local acoustic surveys using fishing and scientific vessels that are planned by CCAMLR as part of the FBM development will make it possible to obtain information in relation to fishable biomass and total biomass by partially covering the subarea under investigation and focusing on SSMUs containing the main krill fishing grounds. At the same time, it is important also to have information on current krill distribution and the status of krill resources in all of Area 48, as well as new estimates of allowable krill catch in Area 48. This is all the more important as the climatic changes that are taking place could lead not only to the spatial redistribution of krill, but also cause changes in the functional structure of its habitat. It was proposed to complement the abovementioned local acoustic surveys with a large-scale (synoptic) international acoustic survey (or a number of surveys).

3.51 Dr Kasatkina noted that currently there are no scientifically based estimates of the fishery's impact on krill resources and criteria for assessing competition between the fishery and krill-dependent predators. Implementation of the abovementioned approach to FBM requires clarity in terms of how possible it is, under the current level of fishing, to determine the impact of catch on the status of krill resources and the status of monitored species or groups of krill-dependent predators. The example of the Antarctic Peninsula (Subarea 48.1) gives some grounds for doubt.

3.52 Dr Kasatkina believed it would be appropriate to conduct an integrated analysis of available time series of fishery data, krill biomass estimates and CEMP parameters in Area 48 to obtain adequate information to answer the question: Is it possible that fishing has an impact on krill resources and the status of dependent species under current catch levels and, if so, then where and under what conditions?

3.53 Dr Kasatkina proposed to use in such an analysis standardised indices of CPUE to describe temporal patterns of krill biomass by subarea and SSMU, taking into account the acute lack of such information from acoustic surveys. Incorporating standardised CPUE indices into a dynamic production model would create an opportunity to analyse statistical characteristics of krill biomass dynamic with estimates of uncertainty in the area under investigation over the entire fishing season. Russia proposed to test the applicability of dynamic production models to assess spatial and temporal krill biomass dynamics on the basis of CPUE indices.

3.54 The Scientific Committee recommended that the ideas in this paper be submitted as a fourth approach for FBM (following the pro forma) to WG-EMM-16. It noted the need for clear criteria for evaluating different management approaches ('performance criteria'), and that both conservation and fishery objectives should be considered. SC-CAMLR-XXXIV/11 usefully highlighted the need for assessment against fishery objectives.

3.55 Dr Trathan introduced CCAMLR-XXXIV/22, which proposed a precautionary seasonal nearshore closure of waters within 10 km of land to krill harvesting between 1 November and 1 March in Subareas 48.1 and 48.2. He noted that harvesting now takes place in close proximity to many penguin colonies, most of which are not monitored. He argued that there is no way to evaluate the impact of krill harvesting on these populations. Additionally, spatial concentration of krill fishing into smaller areas (e.g. Bransfield Strait) and an increased level of fishing during late summer means that the percentage of catch taken during the penguin breeding season (relative to the trigger level) has been increasing in recent years. The paper noted that although CM 51-07 provides some protection for krill predators by spatially distributing the catch, it does not afford protection at the within-subarea scale where penguin populations are located. The paper noted that as climate change continues to impact the Antarctic, increases in ice-free duration of the summer months will afford greater access to the fishery, including in areas where penguins forage and in areas where no monitoring exists. The paper argued that this creates a risk to the marine ecosystem which necessitates management consideration. Dr Trathan noted that the proposed precautionary measure would have only limited impact on the krill fishery.

3.56 Dr T. Ichii (Japan) noted that CCAMLR Members have been collecting data on predator performance during the breeding season for 30 years, but there is no evidence of a fishery effect on predator performance. He noted that krill consumption by predators and fishery catch were very limited spatially and temporally compared to krill biomass within the preferred fishing areas during the breeding season in those years when the main fishing season was summer, and that as the fishery has shifted to winter, the 10 km zone of protection is not based on the current pattern of krill fishing. Additionally, Dr Ichii noted that some species of penguin are declining despite a lack of trend in krill abundance since the 2000s.

3.57 Dr Godø expressed similar concerns to those expressed by Dr Ichii. He noted that the fishery has been identified as sustainable, and questioned the urgency of the need for this spatio–temporal closure. He suggested that experimental studies could provide data regarding the effects of the fishery on top predators and that this could provide information regarding the width of the closed area and should be considered by WG-EMM.

3.58 Dr E. Barrera-Oro (Argentina) stated that Argentina supported the proposal and noted that such spatial closed areas would protect not only penguins but also fish larvae of species that were overfished in the past and are in the process of recovery, and also pinnipeds. Additionally, because of the retreat of ice observed in the last seasons due to climate change effects, it is probable that the fishery will continue expanding its activities further to the south in Subarea 48.1 (e.g. the Gerlache Strait in the Bransfield Strait) potentially competing with predators (e.g. penguins and seals) in areas of their foraging range.

3.59 Prof. O. Pin (Uruguay) noted the importance of considering the interaction of the fishery with land-based pinnipeds. He agreed with a minimum protection range.

3.60 The Scientific Committee agreed that the proposal in CCAMLR-XXXIV/22 for spatial closure of the krill fishery should be referred to WG-EMM for a more in-depth evaluation. It noted that data from at-sea tracking of predators from colonies could provide better constraints on the appropriate buffer size.

3.61 Dr R. Werner, on behalf of ASOC, made the following statement:

> 'ASOC strongly supports the development of a robust FBM system, and also understands that the technical challenges ahead are important. ASOC is glad that the Scientific Committee endorsed the suggestion by WG-EMM of holding an intersessional workshop, to evaluate the various approaches and proposed decision rules.
>
> Furthermore, FBM is a complex, technical subject, thus, ASOC would like to highlight the importance of the recommendation that the presentation of any approach needs to be accompanied by a simple and concise explanation that describes how this specific FBM approach would be implemented.
>
> Until a fully developed feedback management system is in place, ASOC agrees with WG-EMM that maintaining the subarea catch limits established in CM 51-07 would help to avoid further concentration of fishing operations which could have a detrimental effect on krill-dependant predators. Although CM 51-07 has been effective in redistributing krill fishing effort and catches between subareas, it does not address this recent concentration of krill fishing in coastal areas where penguins and other predator species forage. Climate change is also increasingly impacting the Antarctic environment.
>
> Thus, beside keeping the catch limits as established by CM 51-07, it is imperative to implement interim protective measures such as the adoption of temporal closures, such as the one proposed by the EU (which ASOC supports), so as to closing coastal areas to protect foraging grounds of penguin colonies that have declined in the last 30 years; or by redistributing subarea catch limits between coastal and pelagic areas.'

### Further development and implementation of feedback management

3.62 The Scientific Committee agreed that interactions with the fishing industry and Members to promote monitoring would be essential for the development and implementation of FBM for krill. This could be through a workshop or some other mechanism such as a subgroup that involved industry (Annex 6, paragraph 2.158).

3.63 The Scientific Committee agreed that significant progress has been made in developing options for stage 2. For the coming year, the Scientific Committee recommended that the following topics are a high priority on which progress needs to be made:

(i) the current state of the krill-based ecosystem and managing the effects of fishing
(ii) stage 2 subdivision of catch and/or update of trigger level
(iii) precautionary requirements for predators at SSMU scales
(iv) krill surveys and CEMP at SSMU scales in stage 2.

3.64 The Scientific Committee requested proponents of the submitted approaches to continue work in the year as indicated in Tables 2, 3 and 4 of the WG-EMM report (Annex 6), and also requested Members to work on evaluating the likely performance of proposed approaches with respect to krill, krill predators and the fishery.

3.65 The Scientific Committee recognised the fundamental importance of krill surveys and CEMP indices that require long-term commitments by Members. The Scientific Committee highlighted the importance of both these data sources to the Commission so that Members may consider ways to ensure their continuation and expansion. It also requested the Scientific Committee to consider the mechanisms that may be needed to sustain these monitoring activities into the future.

3.66 The Scientific Committee requested that Members continue to develop a list of technical requirements for fishing vessels undertaking pilot research surveys during the upcoming fishing season (Annex 6, paragraphs 2.168 and 2.169).

3.67 The Scientific Committee noted that WG-EMM had agreed to establish an e-group to develop the proposed work plan for FBM and a timeline for consideration by the Scientific Committee (Annex 6, paragraph 2.177), as well as:

(i) the need to engage with stakeholders and the wider scientific community

(ii) the need to be realistic on what can be achieved in the coming year, given existing commitments

(iii) the cost of bringing experts to multiple meetings within one year, including working group meetings.

3.68 The Scientific Committee considered its management of the agenda and priorities for working groups next year in order that sufficient consideration of FBM can be achieved (see Item 13).

### Integrated assessment model

3.69 The Scientific Committee welcomed the continued work on the development of an integrated modelling framework for krill. The Scientific Committee acknowledged the importance of developing a suite of diagnostics for evaluating the performance of assessment models and suggested it to be reviewed by WG-SAM-16. The Scientific Committee further acknowledged that integrated assessment models could potentially be used within FBM strategies for krill.

### Multinational coordination

3.70 The Scientific Committee requested that Members that undertake krill fishing activities liaise with their industry to determine whether their krill vessels are willing to participate in multinational coordinated subarea-scale surveys (which underline the potential of using multinational fishing vessel effort for potential area-scale surveys in the future; Annex 6, paragraph 2.248).

3.71 The Scientific Committee recalled that absolute estimates of krill biomass in the whole of Area 48 are unlikely to be available on a regular basis, and that management approaches will need to take account of this (SC-CAMLR-XXXIII, paragraph 3.39). Nevertheless, large-scale surveys provide essential data to inform understanding of variability and trends at subarea scales, and to assist in understanding the impacts of climate change (Annex 6, paragraph 2.249).

### CEMP

3.72 The Scientific Committee recognised the value of the growing network of cameras to support CEMP, and agreed that, prior to the incorporation of data from camera studies into management processes, validation of the time series of data and derived estimates will be required (Annex 6, paragraph 2.185).

3.73 With regard to applications of unmanned aerial vehicle (UAV) technology for monitoring predator populations (Annex 6, paragraph 2.189), the Scientific Committee agreed that UAVs offer great potential for efficient monitoring of land-breeding predator populations, but noted concerns from WG-EMM-15 about the potential for UAVs to disturb wildlife. The Scientific Committee recognised this as an area of mutual interest between CCAMLR and the CEP and endorsed CEP taking the lead on the development of guidelines for the use of UAV technology.

3.74 The Convener of the CEMP Special Fund Management Group (hereinafter referred to as the 'management group'), Dr Ichii, announced the decision of the management group on the four proposals submitted in 2015:

(i) tracking the overwinter habitat use of krill-dependent predators from Subarea 48.1 (Dr Watters)

(ii) penguin habitat preference and extrapolation to data-deficient colonies to model how krill-dependent predators overlap with krill fishing in Area 48 (Dr Trathan)

(iii) developing an image-processing software tool for analysis of camera network monitoring data (Dr C. Southwell (Australia))

(iv) a comparison of penguin diet sampling techniques; the CEMP standard method (stomach lavage) versus DNA sampling of prey remains in penguin guano (Dr C. Waluda (UK)).

3.75 The management group (Drs Ichii (Chair), J. Arata (Chile) (Senior Vice-Chair) and Melbourne-Thomas (Junior Vice-Chair)) evaluated the four proposals during WG-EMM-15 and made their final decision after consideration of responses received to feedback and questions posed following first-round evaluations. The management group agreed that the proposals submitted by Drs Watters and Southwell demonstrated a clear fit to objectives and were suitable for funding. The proposal and response to evaluation submitted by Dr Trathan also demonstrated a clear fit to objectives and would support immediate priorities for the development of FBM for the krill fishery. The management group noted clear linkages and overlap of this proposal with the Retrospective Analysis of Antarctic Tracking Data project

(RAATD) being undertaken by the SCAR Expert Group on Birds and Marine Mammals. The management group recommended that supporting this proposal would significantly accelerate the delivery of outcomes of particular interest to CCAMLR from the RAATD project.

3.76 The management group reported that the proposal submitted by Dr Waluda addressed important methodological questions and was a soundly structured proposal that would be likely to attract support through national and international funding programs. However, the fit of this project to objectives for CEMP and the Special Fund, and the way in which outcomes would link to immediate priorities for developing management approaches for the krill fishery, as articulated by WG-EMM, was not as well clarified as for the other three proposals.

3.77 The management group therefore recommended that proposals submitted by Drs Watters, Southwell and Trathan be funded in 2015. It commended the quality of all four applications and hoped proposals would continue to be of such high quality.

3.78 The Scientific Committee congratulated the successful recipients. The recipients expressed their thanks and clarified that the timeline for delivery of results from their respective projects was closely linked to the planned timeline of development of FBM approaches by WG-EMM.

## Fish resources

### Status and trends

3.79 The Scientific Committee noted that the following finfish fisheries operated in the Convention Area in 2014/15:

(i) fisheries for mackerel icefish (*Champsocephalus gunnari*)

  (a) Subarea 48.3 (CM 42-01)
  (b) Division 58.5.2 (CM 42-02).

(ii) fisheries for Patagonian toothfish (*Dissostichus eleginoides*) and/or Antarctic toothfish (*D. mawsoni*)

  (a) Subarea 48.3 (CM 41-02)
  (b) Subarea 48.4 (CM 41-03)
  (c) Subarea 48.6 (exploratory fishery, CM 41-04)
  (d) Division 58.4.1 (exploratory fishery, CM 41-11)
  (e) Division 58.4.2 (exploratory fishery, CM 41-05)
  (f) Division 58.4.3a (exploratory fishery, CM 41-06)
  (g) Division 58.5.1 (waters adjacent to the Kerguelen Islands, French EEZ)
  (h) Division 58.5.2 (CM 41-08)
  (i) Subarea 58.6 (waters adjacent to the Crozet Islands, French EEZ)
  (j) Subareas 58.6, 58.7 (waters adjacent to the Prince Edward Islands, South African EEZ)
  (k) Subarea 88.1 (exploratory fishery, CM 41-09)
  (l) Subarea 88.2 (exploratory fishery, CM 41-10).

3.80 Catches of *C. gunnari* and *Dissostichus* spp. taken in the Convention Area in 2014/15 to 16 September 2015 are summarised in Table 1 of SC-CAMLR-XXXIV/BG/01, catches taken in 2013/14 are summarised in Table 2 of that paper. These summaries include by-catch and catches taken during research fishing in areas closed to fishing (Subareas 48.2 and 48.5 and Divisions 58.4.4a and 58.4.4b).

3.81 Research fishing for *Dissostichus* spp. in 2014/15 was carried out in the closed area of Subarea 48.2 (35 tonnes), while planned research fishing in Division 58.4.4b for 2014/15 had not taken place by 16 September 2015. The Secretariat also closed the following fisheries this season for *Dissostichus* spp.: Subarea 48.4 on 22 April (at 99% of catch limit for *D. eleginoides* and at 99% for *D. mawsoni*), Subarea 48.6 on 10 March (at 98% of catch limit), Subarea 88.1 on 1 February (at 97% of catch limit) and Subarea 88.2 on 14 February (at 101% of catch limit). There were also closures at SSRU level in Subareas 88.1 and 88.2 (see CCAMLR-XXXIV/BG/02).

### Research priorities

3.82 The Scientific Committee discussed research priorities for future stock assessment work of WG-SAM. It noted its discussions on general research priorities and that these priorities needed to be evaluated with respect to the risk of not achieving the objectives of Article II of the Convention (see Item 13).

3.83 The Scientific Committee requested the following as focus topics for WG-SAM:

(i) developing methods to quantify the level of spatial overlap between tagged fish and subsequent fishing effort, and evaluate the potential bias introduced into stock assessments and tag-based biomass estimates when the distributions of tagged fish, fishing effort and the underlying stock distribution are spatially heterogeneous

(ii) developing methods to estimate uncertainty in assessments and provide management advice that is consistent with the CCAMLR decision rules, for example, for tag-based assessments with low numbers of tag recaptures or fish stocks that had experienced illegal, unreported and unregulated (IUU) catches prior to the time when the assessment time series starts and thus the $B_0$ estimated by an assessment may not represent an unfished $B_0$.

### Toothfish released untagged

3.84 Based on a summary of the frequency and location of the releases of live untagged *Dissostichus* spp. in exploratory fisheries (CCAMLR-XXXIV/07), the Scientific Committee acknowledged that, while there was no length data available for the toothfish that had been released untagged, it was likely that these were small fish (approx. 50 cm length).

3.85 The Scientific Committee recommended that all fish, regardless of size, should be treated in the same way (i.e. there should be no release of live untagged fish), including in respect of collection of biological and tagging data.

### Offal discharge

3.86 In response to a request from New Zealand (COMM CIRC 15/15), the Secretariat assembled data related to reported incidences of offal discharge in the Ross Sea from CCAMLR observer reports, vessel monitoring system (VMS) records and other information the Secretariat has available (CCAMLR-XXXIV/BG/10). The Scientific Committee expressed concern that offal appeared to be discharged in an area where such a discharge was prohibited, noting especially that hooks in the offal presented a risk for seabirds and that discharge of offal may also have implications for the likelihood of depredation.

3.87 Noting that some of the offal reported still had hooks attached, the Scientific Committee requested the Commission to consider the introduction of vessel-specific marking of hooks (paragraph 4.7).

### VMS data quality assurance

3.88 The Scientific Committee noted the potential use of CCAMLR VMS data for compliance and data quality assurance, in particular to determine an appropriate spatial and temporal overlap where a VMS location would be expected within a radius of 20 n miles and within four hours of the reported time of the fishing event.

3.89 The Scientific Committee noted that the minimum frequency that the VMS position data is required to be provided is every four hours and that there was currently a proposal to change the reporting frequency to every one hour and that such a change would reduce the radius of the overlap range to 5 n miles. The Secretariat could accommodate VMS data for all vessels at a higher frequency than currently required and noted that the generally recognised best practice of recording VMS data was at a frequency of every 15 minutes.

3.90 The Scientific Committee agreed that it was vital that the locations of where catches were made are accurate. It agreed that using the VMS data at appropriate resolution (at 15-minute intervals) was the best method for the data quality assurance processes.

3.91 At the time of adoption, Dr Zhao made the following statement:

> 'I cannot agree in full with the statements in paragraph 3.90 above. While agreeing to the importance of knowing the accurate location of the catch, it is also noted there is a difference in the usage of the catch-related data. For toothfish, catch data is the primary data for stock assessment; whereas for krill, acoustic data is the primary data for stock assessment.
>
> Dr Zhao further noted that it is legitimate to commenting on and contributing to the accurate articulation of a statement at any time. For paragraph 3.90, confining it to toothfish is logical in the context of its preceding and following paragraphs, given the distinct differences in stock assessments.'

3.92 The Scientific Committee also noted that this use of VMS data, and the required data quality assurance processes for the VMS data itself, would improve the utility of the VMS data for the Commission. The Scientific Committee requested that the Secretariat implement the data quality assurance processes.

### Conversion factors

3.93 The Scientific Committee noted that there was considerable inter-vessel variability in the green weight conversion factors used in the toothfish fishery, with 'headed, gutted and tailed' (HGT) being the most frequently used processing code. Even within single processing methods, such as HGT, there were many factors that could influence the actual conversion factor, including the type and location of cut used and how this changes over time depending on market demands and the equipment available on board to weigh pre-processed fish.

3.94 The Scientific Committee agreed that it was important to highlight how variability in conversion factors could affect the green weight estimation and the consequences of this for the stock assessment and reconciliation of C2 and CDS data and requested additional information on the specific details of how the fish are actually processed be collected and presented to WG-SAM-16 (Annex 7, paragraph 3.37).

### Icefish assessments

#### *Champsocephalus gunnari* Subarea 48.3

3.95 Details of this fishery and the stock assessment of *C. gunnari* are contained in the Fishery Report (www.ccamlr.org/node/75667), and discussion by WG-FSA is in Annex 7, paragraphs 4.1 to 4.6.

3.96 In 2014/15, the catch limit for *C. gunnari* in Subarea 48.3 was 2 695 tonnes. The fishing season started on 1 December 2014 and remains open to date. Fishing was conducted by two vessels using midwater trawls, and the total reported catch up to 16 September 2015 was 277 tonnes.

3.97 The Scientific Committee noted an updated length-based stock assessment of *C. gunnari* in Subarea 48.3. The assessment was based on a random stratified bottom trawl survey of the South Georgia and Shag Rocks shelves that the UK undertook in January 2015 as part of its regular monitoring program. A total catch of 7.2 tonnes was reported from the research survey.

3.98 A bootstrap procedure was applied to the survey data to estimate the demersal biomass of *C. gunnari* in this subarea. The bootstrap estimated the median demersal biomass at 59 081 tonnes, with a one-sided lower 95% confidence interval of 36 530 tonnes. The harvest control rule ensuring 75% biomass escapement after a two-year projection period yielded a catch limit of 3 461 tonnes for 2015/16 and 2 074 tonnes for 2016/17.

3.99 The Scientific Committee noted that the fishing effort deployed in Subarea 48.3 has been low in recent years and that this has resulted in the low uptake of quota by the fishery. In addition, the availability to the pelagic fishery of icefish in the water column is highly variable within and between years. The Scientific Committee also noted that the catch to survey biomass ratio from each year that the survey was conducted as an index of exploitation rate showed that the exploitation rates to which the stock is subjected are very low and do not impact the stock dynamics.

3.100 Dr Barrera-Oro thanked the authors of WG-FSA-15/25 for including information on the relationship between effort exerted by vessels in the fishery and the quota uptake. He noted that in recent years there was a low amount of fishing effort exerted in the region and that this had resulted in the low uptake of the quota, on average less than 10%. He noted the discussion on the interaction between the lack of availability of icefish in the water column to the semi-pelagic fishery and lack of effort, and asked whether the fishery loses interest when the catch rates are low. In addition, he also noted the low catch of *C. gunnari* (4 tonnes) that has been taken by the fishery up to September in 2014/15 in Division 58.5.2.

3.101 Dr Darby also noted that in Subarea 48.3 an industry-funded PhD study was examining the acoustic data from the commercial vessels as well as using cameras mounted on the icefish trawl gear to help with the identification of the distribution of icefish within the water column and to help the industry identify icefish marks. He noted that the effort exerted by the fishery and consequent uptake of the quota was determined by the availability of the stock in the water column to the fishing vessels. Vessels had searched for fish at the start of 2014/15 following the UK survey as well as during September and October, however, despite the survey identifying a substantial abundance of icefish in the benthic zone, pelagic catch rates were low. The vessels left the area after a relatively short fishing season.

3.102 Dr Welsford noted that a strong seasonal variability in the availability of *C. gunnari* to the fishery seems to be a common factor across icefish fisheries as highly variable catch rates were also observed in the *C. gunnari* fishery in Division 58.5.2.

### Management advice

3.103 The Scientific Committee recommended a catch limit for *C. gunnari* in Subarea 48.3 of 3 461 tonnes for 2015/16 and 2 074 tonnes for 2016/17 based on the assessment in 2015.

### *Champsocephalus gunnari* Division 58.5.2

3.104 Details of this fishery and the stock assessment of *C. gunnari* are contained in the Fishery Report (www.ccamlr.org/node/75667), and discussion by WG-FSA is in Annex 7, paragraphs 4.7 to 4.12.

3.105 In 2014/15, the catch limit for *C. gunnari* in Division 58.5.2 was 309 tonnes. The fishing season started on 1 December 2014 and remains open to date. Fishing was conducted by two vessels using bottom trawls, and the total reported catch up to 16 September 2015 was 4 tonnes.

3.106 The Scientific Committee noted that Australia had undertaken a random stratified trawl survey in Division 58.5.2 during May 2015. In this survey, catch rates of *C. gunnari* were close to the long-term average from 2006 to 2014. The length–weight relationship was updated using the survey data, while other biological parameters were unchanged from the previous assessment. The best fit of CCAMLR's mixture analysis program (CMIX) to the survey length distribution was achieved when the population was estimated to consist of four year classes from 1+ to 4+, with the 2+ cohort containing the largest number of fish, and estimated to make up 69% of the biomass.

3.107 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 3 048 tonnes of ages 1+ to 3+ fish from the 2015 survey and fixed model parameters.

### Management advice

3.108 The Scientific Committee recommended a catch limit for *C. gunnari* in Division 58.5.2 of 482 tonnes in 2015/16 and 357 tonnes in 2016/17 based on the assessment in 2015.

## Toothfish assessments

### *Dissostichus eleginoides* Subarea 48.4

3.109 Details of this fishery and the stock assessment of *D. eleginoides* are contained in the Fishery Report (www.ccamlr.org/node/75667), and discussion by WG-FSA is in Annex 7, paragraphs 4.13 to 4.21.

3.110 The catch limit for *D. eleginoides* in 2014/15 for Subarea 48.4 was 42 tonnes. Fishing was conducted by two vessels using longlines, and the total reported catch up to 16 September 2015 was 42 tonnes.

3.111 The Scientific Committee noted an updated integrated stock assessment for *D. eleginoides* in Subarea 48.4. Compared to the last assessment in 2014, this model was updated with observations for 2014/15, revised tagging and recapture data for the full time series, a maturity ogive from Subarea 48.3 and changes to the assumed tag growth retardation period from 0.5 years to 0.75 years.

3.112 The Scientific Committee noted that the assessment model was rerun during WG-FSA-15 with fixed year-class strength (YCS) from 2008 to 2015. This model estimated unfished spawning stock $B_0$ at 1 476 tonnes (95% CI 1 241–1 781 tonnes) and a spawning stock status in 2015 at 83% (95% CI 78–89%). The long-term catch limit that satisfied the CCAMLR decision rules was 47 tonnes.

3.113 The Scientific Committee noted that, while tag-recapture data show a small number of toothfish moving from Subarea 48.4 to Subarea 48.3 and genetic analysis indicated that both stocks belong mostly to the same genetic population, different growth rates and maturity suggested that there is no regular exchange between the two areas. The Scientific Committee agreed that the two areas should be assessed separately until further information is available, as this is the most precautionary approach given the limited knowledge.

3.114 The assessment model estimated that the time series of YCS indicated two strong peaks in 1994 and 1997, followed by a period of lower recruitment. Considering recruitment in Subarea 48.4 seems to be dominated by sporadic strong recruitment pulses, the Scientific Committee recommended that alternative approaches for recruitment variability in stock projections be explored, such as resampling from the historical time series, and including autocorrelation in the projected recruitment. It also recommended inclusion of data from fish recaptured within only four years of release.

### Management advice

3.115 The Scientific Committee recommended that the assessment is performed on a biennial cycle without incurring significant additional risk (SC-CAMLR-XXVI, paragraphs 2.11 and 14.6).

3.116 The Scientific Committee recommended a catch limit for *D. eleginoides* in Subarea 48.4 of 47 tonnes for 2015/16 and 2016/17 based on the results of the assessment in 2015.

### *Dissostichus mawsoni* Subarea 48.4

3.117 Details of this fishery and the stock assessment of *D. mawsoni* are contained in the Fishery Report (www.ccamlr.org/node/75667), and discussion by WG-FSA is in Annex 7, paragraphs 4.22 to 4.28.

3.118 The catch limit for *D. mawsoni* in Subarea 48.4 in 2014/15 was 28 tonnes. Fishing was conducted by two vessels using longlines, and the total reported catch up to 16 September 2015 was 28 tonnes.

3.119 The Scientific Committee noted a tag-recapture-based population assessment for *D. mawsoni* in Subarea 48.4 using the method agreed at WG-FSA-14 and a general review of the Chapman tag-based stock estimation method. The review identified two main issues, namely the appropriate catch–weight correction application of the Chapman estimation method when applied to estimate low tag-recapture rate population abundance and the misidentification of species at release in Subarea 48.4.

3.120 The Scientific Committee agreed that the proposed correction for the average weight of an individual fish should be applied as in other tag-based assessments in the CCAMLR area and that the corrections applied for toothfish identified to species at recapture was appropriate.

3.121 The Scientific Committee noted the problems associated with zero values in fisheries with low numbers of tag recaptures. The high proportion of zero values to which 1 is added within the Chapman correction can increase abundance estimates in years for which no data is available. Some zeros are due to the low probability of expected recaptures, while others are due to violation of assumptions from the tagging program, such as high tag-release mortality, migration out of the area of the fishery, lack of mixing or a lack of overlap in the spatial distribution of tagged fish and fishing effort. The Scientific Committee requested that this subject be reviewed and discussed at WG-SAM.

3.122 The Scientific Committee agreed that the Chapman estimation method that uses an assumption of a single population of tags in each year of recapture should be applied in the current assessment for *D. mawsoni* in Subarea 48.4 to reduce the influence of zeros in the assessment process.

3.123 The Subarea 48.4 assessment 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 estimated population estimates across years, a geometric mean of the relatively short time series was used as the basis for the final stock abundance of 1 014 tonnes. At a harvest rate of $\gamma = 0.038$, this indicates a 2015/16 yield of 39 tonnes for *D. mawsoni* in Subarea 48.4.

### Management advice

3.124 The Scientific Committee recommended a catch limit for *D. mawsoni* in Subarea 48.4 of 39 tonnes for 2015/16 based on the assessment in 2015.

### *Dissostichus eleginoides* Subarea 48.3

3.125 Details of this fishery and the stock assessment of *D. eleginoides* are contained in the Fishery Report (www.ccamlr.org/node/75667), and discussion by WG-FSA is in Annex 7, paragraphs 4.29 to 4.37.

3.126 The catch limit for *D. eleginoides* in Subarea 48.3 in 2014/15 was 2 400 tonnes. Fishing was conducted by six vessels using longlines, and the total reported catch up to 16 September 2015 was 2 194 tonnes.

3.127 The Scientific Committee noted an updated integrated assessment for *D. eleginoides* in Subarea 48.3. Compared to the last assessment in 2013, this model was updated with available data from 2013/14 and 2014/15 and revised tagging data received from the CCAMLR database from earlier fishing seasons.

3.128 The assessment estimated unfished spawning biomass at 85 900 tonnes (95% CIs: 81 600–91 300 tonnes) and spawning stock biomass (SSB) status in 2015 at 0.52 (95% CIs: 0.50–0.54). The long-term catch limit that satisfied the CCAMLR decision rules was 2 750 tonnes.

3.129 The Scientific Committee noted that, while the median SSB was estimated to have fallen below the target level of 50% of the pre-exploitation median SSB from 2009 to 2012, it was above the target level in 2015 and did not fall below the target for the remainder of the projection period under the recommended yield. The Scientific Committee noted that this was due to changes in the estimation of the virgin biomass $B_0$ and not changes in the abundance of the recent biomass estimates which were relatively consistent between assessments.

3.130 The Scientific Committee noted that the model fitted the observed tag-recapture data very well. However, there were trends in lack of model fits to the commercial age composition data and the survey biomass index, with the model generally underestimating observations up to 2006 and overestimating observations after 2006. In addition, the observed age composition contracted after 2006.

3.131 The Scientific Committee recommended further work exploring the underlying causes for this lack of model fits, including the effects of increased data weighting of the survey. The Scientific Committee also noted that the planned ageing of the survey samples and future use of survey age proportions may improve the estimation of YCS.

3.132 In addition, the Scientific Committee recommended a consistent application of the dispersion parameter for tagging data and an evaluation of alternative approaches to data weightings of all observations.

### Management advice

3.133 The Scientific Committee recommended a catch limit for *D. eleginoides* in Subarea 48.3 of 2 750 tonnes for 2015/16 and 2016/17 based on the results of the assessment in 2015.

### *Dissostichus eleginoides* Division 58.5.1

3.134 Details of this fishery and the stock assessment of *D. eleginoides* are contained in the Fishery Report (www.ccamlr.org/node/75667), and discussion by WG-FSA is in Annex 7, paragraphs 4.38 to 4.43.

3.135 The fishery for *D. eleginoides* in Division 58.5.1 is conducted within the French EEZ. In 2014/15, the catch limit for *D. eleginoides* was 5 100 tonnes. Fishing was conducted by seven vessels using longlines, and the total reported catch up to 31 July 2015 was 2 884 tonnes.

3.136 The Scientific Committee noted an updated stock assessment of *D. eleginoides* within the French EEZ in Division 58.5.1, which included recommendations from WG-FSA-14 and the first ageing data and growth curve from the area. Preliminary results of a sex-based model were also presented at the meeting.

3.137 The Scientific Committee noted that the fish growth parameters estimated for this division suggest that fish grow faster and to larger sizes than in the adjacent Division 58.5.2, and recommended inter-laboratory comparisons of fish age estimates from otoliths and further work on growth estimation.

3.138 The Scientific Committee recommended further work on:

(i) updating estimations of whale depredation using methods like the comparative CPUE analysis from WG-FSA-14/10 and include these estimates in the stock assessment

(ii) investigating the use of a uniform-log prior for $B_0$, a lognormal prior for YCS, double-normal plateau selectivities and application of YCS variability in stock projections when it has not been estimated in the model

(iii) further exploring the sex-based model.

Management advice

3.139 The Scientific Committee noted that model R1 with fixed YCS, as described in WG-FSA-15/68, could be used to provide management advice for 2015/16. Although the long-term precautionary yield was not calculated, the catch limit set for 2015/16 by France of 5 300 tonnes satisfied the CCAMLR decision rules.

3.140 No new information was available on the state of fish stocks in Division 58.5.1 outside areas of national jurisdiction. The Scientific Committee recommended that the prohibition of directed fishing for *D. eleginoides*, described in CM 32-02, remain in force in 2015/16.

*Dissostichus eleginoides* Subarea 58.6

3.141 Details of this fishery and the stock assessment of *D. eleginoides* are contained in the Fishery Report (www.ccamlr.org/node/75667), and discussion by WG-FSA is in Annex 7, paragraphs 4.44 to 4.48.

3.142 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 2014/15, the catch limit for *D. eleginoides* was 850 tonnes. Fishing was conducted by seven vessels using longlines, and the total reported catch up to 31 July 2015 was 433 tonnes.

3.143 The Scientific Committee noted that the recommendations it made for the Kerguelen stock assessment (paragraph 3.138) also applied to this stock assessment. It further recommended that the annual depredation calculations be presented in future stock assessments papers.

Management advice

3.144 The Scientific Committee noted that model R1 with fixed YCS, as described in WG-FSA-15/69, could be used to provide management advice for 2015/16. The Scientific Committee noted that a catch limit of 1 780 tonnes would satisfy the CCAMLR decision rules. It noted that France had set a catch limit of 1 000 tonnes for 2015/16.

3.145 No new information was available on the state of fish stocks in Subarea 58.6 outside areas of national jurisdiction. The Scientific Committee recommended that the prohibition of directed fishing for *D. eleginoides*, described in CM 32-02, remain in force in 2015/16.

*Dissostichus eleginoides* Division 58.5.2

3.146 Details of this fishery and the stock assessment of *D. eleginoides* are contained in the Fishery Report (www.ccamlr.org/node/75667), and discussion by WG-FSA is in Annex 7, paragraphs 4.49 to 4.57.

3.147 In 2014/15, the catch limit for *D. eleginoides* in Division 58.5.2 was 4 410 tonnes. Fishing was conducted by six vessels using bottom trawls and longlines, and the total reported catch up to 16 September 2015 was 2 675 tonnes.

3.148 The Scientific Committee noted an update of the tagging and ageing program for *D. eleginoides* in Division 58.5.2. Tagging rates have been increased from 2 tags per 3 tonnes in previous fishing seasons to 2 tags per tonne in the current season. The Scientific Committee recalled that there is a need to evaluate the bias introduced into stock assessment when fishing effort, tag distribution and underlying stock distribution is spatially heterogeneous, and recalled that Australia is currently undertaking a project to address these issues for toothfish stocks on the Kerguelen Plateau.

3.149 The Scientific Committee noted an updated assessment for *D. eleginoides* in Division 58.5.2 with data until the end of July 2015 and tag data from 2012 to 2015. Compared to the last assessment in 2014, the assessment also updated fish growth parameters, changed the priors on survey catchability $q$, $B_0$ and YCS, and split the trawl fishery into two periods of 1997–2004 and 2005–2015.

3.150 The estimated $B_0$ was strongly influenced by including recaptures in 2014 and partial recaptures in 2015, while updating the growth model and changing model priors for survey catchability $q$, $B_0$ and YCS, and splitting the trawl fishery into two periods had relatively little effect on the estimated $B_0$.

3.151 The updated assessment model estimated virgin SSB $B_0$ at 87 077 tonnes (95% CI: 78 500–97 547 tonnes). Estimated SSB status in 2015 was 0.64 (95% CI: 0.59–0.69). The long-term catch limit that satisfied the CCAMLR decision rules was 3 405 tonnes.

3.152 The Scientific Committee noted the difference in *D. eleginoides* growth functions between the adjacent Divisions 58.5.1 and 58.5.2, and recommended calculation of growth parameters as a focus topic for WG-SAM. The Scientific Committee further recommended that sensitivities be run including the tag data from 2010 to 2012, with an investigation of the diagnostics. The Scientific Committee noted that depredation was currently minimal and recommended that monitoring continues and depredation be included in the model should depredation increase.

3.153 Dr Arata drew the attention of the Scientific Committee to the ongoing bottom trawling in Division 58.5.2. The Scientific Committee recalled its discussions on the effects of bottom fishing on benthic habitats (SC-CAMLR-XXXII, paragraph 3.110(i); SC-CAMLR-XXXIII, paragraph 3.132). In Division 58.5.2, a report on the effects of bottom fishing estimated that since 1997 bottom fishing has damaged less than 1.5% of the biomass in waters under 1 200 m which is where trawl fishing has been undertaken (0.5% from bottom trawling and 1% from longlines, WG-FSA-14/P06). Furthermore, the Heard Island and McDonald Islands Marine Reserve, established in 2003, is estimated to contain over 40% of the biomass of the groups of benthic organisms considered as most vulnerable to bottom fishing, and therefore plays an important role in protecting benthic habitats and biodiversity in the region.

#### Management advice

3.154 The Scientific Committee noted that although estimates of unexploited biomass have been variable over the last few years, estimates of stock status had been very consistent at about 0.65, and the biomass was above target, and recommended that the assessment could be performed on a biennial cycle without incurring significant adverse risk (SC-CAMLR-XXVI, paragraphs 2.11 and 14.6).

3.155 The Scientific Committee recommended a catch limit for *D. eleginoides* in Division 58.5.2 of 3 405 tonnes for 2015/16 and 2016/17 based on the outcome of the assessment in 2015.

### Advice to the Commission

3.156 The recommended catch limits in established fisheries are summarised in Table 1.

### Role of fish in the ecosystem

3.157 The Scientific Committee noted the discussion on Type C killer whales' long-distance movements between the southern Ross Sea and subtropical New Zealand waters, their site fidelity and the importance of monitoring their prey (Annex 6, paragraphs 2.84 to 2.87).

3.158 The Scientific Committee agreed that a possible mechanism to address depredation questions might be a group to consider top–down structuring mechanisms for ecosystems (Annex 6, paragraph 2.88).

3.159 The Scientific Committee noted the discussion by WG-EMM on the hypothesis that predation release of Antarctic silverfish (*Pleuragramma antarctica*) due to fishing of *D. mawsoni* could have contributed to the increase in the number of breeding pairs of Adélie penguins (*Pygoscelis adeliae*) in the southern Ross Sea (Annex 6, paragraphs 2.89 to 2.92). This was considered further in WG-FSA-15/41 discussed by WG-FSA-15 (Annex 7, paragraphs 9.3 to 9.5) which found little evidence to support this hypothesis.

3.160 The Scientific Committee noted the importance of these studies around the role of fish in the ecosystem but that these studies have typically not found a home within working groups' growing commitments. It recommended that questions around fish-based food-web and ecosystem processes be considered as a priority for WG-FSA-16 (see Item 13).

## Fish and invertebrate by-catch

3.161 The Scientific Committee noted that not all Members participating in CCAMLR fisheries had replied to SC CIRC 15/44 requesting information on how C1 and C2 data is collected. It noted that this information was essential to the work of CCAMLR, in particular the work of WG-FSA in assessing the impact of fishing on by-caught species. The Scientific Committee requested the Commission to encourage Members to respond to circulars that contain requests for information.

3.162 The Scientific Committee noted that the analyses in WG-FSA-15/04 Rev. 1 indicated that there was inconsistent reporting of by-catch between vessels fishing in the Ross Sea region, and that it is likely that this problem also exists in other areas. The Scientific Committee further noted there were also inconsistencies between vessel by-catch reporting in the krill fishery.

3.163 The Scientific Committee agreed that accurate by-catch data are fundamental to the Scientific Committee and the Commission in achieving the objectives of Article II of the Convention. It expressed concern that vessels from some Flag States reported a by-catch rate that was 50% lower than others, apparently associated with whether the allocation of the task of recording by-catch data was allocated to the crew or to scientific observers.

3.164 The Scientific Committee also noted that the implementation of a process to collect accurate catch and by-catch data should form part of an evaluation of the track record of a vessel's suitability for undertaking research fishing (Annex 7, paragraph 5.14).

3.165 The Scientific Committee endorsed the conclusions of WG-FSA (Annex 7, paragraph 8.8) recalling that the Flag State is responsible for complying with catch and by-catch reporting in conservation measures, and that the role of the observer is to collect data on attributes (such as the fish length, weight, maturity, etc.) of samples from that catch. It noted that it was not possible for observers to take on accurate catch recording responsibilities beyond those under SISO given the workload involved. It further agreed that if the responsibility for reporting C1 and C2 data is given to the observer, the expectation of independence of observer data is undermined.

3.166 The Scientific Committee requested that the issue of inconsistent reporting of data in the C1 and C2 forms, and tasking of observers, be considered by the Commission.

3.167 The Scientific Committee thanked the Secretariat for the analysis and noted that wide-ranging issues with data collection and observer programs are often not recognised until a division-wide cross-fleet analysis is done as in the presented case.

3.168 Paragraphs in WG-FSA-15 (Annex 7) referring to new biological information and biomass assessments of by-catch species of unicorn icefish (*Channichthys rhinoceratus*), *Macrourus caml* and grey rockcod (*Lepidonotothen squamifrons*) in Division 58.5.2 were noted by the Scientific Committee. Paragraphs 8.11, 8.12, 8.23 and 8.26 of Annex 7 detailed recommendations for the following changes to CM 33-02, which were endorsed by the Scientific Committee:

(i) change the move-on trigger limit for *C. rhinoceratus* from 2 tonnes to 5 tonnes

(ii) change the move-on trigger limit for all *Macrourus* spp. combined from 2 tonnes to 3 tonnes

(iii) revise the maximum catch limit for *C. rhinoceratus* to a maximum of 1 663 tonnes per year

(iv) revise the catch limits for *Macrourus* spp. for 2015/16 as follows: 409 tonnes for *M. caml* and Whitson's grenadier (*M. whitsoni*) combined, and 360 tonnes for bigeye grenadier (*M. holotrachys*) and ridge-scaled grenadier (*M. carinatus*) combined.

3.169 The Scientific Committee noted that the catch limits proposed for *Macrourus* spp. should be reviewed at WG-FSA as new by-catch information becomes available.

3.170 WG-FSA-15 had noted the issue of autolines connected by floating sections of rope (as seen in Figure 7 of WG-FSA-08/60) where combined sections (or magazines) of fishing gear with an anchor at each end are recorded as a single line. The way in which lines are defined and recorded is important as it is a metric used to define a trigger for the by-catch move-on rules. WG-FSA-15 requested that the Scientific Committee review the definition of a set line.

3.171 The Scientific Committee requested that the Commission redraft CM 33-03 to include a clear definition of a single longline as one contiguous piece of fishing gear regardless of how sections of that gear are connected.

## Exploratory fisheries

3.172 Exploratory longline fisheries for *Dissostichus* spp. were conducted in Subareas 48.6, 88.1 and 88.2 and Divisions 58.4.1, 58.4.2 and 58.4.3a in 2014/15; the season's catches and activities in these fisheries are detailed in Annex 7, Table 1, and the relevant Fishery Reports (www.ccamlr.org/node/75667). No new fishery was conducted in 2014/15.

3.173 The Scientific Committee noted that management areas in three exploratory fisheries for *Dissostichus* spp. were closed by the Secretariat in 2014/15. These closures were triggered as catches of *Dissostichus* spp. neared their relevant catch limits (SC-CAMLR-XXXIV/BG/01). In SSRUs 882C–H, two vessels fished in SSRU H in 2014/15. Their fishing operations appeared to have been constrained by sea-ice in that region (Annex 7, paragraph 3.7). A two-day closure notice for SSRU 882H was transmitted by the Secretariat prior to the closure date when total area catch was at 89% of the catch limit. However, higher catches in the final two days resulted in an 8-tonne overrun of the catch limit in SSRU 882H – in turn causing a 4-tonne overrun of the Subarea 88.2 combined catch limit for SSRUs 882C–H. Overall, the Subarea 88.2 catch limit as a whole was under-caught (Annex 7, Table 1).

3.174 Notifications for exploratory fisheries for *Dissostichus* spp. were submitted in accordance with CM 21-02 and are summarised in Table 1 of CCAMLR-XXXIV/BG/03. Updates to notifications, including withdrawals, are available on the CCAMLR website (www.ccamlr.org/en/fishery-notifications/notified). The Scientific Committee noted Members' notifications to fish in exploratory fisheries for *Dissostichus* spp. in 2015/16. These notifications followed a pattern similar to recent seasons. Notifications were received from nine Members for a total of 20 vessels in Subarea 88.1, eight Members and 19 vessels in Subarea 88.2, two Members and two vessels in Division 58.4.3a, three Members and three vessels in Subarea 48.6, five Members and five vessels in Division 58.4.1 and five Members and five vessels in Division 58.4.2. There were no notifications submitted for the exploratory fishery in Division 58.4.3b or for new fisheries, and the research plans for notified data-poor fisheries in Subareas 48.6 and 58.4 were submitted to WG-SAM-15 for review.

3.175 The Scientific Committee noted that WG-FSA had considered metrics of capacity and capacity utilisation which have been used annually for monitoring of trends in capacity in exploratory toothfish fisheries in Subareas 88.1 and 88.2 (Annex 7, paragraphs 4.58 to 4.60).

3.176 The Scientific Committee agreed that, while it was evident that an excess capacity of notified vessels could impact the management of the fishery, this situation had not yet actually occurred. Nevertheless, it noted that it was important to highlight potential situations where an excess of fishing capacity might make closure forecasting difficult. Identification of these potential situations would enable time to consider and evaluate potential solutions rather than reacting with a less considered response should such a problem occur.

3.177 The Scientific Committee agreed that, whilst these metrics did not currently indicate a capacity problem, there was the potential for large overruns in SSRUs with small catch limits if all the vessels entered the fishery at once. The Commission may wish to consider available options to deal with the issue which may include a higher frequency of reporting (e.g. 12-hourly reporting) and setting shorter lines, thus reducing hook numbers once a certain proportion of the catch had been reached.

### *Dissostichus* spp. Subarea 88.1

3.178 The exploratory fishery for *Dissostichus* spp. in Subarea 88.1 operated in accordance with CM 41-09 and associated measures. In 2014/15 the catch limit for *Dissostichus* spp. was 3 044 tonnes, including 68 tonnes set aside within the combined shelf SSRUs (J, L) catch limit for the sub-adult survey and 200 tonnes set aside for the research survey in the northern parts of SSRUs 882A–B. The total catch taken was 2 834 tonnes, including 23 tonnes from the sub-adult survey and 109 tonnes from the SSRUs 882A–B north survey.

3.179 The Scientific Committee noted the discussion in WG-FSA-15 that a sea-ice analysis had shown that 2014/15 was the third-worst ice year on record with associated negative effects on fishing operations, and that such ice analysis summaries could be included in Fishery Reports (Annex 7, paragraphs 4.62 and 4.63). It also noted that the bad ice conditions in 2014/15 had led to an uneven distribution of catch across the three slope SSRUs, with associated potential effects on the recapture of tags, and the need to develop a spatial overlap statistic (paragraph 3.83). The Scientific Committee agreed on the value of spatial models as tools to assess the effects of sea-ice on assessments.

3.180 The stock of toothfish in Subarea 88.1 and SSRUs 882A–B was assessed using a revised CASAL assessment as described by WG-FSA-15 (Annex 7, paragraphs 4.72 to 4.74). It included updated catch, catch-at-age and tag data from 2013/14 and 2014/15 and the results of the four sub-adult surveys from 2012 to 2015, which had enabled the estimation of YCS in this area for the first time. The yield, using the CCAMLR decision rules and current relative catch distribution between the shelf, slope and north areas of the Ross Sea region, was either 2 855 tonnes or 2 870 tonnes from the two reference-case model runs R1 (including quarantined data) and R2 (excluded).

3.181 For the Ross Sea assessment, the Scientific Committee recalled the advice from the Commission in 2014 (CCAMLR-XXXIII, paragraph 5.66) and agreed that the quarantined data should not be used in providing advice for the 2015 stock assessment.

3.182 The Scientific Committee discussed the issue of how quarantined data should be used in stock assessments. It noted that quarantined data include a catch associated with the fishing, which would be required for an assessment, as well as other observations such as tag data and length data which are not essential for an assessment. It further noted advice from WG-FSA that quarantined tagging data could result in a number of analytical effects (Annex 7, paragraph 4.68). It endorsed the approach used for R2 (inclusion of all quarantined catch estimate, exclusion of all quarantined tagging and length data) and requested the Commission to provide advice on how to treat quarantined data in the future.

3.183 The Scientific Committee noted that the current allocation of catches by SSRU using mean CPUE and fishable area was 13% to the shelf SSRUs 881J, L, 74% to the slope SSRUs 881H, I, K and 13% from the northern SSRUs 881B, C, G (SC-CAMLR-XXVII, Table 4) and agreed that as the CPUE showed no trend, the proportional allocation by SSRU should remain as applied in the current conservation measure.

3.184 An investigation of the effect of differing catch allocations from the Ross Sea shelf, slope and northern offshore areas showed that reallocating the total catch into one of these three locations resulted in a difference to the long-term yield of less than 10%.

3.185 The Scientific Committee agreed that the spatial population model (SPM) may be able to provide advice on catch allocations to the Scientific Committee and Commission. It noted, however, that methods for presenting diagnostics of such results remain to be determined and will need to be developed to accompany advice that may arise. The Scientific Committee agreed that exploring spatial allocation factors other than seabed area and CPUE, such as other ecosystem features, predator–prey overlap, ice dynamics, etc. would be valuable toward potential future refinement of the subdivision of the catch limit into SSRUs in the Ross Sea.

#### Management advice

3.186 The Scientific Committee recommended that the catch limit for *Dissostichus* spp. in Subarea 88.1 and SSRUs 882A–B should be set at 2 870 tonnes for 2015/16 and 2016/17, based on the outcome of the assessment. It further recommended that the proportional allocation by SSRU should remain as applied in the current conservation measures, after taking into account the research survey proposals below.

#### Catch limits for research surveys

3.187 The Scientific Committee welcomed the review of the data collection plan for the Ross Sea and its consideration of ways to manage the many tasks comprising the workload of scientific observers. The Scientific Committee agreed that the quality and quantity of observer data was critical to the work of the Commission and that priority needed to be given for the development of identification guides, instructions and sampling protocols to assist in the collection of required information. It also noted that processes should be implemented to enable the participation of all Members in forming and refining the data collection plan.

3.188 Data collection proposals to collect information consistent with the medium-term research plan objectives (CCAMLR-XXXIII, paragraph 5.52) were discussed by WG-FSA as follows: (i) a shelf survey of sub-adult toothfish in the southern Ross Sea (Annex 7, paragraphs 4.82 to 4.84); (ii) a winter survey proposal in the north of Subarea 88.1 (Annex 7, paragraphs 4.80 and 4.81); (iii) a research proposal in the north of SSRUs 882A–B (Annex 7, paragraphs 4.97 to 4.107); and (iv) a research proposal for the south of SSRU 882A (Annex 7, paragraphs 4.108 to 4.114). The first two survey proposals are discussed below in paragraphs 3.189 to 3.192, whilst the other two surveys are discussed in paragraphs 3.198 to 3.203.

### Ross Sea shelf survey

3.189 The Scientific Committee noted that WG-SAM had considered a report of results of the four sub-adult surveys completed to date, noting that the 2015 survey showed high catch rates of large sub-adult and adult toothfish in Terra Nova Bay relative to the other survey areas. It noted that the survey is intended to focus primarily on estimating the relative abundance of sub-adult toothfish in the core strata in SSRUs 881J and L so as to provide a time series of recruitment of toothfish for use in the Ross Sea assessment model (paragraph 3.180). Following the recommendations of WG-FSA-14 (SC-CAMLR-XXXIII, Annex 7, paragraph 5.108) and WG-EMM-15 (Annex 6, paragraph 2.86), an additional secondary survey objective was added to biennially monitor larger (sub-adult and adult) toothfish in McMurdo Sound and Terra Nova Bay, where toothfish are believed to form an important part of the diet of top predators. A nominal catch limit of 40 tonnes is requested for each survey year.

3.190 The Scientific Committee recommended that the Ross Sea shelf survey go ahead with a catch limit of 40 tonnes for each of 2015/16 and 2016/17, and that as in previous years the catch could be taken from the catch limit on the shelf.

### Ross Sea winter survey

3.191 The New Zealand proposal for the winter survey in SSRUs 881B–C was outlined for June 2016, and future years, with the potential for other Members to provide vessels for future years having suitable safety qualifications. For a catch limit, 100 tonnes (~3 100 fish) was requested – sufficient for 60 sets over 2–3 strata with at least 10 sets per strata. A catch limit would be set by stratum to ensure multiple strata are sampled. This catch limit was required to obtain adequate samples while maintaining an incentive for a suitable vessel to participate.

3.192 The Scientific Committee considered that the first year was a proof of concept as a foundation for future work, which would provide important insights into the toothfish biology within the northern area in winter. It endorsed the advice from WG-FSA-15 and WG-SAM-15 that the survey would address CCAMLR-agreed priorities. Recalling its discussions on spatial assignment of research catch limits from last year (SC-CAMLR-XXXIII, paragraphs 3.210 to 3.213), it agreed that the catch limit for the survey should be allocated from the total Ross Sea yield.

### Other research activities in Subarea 88.1

3.193 The Scientific Committee noted a number of other research activities being pursued in Subarea 88.1 which address the data collection plan (Annex 7, paragraphs 4.85 to 4.94).

These include an ice-based survey at McMurdo Sound, which showed high catch rates of large old toothfish in this area similar to those observed prior to 2002; a proposal to release 10 archival tags in 2016 to look at toothfish movement on the shelf and parts of the Ross Sea slope in the region of the proposed special research zone (SRZ) (CCAMLR-XXXIV/29 Rev. 1); and the use of the SPM to predict the likely effects of alternative marine protected area (MPA) scenarios on the toothfish yield estimates and localised depletion levels.

3.194 The Scientific Committee agreed that the approach used for evaluating the likely effects of alternative MPA scenarios and the consequent redistribution of fishing effort on the toothfish population may also be useful for the development of management strategy evaluations in the region. The Scientific Committee considered that the potential effect of sea-ice to bias toothfish assessments (paragraph 3.179) and the spatial allocation of catch limits (paragraph 3.184) were two priority issues that could be addressed using this approach.

### *Dissostichus* spp. Subarea 88.2

3.195 In 2014, the Scientific Committee and the Commission agreed to a two-year research plan in Subarea 88.2 in which the catch limit for SSRU 882H was 200 tonnes, and fishing in SSRUs 882C–G was restricted to the four research blocks with a combined catch limit for SSRUs 882C–G in 2015 of 419 tonnes, with no more than 200 tonnes to be taken from any one of the research blocks. In addition, a multi-Member research survey was agreed by the Scientific Committee and the Commission for SSRUs 882A–B for 2014/15 and 2015/16. The Commission agreed a catch limit of 50 tonnes per vessel and four vessels participated in 2014/15.

3.196 In 2015, the total reported catch of *Dissostichus* spp. in Subarea 88.2 (SSRUs 882C−H) was 624 tonnes. This was divided between research blocks 882_2 (188 tonnes), 882_3 (146 tonnes), 882_4 (82 tonnes) and SSRU H (208 tonnes). In addition, 109 tonnes were taken from the research blocks in SSRUs 882A (82 tonnes) and 882B (27 tonnes) (Table 1). A total of 1 128 tagged fish were released with 24 recaptures, including two between seasons. For 2016, eight Members with a total of 19 vessels have notified their intention to participate in the exploratory fishery for *Dissostichus* spp. in Subarea 88.2.

3.197 The Scientific Committee recalled its management advice for SSRUs 882C–H from 2014 (SC-CAMLR-XXXIII, paragraphs 3.173 and 3.174) and agreed that it had no further advice.

#### Proposed survey of SSRUs 882A–B north

3.198 The first year of the two-year multi-Member longline survey for toothfish in the northern Ross Sea region (SSRUs 882A–B) had variable but generally high catch rates, almost exclusively of *D. mawsoni*, with low levels of by-catch. Most fish were mature, with an age structure in each research block comparable to cell-specific estimates from the Ross Sea region SPM (Mormede et al., 2014). The survey proponents recommended minor modifications for the second year of operations to aid in the achievement of the objectives, including specification of data collection requirements, bathymetric survey requirements, research block-specific catch limits (25 tonnes per research block) to ensure a greater spread of effort, and a higher level of scientific oversight of survey operations to ensure optimal scientific design and data collection.

3.199 The Scientific Committee recommended that vessels return to the same four blocks sampled in 2015 to enable the recapture of tagged fish and improve estimates of age composition; following this, any remaining effort could be used to sample new research blocks to improve the characterisation of the area.

3.200 Dr Kasatkina proposed to undertake further analysis for consideration by WG-SAM of the data collected from the SSRUs 882A–B north survey in 2015, with a particular focus on:

(i) reconciling the VMS data with reported haul locations
(ii) the relationship between hauling speed and number of fish caught per unit effort
(iii) the relationship between hauling time and catches.

3.201 The Scientific Committee noted that the survey proponents had agreed to provide support for this process by conducting an analysis of CPUE variability, haul duration and haul speed for WG-SAM-16 and include a comparison with all exploratory fisheries and closed areas. The survey proponents agreed that they would undertake an analysis of the data from this survey as well as all exploratory and closed area fishing and research studies and provide a report to WG-SAM-16 and WG-FSA-16.

3.202 The Scientific Committee noted that a Norwegian vessel would not be able to participate in the survey this year. It recalled the recommendation of WG-SAM-15 (Annex 5, paragraph 4.36) and requested that the Commission consider contingency plans for research survey proposals this year to enable alternative vessels with appropriate gear configurations to be substituted to ensure necessary data collection and continuity of the research survey. It noted that Australia has notified a suitable vessel to conduct research in Subarea 88.2.

3.203 The Scientific Committee recommended that the second year of the survey proceed applying the agreed design with a maximum of 6 900 hooks per set and 17 250 hooks per cluster, a minimum cluster separation of 10 n miles and a total effort limit of 244 950 hooks set per vessel and a tagging rate of 3 fish per tonne of catch. The Scientific Committee agreed that a catch limit of 50 tonnes per vessel, and no more than 25 tonnes per research block, deducted from the catch limit of the Ross Sea region, was appropriate. It recommended that all survey participants complete the data collection requirements and bathymetric survey requirements and provide daily data summaries, as described in WG-FSA-15/32.

### Survey in SSRU 882A south

3.204 The Scientific Committee noted that WG-FSA-15 had considered a proposal from Russia to carry out a research program on the resource potential and life cycle of *Dissostichus* spp. from SSRU 882A from 2015 to 2018 (Annex 7, paragraphs 4.108 to 4.114).

3.205 Russia noted the recommendations of both SC-CAMLR-XXXIII (paragraphs 3.226) and WG-SAM-15 have been addressed in the updated version of its research program (WG-FSA-15/17):

(i) the catch limit of 100 tonnes for this research fishing should be subtracted from the Ross Sea catch limit (SC-CAMLR-XXXIII, paragraph 3.226)

(ii) an alternative vessel with appropriate gear configuration has been notified to participate in the research fishing. The longline vessel *Palmer*, which deploys the autoline system, will carry out the Russian research program in the southern region of SSRU 882A. Moreover, there is opportunity to invite scientists from other Member countries to take part in the Russian survey.

3.206 Russia 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). The design of a multiyear survey by Russia provides the possibility for combining data in the southern region of SSRU 882A with the SSRUs 882A–B north survey, consistent with the advice of SC-CAMLR-XXXIII (Annex 5, paragraph 4.20).

3.207 The Scientific Committee noted the potential of the Russian research program to provide data to be used by the SPM of the Ross Sea region and to better understand toothfish movement and distribution relative to the remainder of the Ross Sea stock as well as to support the fishery-dependent data collection plan for the Ross Sea region.

3.208 Dr Watters noted that the SRZ in the proposed Ross Sea region MPA had been expanded into SSRU 882A south and that the specific objectives for the SRZ had been revised to include improvement of the understanding of toothfish distribution and movement within the Ross Sea region (CCAMLR-XXXIV/29 Rev. 1). The idea of including part of SSRU 882A south within an SRZ so as to ‘better understand toothfish distribution and movements on the Ross Sea slope and potential implications for stock structure and potential bias in the stock assessment’ was presented to the Commission in 2013 (CCAMLR-XXXII, paragraph 7.14; SC-CAMLR-XXXII, paragraph 3.76(iv)b), and many Members welcomed and supported this idea (CCAMLR-XXXII, paragraph 7.19). Thus, Dr Watters considered that the management approach envisioned within the revised SRZ provided an alternative to the Russian proposal for research fishing in SSRU 882A south.

3.209 Some Members considered that the Russian proposal for research fishing in SSRU 882A south, and the revisions proposed to the SRZ within the proposed Ross Sea region MPA, could both potentially provide data that might improve the sustainable management of the toothfish fishery in the Ross Sea region. However, there are notable differences between the two proposals. The Russian proposal would allow research fishing by a single Member (Russia) but can be implemented in 2015/16. The proposed Ross Sea region MPA would potentially allow all Members to carry out research fishing in SSRU 882A south, but is contingent on adoption of the MPA and, thus, could only be implemented in subsequent years. Another difference between the two proposals is the temporal linkage to the research fishing proposed in SSRUs 882A–B north (in 2015/16 versus a delay until at least 2016/17 for the Russian and MPA proposals respectively).

3.210 These Members agreed that choosing between the Russian proposal and the proposed Ross Sea region MPA is a matter for the Commission. They advised that the Commission should base its decision on:

(i) Russia's track record with respect to the conduct and completion of research fishing

(ii) how it wishes to prioritise research fishing by a single Member versus multiple Members

(iii) how it wishes to prioritise research fishing that is implementable in 2015/16 versus 2016/17 at the earliest.

3.211 Russia considered that its proposal would provide the required data in a timely fashion and should proceed in 2015/16.

### Additional management proposals

3.212 Dr Kasatkina presented the proposal of Russia to change the boundaries of Subarea 88.1 (SC-CAMLR-XXXIV/10). She recalled that the Scientific Committee recommended that the boundary between Subareas 88.1 and 88.2 be revised or that the scope of CMs 41-09 and 41-10 be revised such that the Ross Sea region (Subarea 88.1 and SSRUs 882A–B) is managed within a single conservation measure (SC-CAMLR-XXXII, paragraph 3.160) and noted that discussions surrounding activities with respect of toothfish in SSRUs 882A–B would be clearer if these SSRUs were more clearly identified with the Ross Sea stock (SC-CAMLR-XXXIII, paragraph 3.227).

3.213 Dr Kasatkina recalled that the SSRUs 882A–B have been closed to fishing for many years and have catch limits of zero, which hampers progress in understanding the relationship between the stocks in SSRUs 882A–B and the Ross Sea. The fishery in SSRUs 882A–B has been closed since 2005/06. In 2011 and 2012, Russia carried out research fishing in SSRU 882A and a possible yearly catch quota of 286 tonnes (based on a CPUE by seabed analogy method) was recommended based on the results. Moreover, in 2013 the Scientific Committee provided advice to the Commission to commence research in SSRU 882A on tagging and tag returns from this SSRU for all Members' vessels with a catch limit of 286 tonnes (SC-CAMLR-XXXII, paragraph 3.155), but this was not adopted by the Commission.

3.214 Dr Kasatkina noted that Russia proposed that the Commission be advised to undertake a revision of the boundary between Subareas 88.1 and 88.2, taking into account the opening of SSRUs 882A–B to fishing with the following catch limits: 286 tonnes for SSRU 882A and 33 tonnes for SSRU 882B (as was the case before these SSRUs were closed). Thus, a revision of the boundaries can only be carried out with the opening of SSRUs 882A–B.

3.215 The Scientific Committee questioned whether these catch limits were additional to the existing catch limits for Subareas 88.1 and 88.2, whilst noting that the toothfish population in these SSRUs was already assessed within the Ross Sea (Subarea 88.1 and SSRUs 882A–B) stock assessment. It further noted that, if these catch limits were additional to the existing catch limits for Subarea 88.1, then the cumulative catch limits would lead to a higher catch and exploitation rate than the yield derived using the CCAMLR decision rules and would be effectively overfishing the stock.

3.216 The Scientific Committee recalled previous discussions of this issue where it provided advice to the Commission recommending that the boundary between Subareas 88.1 and 88.2 be revised or that the scope of CMs 41-09 and 41-10 be revised such that the Ross Sea region (Subarea 88.1 and SSRUs 882A–B) is managed consistent with the biological stock and within a single conservation measure (SC-CAMLR-XXXII, paragraph 3.160; SC-CAMLR-XXXIII, paragraphs 3.227 and 3.228). It agreed to reiterate this recommendation to the Commission.

3.217 The Scientific Committee agreed that the question of boundaries could be discussed through an e-group.

3.218 Dr Kasatkina also presented the Russian proposal 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 (SC-CAMLR-XXXIV/12). 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).

3.219 Dr Kasatkina proposed that research catch limits be set for all closed SSRUs in the Ross Sea and Amundsen Sea. According to CCAMLR regulations, an overall assessment is carried out for the stock in the Ross Sea and Amundsen 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. If all the planned longlines have been set and the research catch limit remains, then that catch limit shall not be added or carried over to the next year, but shall simply remain untaken in that SSRU. In the following year in that SSRU, there will already exist an established new research catch limit. Therefore, the overall catch limit for Subarea 88.1 will remain untaken and will be used only by fishing vessels operating under the Olympic system.

3.220 The Scientific Committee agreed that having a dedicated research catch which came from the total overall catch limit was a sensible idea and thanked Russia for its proposal. However, it noted that a research catch needs to have a research proposal to go with it, with clearly defined objectives, as is the current practice when research is carried out in other CCAMLR management areas. It recalled its previous advice on CCAMLR-sponsored research from 2008 (SC-CAMLR-XXIX, paragraphs 8.9 and 8.10), which outlined guidelines for research proposals.

3.221 Dr Kasatkina advised the Scientific Committee that the expert involved in the analysis was unable to attend the 2015 meetings of WG-FSA and the Scientific Committee, and that Russia would submit updated papers on both proposals to WG-FSA and the Scientific Committee next year.

### Research to inform current or future assessments in exploratory fisheries and other fisheries

#### General

##### Fishery nomenclature and the regulatory framework

3.222 The Scientific Committee welcomed the paper prepared by Dr Jones, in response to a request from the Commission last year (CCAMLR-XXXIII, paragraph 5.37), reviewing the CCAMLR regulatory framework and providing recommendations for streamlining the assignment of fishery status (CCAMLR-XXXIV/17 Rev. 1).

3.223 The Scientific Committee noted that there was potential to harmonise the nomenclature of *Dissostichus* spp. fisheries by including all research fishing activities targeting *Dissostichus* spp. in exploratory fisheries, closed areas and areas with no catch limits under CM 41-01. It noted that the review of all research plans and objectives for *Dissostichus* spp. research in Subareas 48.2, 48.5, 48.6, 88.3 and Divisions 58.4.1, 58.4.2, 58.4.3a and 58.4.4 indicated that they shared all the characteristics of exploratory fisheries. It also noted that the history of fishing and research activities needs to be considered, and requested that the Secretariat develop documents analogous to the existing Fishery Reports to assemble this information.

3.224 The Scientific Committee agreed that the state of knowledge about stock and the ecosystem in the Ross Sea fishery meant that it had more in common with the established fisheries than the other exploratory and research fisheries, and hence a specific conservation measure could be developed for this fishery, based on CM 41-01, to reflect this.

3.225 Dr Kasatkina expressed concern that the recommendations in CCAMLR-XXXIV/17 Rev. 1 had the potential to have significant impacts on CCAMLR fisheries. She noted that the proposed recommendations for streamlining fishery status require special consideration with a particular focus on: (i) how the status of some fisheries should be changed and which new/revised conservation measure(s) would be required; (ii) which of the ensuing consequences for CCAMLR fisheries would be provided by streamlining fishery status.

3.226 Dr Kasatkina proposed discussing CCAMLR-XXXIV/17 Rev. 1 during the intersessional period by organising a workshop and presenting a report for consideration by WG-EMM and WG-FSA.

3.227 Dr Zhao noted that a dedicated workshop to harmonise the conservation measures may be desirable, particularly where research plans related to FBM of the krill fishery are concerned. He further noted that it is also desirable that a mechanism be established to ensure consistency in nomenclature across conservation measures and resolutions as they are reviewed and/or modified.

3.228 The Scientific Committee also requested that the Commission consider mechanisms for developing long-term research plans in closed fisheries such as Subarea 48.2 and to progress research fishing in individual research plans towards an exploratory fishery.

### Streamlining the review of research plans

3.229 The Scientific Committee noted that WG-SAM and WG-FSA had spent a considerable amount of time reviewing research plans submitted by Members notifying to conduct research fishing in 2015/16 and considered methods to streamline the review process (Annex 7, paragraphs 5.6 to 5.14). The Scientific Committee noted that keeping track of research proposals and their progress in addressing CCAMLR's objectives was essential and endorsed the proposal by WG-FSA that Fishery Reports should be appended with information on the fishery research in the area. It also agreed that research plans should include clear descriptions of milestones towards the objectives of research plans, to enable a straightforward assessment of whether a research plan is proceeding as planned, or if any revisions are required. It also agreed that plans and milestones should emphasise analysis of samples and data and development of stock assessments and management advice, as well as at-sea sampling.

3.230 The Scientific Committee noted that WG-FSA had requested that the criteria be established whereby the likelihood of research plans achieving their objectives could be assessed. It noted that factors such as the success of previous research could be considered, noting that learning from the past was a key component of the scientific process.

3.231 It further noted that guidelines for developing research plans and evaluating them against their individual objectives has been successful in WG-SAM and WG-FSA, and that it was the role of the Scientific Committee to review and prioritise across all research plans submitted by Members, in particular where the catch limits exceed those shown in CM 24-01, Annex 24-01/B. It recalled its advice in 2008 on CCAMLR-sponsored research and reiterated its advice that the guidelines in SC-CAMLR-XXVII, paragraphs 8.9 to 8.11, be followed when establishing research programs. It also noted that these guidelines should also be considered when prioritising or integrating research plans where multiple proposals may occur with similar objectives.

### Mark recapture data analysis

3.232 The Scientific Committee noted the discussion by WG-FSA on the development of 'best-practice' guidelines on the analysis of mark-recapture data (Annex 7, paragraphs 5.15 to 5.24). It agreed that:

(i) the Secretariat provide a paper to WG-SAM-16 including a summary table including local biomass estimation methods, recommended research catch limits in research blocks, catch reported in 2015, number of tagged fish available and expected and observed recaptures (see SC-CAMLR-XXXIII, Annex 7, Table 5), with details of the methods used to calculate all values presented in the table

(ii) all tagged fish released in all years, beginning in 2009, should be considered suitable for inclusion in estimates of biomass and expected recaptures in Subareas 48.6 and 58.4, except where part of a quarantined dataset.

### Provision of management advice in data-poor fisheries

3.233 The Scientific Committee noted that in some areas where research had been proposed, research catch limits had not been taken due to operational issues. It agreed that where Members had proposed research across multiple areas in Subareas 48.6 and 58.4, priority should be given to research fishing in Subarea 48.6 to ensure that data necessary to perform an integrated assessment is collected in a timely manner.

3.234 The Scientific Committee noted the discussions by WG-FSA-15 on issues around estimating biomass and $B_0$ in stocks without reliable estimates of IUU removals (Annex 7, paragraphs 5.25 to 5.29). It noted that this issue had been identified as a priority for WG-SAM-16 (see Item 13).

### Circumpolar *D. mawsoni* habitat model

3.235 The Scientific Committee noted the development of a Maxent model of circumpolar habitat suitability of *D. mawsoni* (Annex 7, paragraphs 5.31 to 5.33), and encouraged further development of such modelling approaches as described in Annex 7, paragraph 5.29.

### *Dissostichus* spp. Subarea 48.6

3.236 The exploratory fishery for *Dissostichus* spp. in Subarea 48.6 operates in accordance with CM 41-04 and associated measures. In 2014/15, the catch limit for *Dissostichus* spp. was 538 tonnes. Research fishing was conducted in two research blocks by vessels flagged to South Africa and Japan using longlines, and total catches of 189 tonnes were reported to 16 September 2015. Research block 486_3 in SSRU D was closed on 10 March 2015 following completion of research fishing and the total catch of *Dissostichus* spp. in that SSRU was 49 tonnes (98% of the catch limit).

3.237 The Scientific Committee noted that Chile, Japan and South Africa had proposed to conduct research fishing in Subarea 48.6 in 2015/16. It noted that the research planned by Japan and South Africa had been reviewed by WG-SAM-15 (Annex 5, paragraphs 3.2 to 3.5) and WG-FSA-15 (Annex 7, paragraphs 5.56 to 5.60). Chile did not provide a paper describing its research plan.

3.238 The Scientific Committee noted that Japan and South Africa had provided a summary of data collected in this subarea on catch effort and biology of toothfish. It further noted that WG-FSA considered that a preliminary integrated assessment would be developed for research block 486_2 for consideration by WG-SAM-16.

3.239 The Scientific Committee noted that WG-FSA had endorsed an extension to research block 486_4 (Annex 7, paragraph 5.61). The Scientific Committee agreed it was desirable to fish in the original research block as a priority. It further noted that the research block extension overlapped with the Weddell Sea MPA planning area, and that increasing the fishing footprint in this area may impact on the development of the Weddell Sea MPA. It therefore agreed that, as an interim measure, the boundaries of the research block would be revised to exclude the area of Astrid Ridge north of latitude 68°20'S.

3.240 The Scientific Committee noted that WG-FSA had reviewed the catch limits for this subarea and endorsed the advice that catch limits remain unchanged in 2015/16.

### *Dissostichus* spp. Divisions 58.4.1 and 58.4.2

3.241 The precautionary catch limit for the exploratory fishery for *Dissostichus* spp. in Division 58.4.1 in 2015 was 724 tonnes, and this was applied to research fisheries in SSRUs and research blocks within those SSRUs. The fishery was limited to one Korean and one Spanish flagged vessel using longlines. The Republic of Korea was the only Member that conducted research fishing in 2014/15, catching 123 tonnes spread across all five research blocks in this area.

3.242 The precautionary catch limit for the exploratory fishery for *Dissostichus* spp. in SSRU 5842E in 2015 was 35 tonnes. Korea was the only Member to fish in this division catching 11 tonnes.

3.243 Australia, Japan, France, Korea and Spain all notified one vessel to fish in these divisions in 2015/16.

3.244 The Scientific Committee noted that WG-FSA-15 reviewed research plans provided by all five Members (Annex 7, paragraphs 5.68 to 5.78). It further noted that the proponents of the research had developed an allocation system such that all Members notified had sufficient catch to complete their research objectives, avoiding 'Olympic' research, and to reallocate catches if Members were unable to participate in, or complete, research.

3.245 The Scientific Committee noted that Table 6 in WG-FSA-15 (Annex 7) provided a useful basis for ongoing discussions regarding the coordination and allocation of research in these divisions. However, it noted that there were some omissions in the table as it did not take into account revised catch limits scaled by new seabed area calculations for all research blocks, nor the research catch limit allocated to the effort-limited survey proposed by Australia in SSRU 5841G. A revised table was produced by the proponents (Table 2). The Scientific Committee reviewed the catch limits provided in this table and endorsed them as the catch limits that would apply to research in these divisions in 2015/16.

3.246 The Scientific Committee further noted that Members notified to conduct research will confirm whether they intend to pursue research by SC CIRC by 1 February 2016. If any Members are not able to confirm that they will pursue research, their allocation will be redistributed amongst the other notified Members that have confirmed they will pursue research. If any Members have not commenced research fishing by 28 February 2016, their allocation will also be redistributed amongst the other Members that have commenced research fishing. The Scientific Committee recommended that this approach be considered for multi-Member surveys more generally.

3.247 The Scientific Committee encouraged Members to continue to coordinate sample collection and exchange form research in this region. It noted that Australia had undertaken to collect stomachs from 200 toothfish across a range of sizes in research block 5842_1 to facilitate the Republic of Korea's research plan, and Korea will provide representative samples of otoliths from toothfish from research block 5841_5 to Australia for analysis.

*Dissostichus* spp. Division 58.4.3a (Elan Bank)

3.248 The exploratory fishery for *Dissostichus* spp. in Division 58.4.3a operated in accordance with CM 41-06 and associated measures. In 2014/15, the catch limit for *Dissostichus* spp. was 32 tonnes, and fishing was limited to one French and one Japanese flagged vessel using longlines in research block 5843a_1. At the time of the WG-FSA-15 report, only the French-flagged vessel had completed research fishing in Division 58.4.3a with a catch of less than 1 tonne of *D. eleginoides*, whilst the Japanese-flagged vessel had only recently entered the fishery. For 2016, one vessel from France and one from Japan notified their intention to participate in the exploratory fishery for *Dissostichus* spp. in Division 58.4.3a.

3.249 The Scientific Committee noted that there had been further developments of CASAL integrated stock assessment models for this division but that they were not yet sufficiently robust to provide management advice using the CCAMLR decision rules. It encouraged further development of these models in the intersessional period, taking into account the points identified by WG-FSA (Annex 7, paragraph 5.81) and be further reviewed by WG-SAM-16.

3.250 The Scientific Committee also recalled the discussion of the provision of management advice in data-poor fisheries affected by IUU fishing (Annex 7, paragraphs 5.25 to 5.30) and noted that these discussions were also applicable to this division. It further recommended that growth and maturity parameters be further developed for this area.

3.251 In the absence of information to update its advice, the Scientific Committee recommended that the catch limit for this division remains unchanged at 32 tonnes for 2015/16.

*Dissostichus* spp. Subarea 48.2

3.252 The Scientific Committee noted the planned toothfish research fishing in Subarea 48.2 by Ukraine and Chile.

3.253 Ukraine started a longline survey in 2014/15 to estimate the status of *Dissostichus* spp. in this subarea. The vessel completed 29 sets in the effort-limited survey, catching 4 tonnes of *D. eleginoides* and 31 tonnes of *D. mawsoni*, against a nominal catch limit of 75 tonnes. The results from the first year of a three-year investigation indicated that both *D. mawsoni* and *D. eleginoides* are encountered in the northern regions, whilst only *D. mawsoni* are found in southern regions. For 2015/16, Ukraine proposed to stratify the survey by area with a survey region on both the northern bank and the southern seamount area.

3.254 Chile proposed to start a three-year program of toothfish research fishing in Subarea 48.2 in 2015/16. The Scientific Committee noted the similarity in the survey design, station locations and area presented in the proposal with that proposed by Ukraine.

3.255 The Scientific Committee noted the scientific benefits of having more than one vessel participating in the research, although there is the potential for interference between the two research plans. The Scientific Committee requested that Chile and Ukraine coordinate on the research, including the spatial and temporal distribution of fishing effort, deliverables and milestones with respect to sampling efforts at sea, laboratory work and analytical work in view of the common aim of an integrated stock assessment for the area.

3.256 Dr K. Demianenko (Ukraine) recalled that the three-year research plan submitted by Ukraine had been considered by WG-FSA-14 and approved by the Scientific Committee and the Commission. The 2015/16 season will be the second year of the three-year research plan and Ukraine indicated that it has all preconditions for completing the research plan. Dr Demianenko further informed the Scientific Committee that while Chile and Ukraine intend to work on their respective research plans, their research will be temporally coordinated, with Chile intending to conduct its research in February and Ukraine in March.

3.257 The Scientific Committee noted that the plans as set out with respect to laboratory and analytical intentions are very ambitious and undertaking work toward these objectives will require substantial effort by the proponents. The Scientific Committee noted that neither of the proposals included a timeline to develop assessments, either by mark recaptures or other preliminary stock assessment methods, and requested that this should be developed and presented for review.

3.258 The Scientific Committee recommended a tagging rate of 5 fish per tonne for all research fishing in the subarea as long as the condition of the fish allowed tagging at this rate.

3.259 In light of the new research plan by Chile, Drs Demianenko and Arata requested that the Scientific Committee consider an appropriate catch limit of 50 tonnes for each research vessel ensuring that there is adequate spatial coverage in accordance with each research survey plan. The proposed total catch limit of 100 tonnes for the research in Subarea 48.2 is not much higher than the catch limit of 75 tonnes approved for one research vessel in 2014/15. Taking into account the difference in the two research plans and changeable ice conditions in the subarea, Drs Demianenko and Arata proposed that the Scientific Committee consider the catch limit increase, ensuring that this does not imply increasing the actual catches automatically.

3.260 The Scientific Committee noted that Subarea 48.2 had been closed for direct finfish fishing in 1990 by the Commission because the area was determined to be overfished. However, it remains unclear whether *Dissostichus* spp. had also been overfished since the majority of *Dissostichus* stocks are found in waters that are deeper than where historical trawling had occurred in the past. The Scientific Committee noted that if *Dissostichus* spp. had been overfished, then catch limits need to be set such that the stock is not further depleted.

3.261 Consistent with other data-poor regions in the Convention Area, the Scientific Committee agreed that the current catch levels should not increase with the increase in the number of participants undertaking the research. Since there was no new advice on the catch limit in Subarea 48.2, the Scientific Committee recommended to retain the catch limit of 75 tonnes for 2015/16.

3.262 The Scientific Committee noted that it would be desirable to avoid Olympic research fishing, which could be avoided by allocating catch to each Member in a transparent fashion while allowing flexibility by reallocating catch. For Subarea 48.2, the Scientific Committee requested that the Commission consider that half the catch limit be allocated to each of the two vessels, and that the catch of the Chilean vessel be reallocated to the Ukrainian vessel fishing in March should the Chilean vessel not be able to fish in February due to, for example, unfavourable sea-ice conditions.

3.263 The Scientific Committee agreed that, since very little historical fishing data for *D. mawsoni* are available for Subarea 48.2, it was important to collect information on status of target, by-catch and other components of the ecosystem.

3.264 The Scientific Committee requested the Secretariat prepare a Fishery Report for this subarea to help with providing scientific advice.

### *Dissostichus* spp. Divisions 58.4.4a and 58.4.4b (Ob and Lena Banks)

3.265 The Scientific Committee noted that Japan was currently conducting research fishing in Division 58.4.4b (October 2015) and that France may proceed to the area later in 2014/15. France and Japan proposed to conduct research in this division in 2015/16 (Annex 5, paragraphs 4.17 to 4.19).

3.266 The Scientific Committee welcomed the reports describing new biological information and an updated integrated stock assessment using CASAL for this division. It noted that the revised assessments have improved and that further work was undertaken during the meeting. However, it also noted that the area has been the subject of unquantified IUU fishing over a number of years and, therefore, the relative status of the stock cannot be estimated (Annex 7, paragraphs 5.25 to 5.30). It is, therefore, currently unable to be progressed to the point of providing management advice using the CCAMLR decision rules.

3.267 In the absence of information to update its advice, the Scientific Committee 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 2015/16.

### *Dissostichus* spp. Subarea 48.5 Weddell Sea

3.268 The Scientific Committee noted a revised Russian research plan to undertake research for *Dissostichus* spp. in Subarea 48.5 (Weddell Sea) from 2015/16 to 2019/20.

3.269 The Scientific Committee noted that WG-FSA-15 was unable to provide any advice regarding this Russian proposal to continue research in Subarea 48.5 in 2015/16 (Annex 7, paragraph 5.52).

3.270 The Scientific Committee recalled that in 2014, it had been unable to conclude an analysis of the data collected by the *Yantar 35* from the Weddell Sea in 2012/13 and 2013/14, and therefore had agreed it was unable to complete the review of the research design proposed by Russia for 2014/15 in accordance with the requirements of the CM 24-01, paragraph 3(a) (SC-CAMLR-XXXIII, paragraph 3.231).

3.271 The Scientific Committee recalled its request to Russia to finalise an analysis of the data collected by the *Yantar 35* from the Weddell Sea in 2012/13 and 2013/14, with a particular focus on: (i) reconciling the VMS data with reported haul locations, (ii) the relationship between hauling speed and number of fish caught per unit effort, and (iii) tagging activities conducted during the research fishing, and to present its results for consideration by WG-SAM-15 (SC-CAMLR-XXXIII, paragraph 3.232).

3.272 The Scientific Committee noted that Russia had provided a reanalysis of data from 2012/13 to WG-SAM-15. The Working Group was unable to provide any further assessment of the analyses and recommended that the data concerned remain quarantined until such time that the complete analysis has been undertaken and submitted for consideration by WG-SAM (Annex 5, paragraph 4.10).

3.273 The Scientific Committee also noted that WG-SAM-15 had recommended that the report from Russia (WG-SAM-15/22), describing the Russian analysis of the 2012/13 Subarea 48.5 fishing survey, be brought to the attention of the Standing Committee on Implementation and Compliance (SCIC).

3.274 The Scientific Committee noted that some WG-FSA-15 participants consequently requested that the Secretariat undertake an analysis of the quarantined data from research activities in Subarea 48.5 and provide a report to the working groups for further consideration in 2016. The Scientific Committee noted that this analysis should now include all the data collected by the *Yantar 35* in all years across all areas following the advice of WG-FSA-15 (Annex 7, paragraph 3.15). Currently, the data of this vessel throughout the Convention Area are quarantined.

3.275 The Scientific Committee noted that WG-FSA-15 recommended that the results of this and previous Secretariat analyses should be available to WG-SAM and WG-FSA in 2016 before WG-FSA is able to make recommendations in respect of the research proposal going forward. Since the strategy recommended to achieve the research objectives may change once the analysis of the quarantined 2012/13 and 2013/14 data is complete, WG-FSA-15 could not evaluate whether the proposed design is appropriate at this time to reach the original objectives agreed by the Scientific Committee (SC-CAMLR-XXXIII, paragraphs 3.232 and 3.233).

3.276 The Scientific Committee agreed that the two issues on (i) the analyses of the quarantined data collected from the Weddell Sea in 2012/13 and 2013/14, and (ii) the review of the research proposal to continue research in Subarea 48.5, need to be separated. The following paragraphs consider the research proposal.

3.277 Dr Kasatkina recalled the Scientific Committee recommendation that a future Russian research program in the Weddell Sea would need to be consistent with the original research objectives approved in 2012 (SC-CAMLR-XXXIII, paragraph 3.233) and that WG-FSA-15/29 presented the original research program in the Weddell Sea adopted by the Scientific Committee in 2012 (WG-FSA-12/12; SC-CAMLR-XXXI, paragraph 9.16) with some revisions to incorporate the comments of WG-SAM-15 (Annex 5, paragraph 4.13). Dr Kasatkina also noted that the proposal fully meets the requirements of CMs 21-01, 21-02 and 41-01 and that the catch limit for the Russian research proposal in Subarea 48.5 was adopted by the Commission in 2012 (CCAMLR-XXXI, paragraph 5.42).

3.278 Dr Kasatkina noted that WG-SAM-15 raised no objections, other than the number of vessels (two vessels) that participated in research fishing and concern about vessel safety in the Weddell Sea, given potentially heavy ice conditions. She also noted that one vessel was notified for research fishing. Moreover, there is the opportunity to invite scientists from other Member countries to provide full transparency of the research fishing. A Ukrainian researcher will be on board in 2015/16.

3.279 Dr Kasatkina emphasised that the Convention and conservation measures raise no objections against providing research investigations in the Weddell Sea and the quarantined data analysis requested by the Scientific Committee in parallel is an unrelated processes. In the proposal, the number of vessels taking part in the survey has been changed from two vessels to one vessel, and Russia invites an international observer from any CCAMLR Member to be on board to provide complete transparency about the research activity.

3.280 Dr V. Belyaev (Russia) noted that Russia is currently conducting an analysis of the quarantined data from the *Yantar 35* as described in COMM CIRC 15/101–SC CIRC 15/59. He also noted that the *Yantar 35* has been removed from the list of vessels operating in the CCAMLR area, and a possible withdrawal of the vessel's licence to fish in the CCAMLR area is currently being decided.

3.281 Some Members noted that the recollection by Dr Kasatkina that WG-SAM-15 raised no objections, other than the number of vessels (two vessels) that participated in research fishing and concern about vessel safety, was inconsistent with the recollection of the majority of the meeting participants and the WG-SAM report. WG-SAM had highlighted the difficulties and safety concerns with ice cover in the proposed research blocks, but had also noted the inconsistency between the expected line numbers to be set and those that had been achieved (eight), in addition to the incomplete analysis of quarantined data by Russia, created significant uncertainty around the status of the stock in Subarea 48.5 (Annex 5, paragraphs 4.13 to 4.15). Following these discussions, WG-SAM-15 had concluded and agreed that the research plan presented at WG-SAM-15 did not meet the CCAMLR scientific research objectives and thus could not be recommended (Annex 5, paragraph 4.15).

3.282 The Scientific Committee was unable to provide any further advice to that provided by the Scientific Committee in 2014 (SC-CAMLR-XXXIII, paragraphs 3.230 and 3.231), noting that the review of the proposal was not completed at WG-SAM or WG-FSA.

3.283 The Scientific Committee noted that Subarea 48.5 had been closed because there was no advice on any other catch limit at the time. Given that the *Dissostichus* stock in this subarea were likely to be pristine, the Scientific Committee recommended that a data collection plan should be developed that will lead to the development of an assessment for the *Dissostichus* fishery in this subarea.

3.284 The Scientific Committee noted that WG-SAM agreed that, as a result of the uncertainty created by the incomplete analysis conducted by Russia, the Russian revised research plan for Subarea 48.5 did not meet the CCAMLR objectives and could thus not be recommended. WG-SAM noted the request by Russia to conduct collaborative research in the area. WG-SAM agreed it will be able to revisit proposals for this area when the data reanalysis requested by the Scientific Committee in 2014 has been fully evaluated.

3.285 Drs Belyaev and Kasatkina did not agree with the position taken by the Scientific Committee which is based on advice from WG-SAM. They made the following statement:

‘(i) WG-SAM-15 raised no objections, other than the number of vessels (two vessels) participating in research fishing and concern about vessel safety in the Weddell Sea, given potentially heavy ice conditions. However, analysis of ice conditions in the Weddell Sea (2003–2015) undertaken by Russia have provided evidence that research plans could be realised depending on where ice conditions would be favourable. One vessel was notified for research fishing. Moreover, there is the opportunity to invite scientists from other Member countries to provide full transparency of the research fishing.

(ii) The Scientific Committee recommendation that a future Russian research program in the Weddell Sea would need to be consistent with the original research objectives approved in 2012 (SC-CAMLR-XXXIII, paragraph 3.233) and that WG-FSA-15/29 presented the original research program in the Weddell Sea adopted by the Scientific Committee in 2012 (WG-FSA-12/12; SC-CAMLR-XXXI, paragraph 9.16) with some revisions to incorporate the comments of WG-SAM-15 (Annex 5, paragraph 4.13). In view of the abovementioned, consideration of the Russian research program in the context of data from the *Yantar 35* would be unacceptable.

(iii) The Convention and conservation measures raise no objections against providing research investigations in the Weddell Sea and the quarantined data analysis requested by the Scientific Committee in parallel is an unrelated processes.’

3.286 Drs Belyaev and Kasatkina noted that the Scientific Committee noted that there should be a separation of the matter of the plan submitted for research in the Weddell Sea and quarantined data from the *Yantar 35*. The Russian research plan for Subarea 48.5 can be approved. WG-FSA supported the Russian plan.

3.287 Russia made the following statement:

‘The Scientific Committee agreed that there should be a separation of the matter concerning the analysis of quarantined data collected in the Weddell Sea in 2012/13 and 2013/14 and a review of the research proposal for Subarea 48.5. In this regard, we believe it is necessary to point out the following:

When examining this issue it is necessary first of all to be guided by the scientific grounds of the program to study toothfish distribution and stock assessment and its role in Antarctic ecosystems, which will make it possible to give an objective assessment of stock status and rational fishing. In this context, implementation of the Russian plan would make it possible to obtain information essential both for planning an MPA in the Weddell Sea, and for refining and validating data obtained earlier.

However, the scientific aspect of the issue was not considered and the Scientific Committee rejected Russia’s notified research program for the Weddell Sea (Subarea 48.5).

Russia does not support the Scientific Committee’s decision on this matter.’

*Dissostichus* spp. Subarea 88.3

3.288 The Scientific Committee noted that WG-FSA had discussed a three-year research proposal in the closed fishery for *Dissostichus* spp. in Subarea 88.3 starting in 2015/16 by the Republic of Korea (Annex 7, paragraphs 5.88 to 5.91) and that Korea had incorporated recommendations as set out by WG-SAM-15 into the revised research plan.

3.289 The Scientific Committee agreed that the research blocks within Subarea 88.3 should be prioritised. It agreed that the two primary factors that should be taken into account when prioritising research blocks are sea-ice conditions and areas where tagged fish had been released in the past.

3.290 The Scientific Committee recommended 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. Dr S.-G. Choi (Republic of Korea) indicated that Korea was not planning to fish in the other research blocks in 2016.

3.291 The advice to the Commission on research allocations is summarised in Table 3.

## Incidental mortality

4.1 The Scientific Committee noted that 2014/15 had the lowest number of bird by-catch mortalities recorded since the beginning of bird by-catch observations in the Convention Area. The Scientific Committee thanked Members for their diligent work towards minimising bird by-catch.

4.2 Annex 7, paragraph 8.29, summarised a proposal to trial a season extension at the beginning and end of the fishing season in Division 58.5.2.

4.3 The Scientific Committee endorsed the implementation of a season extension trial to include 1 to 14 April and 15 to 30 November with both day and night setting allowed in Division 58.5.2:

(i) for the November period, the current limit of seabird by-catch not exceeding three birds in total will continue to apply

(ii) for the April period, should the limit of three by-caught birds per vessel be reached, the trial will be terminated for that vessel in the extension for that year.

4.4 The Scientific Committee noted that previous experiences from a season extension in Subarea 48.3 (WG-FSA-14/28) recommended avoiding setting in daylight and within three hours of nautical dusk/dawn in the more vulnerable period in the early season extension. It noted that such measures should be considered if other mitigation is not successful in the season extension in Division 58.5.2.

Marine debris

4.5 The Scientific Committee noted a summary of data on marine debris (WG-FSA-15/15 and SC-CAMLR-XXXIV/BG/27) containing information from beach surveys, debris associated with seabird colonies and entanglement of marine mammals, from Subareas 48.1, 48.2 and 48.3 (with additional data from Subarea 58.7) submitted to the Secretariat. Overall, there was no evidence of trends in the occurrence of marine debris but the data highlighted the continued presence of man-made marine debris in the Convention Area.

4.6 The Scientific Committee requested that the Secretariat contact other organisations (e.g. SCAR, CEP, International Maritime Organization (IMO), IWC and UNEP) to investigate potential collaboration on data collection and analysis of marine debris data.

4.7 The Scientific Committee also considered the issue of marking hooks with vessel-specific identification marks, noting that their use could help to trace the provenance of hooks found in seabird colonies, and requested the Commission to consider its implementation (paragraph 3.87).

## Spatial management of impacts on the Antarctic ecosystem

Bottom fishing and vulnerable marine ecosystems

5.1 The Scientific Committee noted discussions on bottom fishing activities and VMEs during WG-FSA-15 (Annex 7, paragraphs 6.1 to 6.5). It noted that WG-FSA had agreed that the method described in WG-FSA-15/62 Rev. 1 provided a useful methodology for rapidly undertaking initial assessments of the interactions of fishing with ecological features of importance to CCAMLR. It also noted that the method might be useful for rapid assessments, such as for 'status of the ecosystem' reports, for possible use in relation to the krill fishery, or for use in the assessment of MPAs and for use in providing advice relevant to management and review of MPAs.

5.2 Dr Barrera-Oro noted that CMs 22-06 and 22-07 provide information about the impacts of longlines, but noted than no similar metrics were available for trawl fisheries or trawl surveys.

5.3 Dr Jones further noted that benthic by-catch data from research trawls can be reported via CM 22-06, Annex 22-06/B. He indicated that it was a matter of expert judgement as to whether scientists chose to report such research survey by-catch data.

5.4 Dr Belchier reported on a meeting that he had attended on behalf of CCAMLR (paragraph 10.11). He noted that CCAMLR was linked into a wide network of VME groups and that some RFMOs have now adopted measures similar to those developed by CCAMLR.

### Marine protected areas

#### Domain 1 the Western Antarctic Peninsula and South Scotia Arc

5.5 The Scientific Committee noted that a number of national and international planning workshops had taken place during the intersessional period. In particular, these included a domestic workshop to identify US stakeholders' objectives and protection priorities for one or more MPAs within Domain 1 and the Second International Workshop for identifying MPAs in Planning Domain 1 held in Buenos Aires, Argentina, and attended by representatives from Argentina, Chile, EU, Germany, Norway, UK, USA, non-governmental organisations and the fishery industry (Annex 6, paragraphs 3.1 to 3.15). New and updated data are now available for Domain 1 and have been shared through a CCAMLR e-group following national activities and analyses by Argentina, Chile, USA and UK which aimed to (i) compile new data, (ii) discuss different conservation objectives, (iii) analyse penguins' habitat modelling, and (iv) identify high-priority areas for conservation within Domain 1 (Annex 6, paragraph 3.10).

5.6 The Scientific Committee noted suggestions during WG-EMM-15 concerning the consideration of CEMP sites as part of the MPA planning process in relation to future work towards refining stage 2 or moving to stage 2 of FBM, through potentially closing or limiting krill fishing near selected CEMP sites (Annex 6, paragraph 3.19).

5.7 Dr M. Santos (Argentina) reported that ongoing work was under way to further update data layers, using the e-group for Members' consideration. She indicated that Argentina and Chile hope to prepare further MPA planning documents (background papers) for Domain 1 for consideration at WG-EMM-16 and an MPA proposal for WG-EMM-17.

#### Domains 3 and 4 the Weddell Sea

5.8 The Scientific Committee noted the discussions during WG-EMM-15 relating to the ongoing MPA planning work within the Weddell Sea Planning Region (Annex 6, paragraphs 3.24 to 3.54). It noted that revised versions of the documents describing the ongoing work (WG-EMM-15/38 Rev. 1, 15/39 and 15/46) had also been submitted to the Scientific Committee (SC-CAMLR-XXXIV/BG/15, BG/16 and BG/17) and that these documents described how scientific issues raised during WG-EMM-15 were being addressed. The Scientific Committee also noted SC-CAMLR-XXXIV/13 which provides an introduction to the other three documents and describes the history of Weddell Sea planning documents previously submitted to SC-CAMLR and WG-EMM.

5.9 SC-CAMLR-XXXIV/BG/15 provided background information on the Weddell Sea MPA Planning Region and the general context for the establishment of MPAs in the region; it was developed by 50 authors from 10 Members. The paper provided a comprehensive description of the Weddell Sea ecosystem with suggestions for future work to fill current knowledge gaps. The document included new chapters on fish, biogeography and climate change scenarios. SC-CAMLR-XXXIV/BG/16 provided a description of the spatial data available and how they have been used, including newly available data from the UK and the USA on Adélie penguin movements during the non-breeding season. SC-CAMLR-XXXIV/BG/17 included a series of general and specific conservation objectives based on CM 91-04; it also described MPA scenario development and data analysis methods.

SC-CAMLR-XXXIV/BG/17 also presented a preliminary cost layer based on potential toothfish fishery areas and identified a number of priority candidate areas for protection.

5.10 Prof. T. Brey (Germany) outlined a number of topics where additional work is still needed, including further work on: flying seabirds, Adélie penguins, development of a toothfish habitat model and demersal and pelagic fish community analyses. He also reported on Germany's intention to include a cost layer based on potential krill fishery areas. Prof. Brey highlighted the need to analyse the boundary region on the border between CCAMLR Domains 1 and 3 (Annex 6, paragraphs 3.55 to 3.59).

5.11 The Scientific Committee thanked Prof. Brey and his co-workers for their comprehensive summary of the ecosystem components that comprise the Weddell Sea. It recognised that the body of work described in the four documents (SC-CAMLR-XXXIV/13, BG/15, BG/16 and BG/17) constituted a very considerable resource that would facilitate MPA planning within the region. It endorsed plans to further develop both the data and the analysis methods, recognising that the body of science in the documents provided the necessary foundation for developing future proposals for candidate MPAs.

5.12 The Scientific Committee agreed that the work described in SC-CAMLR-XXXIV/13, BG/15, BG/16 and BG/17 constituted reference material for the Weddell Sea planning domain and could be placed on the CCAMLR website following the procedure set out in SC-CAMLR-XXXIV/01 and endorsed by the Scientific Committee (paragraphs 16.1 to 16.4).

5.13 The Scientific Committee congratulated Prof. Brey and his co-workers for the clear and transparent communication of their work, noting that the body of research would be valuable for other aspects of CCAMLR's work, in addition to MPA planning.

5.14 The Scientific Committee noted that the description of the MARXAN analyses and the strategy used would help in the identification of which objectives determined the selection of candidate protection areas. It also noted that the strategy used for assessing the suite of conservation objectives could help in building a common standard that could facilitate progress in identifying MPAs in other areas of the Antarctic.

5.15 The Scientific Committee encouraged Prof. Brey and his co-workers to develop a full MPA proposal, in accordance with CM 91-04, focusing on its objectives, management plan and research and monitoring plan, recognising that a large amount of data had now been collated.

5.16 Mr L. Yang (China) congratulated Prof. Brey and his co-workers for providing a comprehensive analysis and encouraged Prof. Brey to develop criteria to assess the conservation objectives under Article XV.2(a) of the Convention.

5.17 Dr Kasatkina introduced SC-CAMLR-XXXIV/08. She noted that analysis of ice conditions in the Weddell Sea undertaken for 2003–2014 revealed that navigating conditions in the Weddell Sea are entirely determined by the location and dynamics of the Atlantic ice massif, and by the development of recurring polynyas. Sites identified in the analysis where, under specific conditions, a protection regime could be introduced, are located at the coordinates given in Table 2 of SC-CAMLR-XXXIV/08. Areas in the eastern part of the Weddell Sea could be considered as areas of high scientific interest. Near the continental coast, there are areas that become free of ice much earlier than does the entire massif, and close much later, which means that these areas could be considered as candidate sites for protection. These areas have depths of up to 500 m.

5.18 In consideration of ice dynamics in the Weddell Sea, Prof. K. Kovacs (Norway) and Dr Trathan emphasised that other potentially ice-covered areas were also worthy of protection, as sea-ice provides important habitat for many species and helps structure ecological communities across many trophic levels.

5.19 Dr Belyaev introduced SC-CAMLR-XXXIV/09. He highlighted that 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*; Antarctic rockcod (*Trematomus eulepidotus*). Potentially commercial species, after further study, could be fish 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. Dr Belyaev noted that data on the state of toothfish as an important component of the ecosystem were currently not available. Such data firstly can be obtained through research fishing, which Russia considers should be undertaken in the Weddell Sea and results included in the MPA planning analysis.

5.20 In response, Prof. Brey invited all Members that hold data related to fish, including on commercial species, to help develop integrated analyses of these taxa so that they could be used in MPA development. Prof. Brey noted that Germany holds data on fish collected over 20 years and invited Dr Belyaev to contribute any relevant data held in Russian archives.

5.21 Drs Kasatkina and Belyaev noted the improvements in the proposal for an MPA in the Weddell Sea. However, they considered that some issues remain, in particular in relation to the research and monitoring plan. They expressed the following concerns:

(i) 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. Analyses undertaken on seasonal and interannual dynamics of ice conditions in the Weddell Sea give some grounds for doubt in relation to an MPA in the Weddell Sea (SC-CAMLR-XXXIV/08).

(ii) Available data on biodiversity in candidate areas to be afforded protection have revealed that there are some fish resources that should be rationally exploited (SC-CAMLR-XXXIV/09).

5.22 Drs Kasatkina and Belyaev noted that Germany's proposal for the establishment of an MPA in the Weddell Sea will be complemented by the materials analysed and the suggestions made here relating to the unanswered questions of biodiversity and the MPAs in terms of annual navigational access to the areas identified for possible protection. They further stated that at this time Russia was therefore not able to support Germany's draft proposal to establish a Weddell Sea MPA.

5.23 Ms J. Hepp, on behalf of ASOC, thanked the proponents of MPA plans in Domains 1 and 3 and encouraged their further work. In particular, she expressed her thanks to the organisers of those planning workshops where non-governmental organisation representatives had been invited, noting the value of such open and transparent engagement. She further noted that in ASOC's view this work constituted a significant step forward in the development of the representative system of MPAs through the best available science.

### Approaches to MPA planning in the boundary region between Domains 1 and 3

5.24 The Scientific Committee noted the discussion at WG-EMM-15 related to the boundary region between Domains 1 and 3 (Annex 6, paragraphs 3.55 to 3.59). It noted that the tip of the Antarctic Peninsula was an area of considerable ecological importance. The Scientific Committee encouraged independent analyses for this boundary region, with reports tabled to the next meeting of WG-EMM-16 (Annex 6, paragraph 3.58).

5.25 The Scientific Committee noted that similar issues may arise for other planning domains, particularly if the boundary region includes a high concentration of features likely to be prioritised as important for achieving conservation objectives. Future MPA planning analyses could consider including a buffer across appropriate boundary areas, if required (Annex 6, paragraph 3.59).

### Domain 8 the Ross Sea

5.26 SC-CAMLR-XXXIV/BG/31 presented an analysis of sea-ice over the past 16 years within and surrounding the boundaries of the proposed Ross Sea SRZ. This analysis highlighted the potential effect of sea-ice on achieving the objectives of the proposed SRZ. The paper included links to animations that represent good, marginal and poor access to the SRZ in years with different ice conditions.

5.27 The influence of sea-ice on achieving the proposed objectives of the SRZ pertains to the deployment and subsequent recovery of tagged fish to examine movements and estimate exploitation rates within the SRZ. Over the past 16 seasons, the SRZ was accessible to fishing in January in eight seasons, open later in four seasons, and remained severely constrained by sea-ice in the remaining four seasons. Even in years where access was poor, some catch was able to be taken.

### Archiving of background information and data layers used in MPA planning processes

5.28 The Scientific Committee noted discussions at WG-EMM-15 concerning the archiving of background information and data layers used in MPA planning processes (Annex 6, paragraphs 3.60 to 3.70). In particular, it noted the importance of making information and data available to all Members through the CCAMLR website; for example, information could be made available in a hierarchical structure where access to some pages would be restricted to Members only:

(i) information on the status of MPAs and general background (public)

(ii) background information and MPA planning documents submitted to CCAMLR meetings (password-protected)

(iii) working information for MPA planning in progress (password-protected, e.g. e-groups).

5.29 The Scientific Committee noted that finding this information from the CCAMLR home page needed to be straightforward and intuitive (Annex 6, paragraph 3.63).

5.30 The Scientific Committee therefore endorsed the following general recommendations (Annex 6, paragraph 3.68) for archiving data related to MPA planning:

(i) data layers used in MPA analyses should be made available for review and use by all Members as far as possible

(ii) multiple updates to different data layers during the MPA planning process will make it critical to have accurate and standardised metadata, and control over use of the most recent version

(iii) metadata records for all data layers should provide information on where the data reside, how to access them, and how to initiate discussions with data owners

(iv) such metadata records could also be included in papers describing analyses in which these data are used

(v) issues of data ownership and access may make it necessary to restrict access to some datasets

(vi) CCAMLR data access rules may need to be revisited to ensure that they provide sufficient protection for unpublished data

(vii) several data portal initiatives (e.g. SOOS, SCAR Biogeographic Atlas, Pangaea) are now assembling datasets. Some Members may choose to make their datasets available elsewhere (see e.g. Annex 6, paragraph 3.30), but it is important that all portals point to the same metadata.

## IUU fishing in the Convention Area

6.1 The Scientific Committee noted previous discussions outlining how IUU fishing affects its ability to provide scientific advice. Because IUU catches and the size- or age-compositions of those catches are often uncertain or unknown, IUU fishing increases uncertainty in estimates of unfished SSB and current stock status. The Scientific Committee continues to be unable to assess stock status in cases where IUU fishing during the 1990s is known to have been extensive, and recent IUU fishing in Subarea 48.6 and Division 58.4.1 may require that the provision of management advice using an estimate of current biomass and a precautionary exploitation rate rather than application of CCAMLR's typical decision rules (Annex 7, paragraphs 5.25 to 5.30).

6.2 The Scientific Committee noted the increased attention given to the issue of IUU fishing during the 2015 fishing season, reviewed CCAMLR-XXXIV/37 and BG/18, and advised SCIC of its consideration of IUU fishing.

6.3 Members thanked the Secretariat for preparing CCAMLR-XXXIV/37, which, inter alia, provided a map of the locations where IUU vessels or IUU fishing gear were sighted and reported pursuant to CMs 10-02, Annex 10-02/A and 10-07, paragraph 6, during 2014/15. The map, when compared to maps of activities from previous fishing seasons, suggests that IUU vessels operate in similar locations from year to year. The map could be enhanced and provide an improved picture of the spatial extent of IUU fishing by including additional information, such as from data from an automatic identification system (AIS).

6.4 It was agreed that CCAMLR-XXXIV/37 should form the basis for development and production of a more thorough 'IUU Report', like the Fishery Reports, that could be updated annually. An IUU Report should:

(i) outline the history of IUU fishing by subarea and division

(ii) provide area-specific detail on the types of gear used by the IUU fishery

(iii) tabulate, where available, estimates of IUU catch and the composition of those catches

(iv) summarise available knowledge about the traffic or trade of IUU fish.

6.5 It was also agreed that area-specific information in an IUU Report should be copied into relevant Fishery Reports so that stock assessment results etc. are presented in association with information on IUU activities. The Scientific Committee requested the Secretariat to draft an IUU Report for its consideration in 2016.

6.6 COLTO introduced CCAMLR-XXXIV/BG/12, which provides estimates of IUU toothfish catches taken during 2014/15. The combined collaborative efforts of industry, conservation groups, nation states and international agencies during 2014/15 provided much improved information on IUU catch rates and estimates of IUU catches for possible use by the Scientific Committee and consideration by the Commission. COLTO noted that the estimated IUU catches did not include 'ghost fishing' by lost or derelict gillnets, the type of gear currently being used by IUU fishers. However, to ensure that catch estimates provided in the paper were precautionary or conservative, COLTO attributed significant additional catch to two vessels from which direct unloading had not been observed. COLTO estimated that IUU vessels achieve catch rates of about 3–5 tonnes per day, and the total estimated IUU catch of between 1 264 and 1 500 tonnes (live weight) during 2014/15 comprised:

(i) 560 tonnes from the *Perlon* (as validated upon arrest)

(ii) 300 tonnes from the *Kunlun* (as validated upon arrest), including fish transhipped from the *Songhua* and *Yongding*

(iii) 50 tonnes from gillnets set by the *Thunder* and retrieved by Sea Shepherd

(iv) 84 to 140 tonnes estimated from the amount of time the *Thunder* fished prior to its pursuit by Sea Shepherd

(v) 270 to 450 tonnes estimated as 'extra IUU catch' taken by the *Songhua* and *Yongding* following transhipment to the *Kunlun*.

6.7 The Scientific Committee thanked COLTO, and its partners that had provided information and data to COLTO, for producing the IUU catch estimates presented in CCAMLR-XXXIV/BG/12 and welcomed continued work to produce such estimates in the future.

6.8 The Scientific Committee also noted that information presented in CCAMLR-XXXIV/BG/18 independently indicated that IUU vessels fishing with gillnets may achieve catch rates of around 3 to 5 tonnes per day.

6.9 Recognising that there may be future opportunities to collect information and data like that used by COLTO, the Scientific Committee requested the Secretariat to produce a form (or forms) that would be useful for recording data (e.g. specifications of recovered gear, the species and size compositions of observed IUU catches, etc.) that could be used to estimate IUU catches and the compositions of these catches. The form(s) should then be posted on the CCAMLR website and, as far as possible, distributed to governments and organisations whose representatives might come into contact with IUU vessels (e.g. those conducting enforcement and compliance activities).

## CCAMLR Scheme of International Scientific Observation

7.1 The Scientific Committee considered the by-catch paper discussed by WG-FSA (WG-FSA-15/04 Rev. 1) and the advice given (Annex 7, paragraphs 8.2, 8.3, 8.6 and 8.8.) which was endorsed.

7.2 The Scientific Committee recalled discussions under Item 3.3 (paragraphs 3.161 to 3.166) and considered the option of including a section in the observer's report outlining the methods used by the vessel to record its by-catch. However, it was emphasised that ultimately the Flag State is responsible for by-catch reporting.

7.3 The Scientific Committee considered advice contained in the reports of WG-EMM-15 (Annex 6, paragraphs 2.28 to 2.43) and WG-FSA-15 (Annex 7, paragraphs 7.1 to 7.6).

### Krill observer coverage

7.4 The Scientific Committee recalled the discussions at the Scientific Committee in 2014 that there was general acknowledgement that 100% coverage (i.e. having an observer on a vessel for all of the time that it was engaged in fishing for krill) was scientifically desirable (SC-CAMLR-XXXIII, paragraph 7.16).

7.5 The Scientific Committee noted that in fisheries where 100% observer coverage was not mandatory, there was not an agreed standard metric to describe the actual level of observer coverage (Annex 6, paragraph 2.34) and that such a metric be developed by WG-EMM in collaboration with WG-SAM.

7.6 Dr Arata referred to analysis that had been carried out on the amount of data collected by scientific observers and cross-referenced it with CM 51-06 (WG-EMM-15/57 Rev. 1) and reflected that, under current application of CM 51-06, there are gaps in the collection of fishery-related data such as by-catch in all subareas and seasons where fishing occurred.

7.7 Dr Zhao indicated that the requirement of 50% observer coverage is referring to vessel coverage as stated in CM 51-06. He also drew the attention of the Scientific Committee to paragraph 6 of CM 51-06.

7.8 Dr Zhao requested that an erratum in relation to the incorrect account in paragraph 2.37 in the WG-EMM-15 report (Annex 6) be attached to the report.

7.9 The Scientific Committee agreed that the Secretariat provide a review of the information to the Scientific Committee on fulfilment of CM 51-06 by the vessels.

7.10 There was extensive discussion on the desired level of observer coverage in the krill fishery. Dr Demianenko reviewed CCAMLR-XXXIV/BG/34 which it argued in favour of 100% coverage as this would reduce the problem of the lack of scientific data for scientists. Some Members also considered that 100% coverage would reduce any confusion with regard to the application of CM 51-06.

7.11 Dr Darby noted that it was surprising that some CCAMLR Members interpreted 50% coverage as:

(i) observing a vessel one year but not the next, or
(ii) observing one vessel but not a second within a year

and that this would be considered adequate scientific coverage of their vessels. Given the differences in vessel fishing gear type, selectivity and locations of fishing, 100% coverage would be desirable for CCAMLR management. He noted 50% coverage of each vessel within the year should be achieved and this should be considered by WG-SAM and WG-EMM during their reviews of CMs 51-06 and 51-07 in 2016.

7.12 Dr Ichii drew the attention of the Scientific Committee to research by Japan, submitted in two papers to WG-EMM-12 (WG-EMM-12/67 and 12/68), which had shown that 50% coverage was suitable for understanding spatial and temporal variation in krill length and additional coverage was not necessary. It was also highlighted that the by-catch of fish larvae differs in numbers so much amongst vessels that it is more important to improve the quality of observer data than the level of observer coverage.

7.13 Dr Constable demonstrated the need for observer data through highlighting a number of papers where analysis of these data had either been the basis for the paper or had been an important component of the analysis. These included papers on catch composition and fishery selectivity for stock assessments, fishery-based surveys of krill using acoustics and length data and fishery-based surveys and other data on krill for indicators in FBM (WG-EMM-15/04, 15/10, 15/11, 15/16, 15/33, 15/36, 15/51 Rev. 1, 15/55 Rev. 1, 15/56, 15/57 Rev. 1; Annex 4).

7.14 Some Members noted that when considering observer coverage the key issues to consider are:

(i) spatial and temporal variability in krill being targeted by the fishery
(ii) spatial and temporal variability in by-catch.

7.15 Some Members noted the fact that without 100% observer coverage it will be necessary to develop models that extrapolate from known data to the other vessels as the absence of data cannot automatically mean the absence of by-catch. To do this effectively will involve knowing the operational variables of vessels and the Commission will need to validate the data being provided. The data are needed now for stock assessment purposes as experience from toothfish fisheries shows that starting data collection later does not enable assessments of stock trajectory.

7.16 Dr Watters stressed that the percentage of observer coverage in the krill fishery needs to be related to the purpose to which the data will be used and 50% coverage may not be applicable in all cases and may not give the spatial and temporal coverage required. Issues such as accurate green weight estimation will also need to be considered as this can also be assisted by observer coverage.

7.17 Dr Godø supported this and added that there were tasks under FBM that cannot be managed by the vessel alone and that they will need an observer to do the tasks necessary to support FBM.

7.18 Dr Kasatkina proposed to undertake statistical analysis of catch data to analyse the variability of catch indices (krill length composition and by-catch) in the different areas the fleet operates in, both for individual vessels and between vessels. This statistical analysis would provide the possibility of investigating any variability in these indices in relation to different levels of observer coverage.

7.19 Dr Zhao presented SC-CAMLR-XXXIV/BG/28 which outlined the Chinese national observer program. For the six years in the krill fishery, eight training courses were held and 67% to 100%, with a mean of 80%, annual observer vessel coverage was achieved.

7.20 The Scientific Committee agreed that there was a need to increase the observer sampling frequency for fish by-catch and that improving the sampling capability should be accompanied by increased training in the collection of data and in the identification of fish to family level.

7.21 The Scientific Committee agreed that the routine data quality report sent to the data providers by the Secretariat when observer data was received could be used to identify a number of issues as a metric to measure improvements in observer data quality (Annex 6, paragraph 2.42).

7.22 Given the increase in the amount of krill observer data, the Scientific Committee agreed to the need for establishing a working group focused on SISO to review and recommend sampling schemes and levels of coverage for finfish by-catch, address data quality issues and clarify the objectives of the observer data collection. The Scientific Committee also agreed that this group coordinates with WG-FSA to determine coverage for finfish by-catch, and with WG-EMM for data collection required for FBM (Annex 6, paragraph 2.43).

New ID guide and observer training material

7.23 WG-EMM noted the development of a new photographic guide to fish by-catch in krill catches and further noted that a series of guides has been developed by various Members and that there is a need to coordinate these developments.

7.24 WG-FSA requested the Secretariat to host a repository for identification guides and the development of a simplified guide to the most frequent by-catch species through a moderated open e-group (Annex 7, paragraph 7.3).

7.25 WG-FSA considered a tool for training observers at sea in seabird species identification developed by Mr N. Gasco (France), noting that this tool could be easily expanded to include general observer tasks and has the potential to become a very useful training and debriefing tool.

7.26 The Scientific Committee thanked Mr Gasco for his hard work in developing the training tool and encouraged its further development. It requested the Secretariat work with Mr Gasco in the intersessional period to progress developing this tool suitable for use by observers across the Convention Area.

7.27 The Scientific Committee endorsed the recommendations in Annex 7, paragraphs 7.3 and 7.5.

COTPAS

7.28 There was a brief discussion of SC-CAMLR-XXXIV/BG/23 which presented the findings of the Technical Peer Review Group (TPRG) on the submission of the Australian observer program for COTPAS accreditation. The Scientific Committee noted that the use of the Australian observer program as a test case had enabled the process of accreditation to be developed and that the Australian observer program is now ready for the final stage of assessment by the Accredited Review Panel (ARP).

7.29 France, New Zealand and South Africa indicated their intention to submit their observer programs to COTPAS.

7.30 Australia requested that the development of the ARP be progressed and that observer programs be reviewed as and when they pass the TPRG rather than waiting for a number of observer programs to progress to the stage of review.

7.31 The Scientific Committee recommended that the ARP be established and that the Australian observer program should be assessed as soon as practical.

## Climate change

8.1 Dr Kawaguchi introduced the work of WG-EMM related to climate change. He noted that one-third of all papers submitted to WG-EMM made reference to climate change. Eleven paragraphs of the Working Group report also made reference to climate change.

8.2 The Scientific Committee endorsed the advice of WG-EMM (Annex 6, paragraph 5.15) that it is vital to bring climate change considerations into its work now to ensure that scientific studies are designed and time series are built on which long-term analyses can be run and serve as the scientific basis for implementation in CCAMLR management approaches, including FBM for krill. It updated the recommendations of WG-EMM and agreed that attention is needed on the following:

(i) building long time series that enable disentangling of trends arising from climate change from natural variability, or changes in variability that may also arise from climate change

(ii) designing scientific studies that can predict or uncover changes in ecosystem function at an early stage, for example, the salp–krill interaction (Annex 6, paragraphs 2.77 and 2.78)

(iii) developing management approaches that work in a changing climate, for example, using models to help develop decision rules and management strategies that can effectively respond to the challenges of climate change.

8.3 The Scientific Committee noted that activities in the Southern Ocean Observing System (SOOS) and Integrating Climate and Ecosystem Dynamics in the Southern Ocean (ICED) may contribute to this work, including:

(i) the development of essential variables by SOOS to monitor dynamics and change in the ecosystem, which would help provide context to CEMP

(ii) the 2018 International Conference on Assessing Status and Trends of Habitats, Key Species and Ecosystems in the Southern Ocean (SC-CAMLR-XXXIV/BG/22)

(iii) the design processes occurring in SOOS and ICED to determine spatial and temporal sampling required to measure variability and change due to climate change.

The Scientific Committee encouraged cross-linkages between the CCAMLR scientific community with SOOS and ICED to help develop this work.

8.4 Prof. P. Koubbi (France) drew the attention of the Scientific Committee to the Southern Ocean Continuous Plankton Recorder (SO-CPR) Survey operated by SCAR, as part of the Global Alliance of CPR Surveys. The SO-CPR is a very valuable activity for measuring change in pelagic systems. While it is operated in many parts of the Southern Ocean, there are still gaps in coverage. The Scientific Committee encouraged Members to become involved in the SO-CPR.

8.5 Dr Trathan introduced a proposal to the Commission for a resolution concerning climate change implication statements (CCAMLR-XXXIV/08). The resolution urges all Members to include, where practicable, statements about the implications of a changing climate. The statement should include the nature and implication of any potential impacts identified, and advise on the steps that should be taken to address any issues arising, including adaptive management, or state that there are no impacts. He highlighted the need for regularly compiling information on climate change to help the Scientific Committee and the Commission to do their work.

8.6 The Scientific Committee noted that the compilations recommended in CCAMLR-XXXIV/08 would be helpful to its work. It also noted that the experience in the Arctic could also help in developing approaches to climate change in the CCAMLR area. It suggested that the Steering Committee of the Joint CEP–SC-CAMLR Workshop might consider inviting an expert on Arctic science to participate in considering what might be done on climate change in Antarctica.

8.7 Dr Zhao suggested that the actual type of data in relation to climate change, instead of a statement, be specified and standard methodologies for analysing and reporting changes be developed, and data analysed, by one of the working groups of the Scientific Committee.

8.8 Dr Trathan introduced CCAMLR-XXXIV/BG/01, which is a compendium of patterns of change in Antarctica; the graphic attached to the paper shows, at a glance, the patterns and magnitudes of change in the climate of Antarctica and the Southern Ocean over recent decades. This was submitted to the Antarctic Treaty Consultative Meeting this year and the UK considered that this graphic would also be of interest to CCAMLR.

8.9 Dr Trathan also introduced SC-CAMLR-XXXIV/BG/34 which describes how Antarctic sea-ice losses may drive gains in benthic carbon drawdown. Prof. Kovacs noted that the conclusions of SC-CAMLR-XXXIV/BG/34 contradict those findings in the Arctic and suggested the consideration of Arctic and Antarctic processes to determine what the underlying mechanisms and processes might be.

8.10 The Scientific Committee noted that it would be desirable to share the data used to derive SC-CAMLR-XXXIV/BG/34.

8.11 Prof. Koubbi indicated that the climate change processes are not only concentrated in surface waters but also concerned deep-sea ecosystems where the changes are predicted to be important.

8.12 Dr Constable drew the attention of the Scientific Committee to the active preparation underway for a 2018 International Conference on Assessing Status and Trends of Habitats, Key Species and Ecosystems in the Southern Ocean, Hobart, Tasmania, Australia (SC-CAMLR-XXXIV/BG/22). This conference will be important to the work of the Scientific Committee on assessing the effects of climate change and for further developing the science programs needed for measuring and taking account of climate change impacts in the future.

8.13 SC-CAMLR-XXXIV/BG/29 identified the importance of strengthening the joint work of the CEP and SC-CAMLR on climate change (see also paragraph 10.11). The paper detailed a number of recommendations for the upcoming Joint CEP–SC-CAMLR Workshop on climate change. ASOC looked forward to attending the workshop and added that it is very supportive of the proposal from Norway and the UK to include within papers and proposals submitted to this meeting, its working groups and the Commission, a statement about the implications of a changing climate, where relevant.

8.14 Dr S. Grant (UK) presented CCAMLR-XXXIV/21 on special areas for scientific study in newly exposed marine areas following ice-shelf retreat or collapse. She noted that 87% of glaciers on the Antarctic Peninsula have retreated in recent decades and that further ice-shelf collapses are predicted to occur. She outlined the scientific rationale of a proposed conservation measure to allow 10 years of scientific study following the collapse of an ice shelf.

8.15 Dr Barrera-Oro noted that this is a useful proposal and that the experience with the 600 m recession of the glacier at Potter Cove (King George/25 de Mayo Island, South Shetland Islands) over 25 years allowed the study of the expansion and colonisation of species. This process is under study by a cooperative research program between Argentina and Germany operating since the early 1990s. The literature produced by the project might provide background information for the proposal of the conservation measure being discussed.

8.16 Prof. Brey noted that the results of this project showed that these changes can occur rapidly and that studies of the consequences may need to extend over more than 10 years.

8.17 Dr Watters indicated the need to indicate the time period to which the rate of retreat applies. Dr Grant confirmed that the rate of retreat would be 10% by area over 10 years.

8.18 Mr Yang expressed in-principle support for this proposal. He further noted that research and monitoring in climate change and its impact on ice and ecosystems is of scientific importance and gains more and more attention from CCAMLR Members. The design of this special area of scientific study is proportionate in terms of time-scale and management to the scientific research time window, in accordance with Article IX.2(g) of the Convention. He asked whether there was an expectation for all areas to be included in the measure, or if there were specific candidate sites for consideration. He also indicated that a research and monitoring plan may be useful if established early.

8.19 Dr V. Siegel (EU) noted that this proposal is not for MPAs but for special science areas and, therefore, would not require research and monitoring plans in the form expected for MPAs.

8.20 Dr D. Freeman (New Zealand) indicated support for the proposal, noting that the designation of areas exposed by the retreat of ice shelves, glaciers and ice tongues as special areas for scientific study, will provide important opportunities for research and monitoring relating to climate change effects and also for enhancing our knowledge of Antarctic marine biodiversity and geological processes.

8.21 Mr J. Morishita (Japan) noted that this proposal addresses interesting and scientifically important phenomena. He encouraged development of a well-coordinated and systematic approach for enhancing the scientific research. In terms of the conservation and management measures proposed, a number of issues will need to be addressed, including:

(i) specifying how and when the 10-year moratorium period would commence with respect to a baseline date and where it would cover in terms of area (i.e. ice extent from which the rate of retreat is to be estimated)

(ii) establishing a process by which fluctuations in ice coverage are differentiated from long-term retreat and collapse

(iii) considering whether separate conservation measures in addition to the proposed general conservation measure may be needed for introducing an individual moratorium for a specific area and time.

8.22 Dr Trathan, on behalf of the EU, thanked Members for the valuable dialogue and proposed that the Scientific Committee forward these comments to the Commission to help inform its discussion of CCAMLR-XXXIV/21. He added that the EU was happy to engage in further discussions to help ensure that the proposed measure achieved the support of the full Commission.

## Scientific research exemption

9.1 Dr Arata reported that Chile will conduct a 23-day random stratified survey in Subareas 48.2 (South Orkney Islands) and 48.1 (South Shetland Islands/Antarctic Peninsula) in January/February 2016. The survey will target benthopelagic fish by using a semipelagic trawl towed close to the bottom. The vessel used will be the commercial trawler *Cabo de Hornos*.

9.2 Australia informed the Scientific Committee that it is undertaking a pelagic fish and euphausiid survey on the Kerguelen axis (from the Antarctic continent to the north across BANZARE Bank) during the 2015/16 austral summer. The survey will be coordinated with activities by France and Japan also occurring in the region.

9.3 Australia announced that it will conduct a demersal fish survey around Heard Island and McDonald Islands in May 2016.

## Cooperation with other organisations

### Cooperation with the Antarctic Treaty System

#### CEP

10.1 The CEP Observer to SC-CAMLR (Dr P. Penhale) reported on topics of mutual interest that were discussed during the 18th Meeting of the CEP, held in Sofia, Bulgaria (1 to 5 June 2015; SC-CAMLR-XXXIV/BG/14). She informed the Scientific Committee that the CEP has developed an Antarctic Environments Portal (www.environments.aq) which presents summarised information in a format aimed at policy makers with an interest in Antarctic science. Also discussed was the planning for the Joint CEP–SC-CAMLR Workshop, which had been endorsed during SC-CAMLR-XXXIII. The agreed general scope of the workshop is to identify the effects of climate change that are considered most likely to impact the conservation of the Antarctic, and to identify existing and potential sources of research and monitoring data relevant to the CEP and SC-CAMLR. The CEP endorsed holding the meeting in 2016 just prior to the 2016 ATCM/CEP meeting in Chile and agreed to the proposed terms of reference.

10.2 Drs Penhale and Grant, as Co-conveners of the Joint CEP–SC-CAMLR Workshop, confirmed that the meeting would be held in Punta Arenas, Chile, on 19 and 20 May 2016. They thanked Chile for its offer to host the meeting, and encouraged Members of the Scientific Committee to participate.

10.3 Drs Grant and Constable, on behalf of the UK and Australia, welcomed the development of the Antarctic Environments Portal and joint workshop. Dr Constable suggested that the participants at the joint workshop be extended beyond CCAMLR Members to groups that may also provide useful contributions such as SCAR, SOOS and ICED, as well as a possible Arctic expert (paragraph 8.6).

10.4 ASOC strongly supported the decision to hold the second joint workshop between the CEP and SC-CAMLR on climate change:

> 'We believe the workshop is a critical opportunity to coordinate work and share learning and experience between the two bodies on this extremely important issue. It is also a chance to consider mechanisms to ensure that the vast amount of scientific information related to climate change such as that contained in the SCAR ACCE summary updates, the Antarctic Environments Portal and other sources are available and applied to support decision making, how to identify and manage areas of conservation importance on the basis of their resilience to climate change, and a chance to consider joint responses to major climate change events such as ice-shelf collapse. We hope that there will be clear outcomes including a detailed work plan building upon the CEP's Climate Change Response Work Programme ensuring that scientific advice relevant to climate change impacts can be incorporated into the decision-making processes. ASOC looks forward to these outcomes and others as detailed in our background paper 29 to this meeting and to participating in the workshop.'

### SCAR

10.5 Prof. M. Hindell (SCAR Observer) presented the annual report of SCAR activities of interest to CCAMLR (SC-CAMLR-XXXIV/BG/18 Rev. 1). In particular, he noted that:

(i) SCAR would engage with the CCAMLR Science Manager to produce an annual background paper summarising relevant SCAR research in a CCAMLR context

(ii) SCAR would contribute to the travel costs of one individual attending one working group meeting each year, for an expert observer that SC-CAMLR had identified that could provide a valuable contribution

(iii) a joint CCAMLR/SCAR paper would be prepared for ATCM summarising the advances in the CCAMLR/SCAR interaction

(iv) several existing synergies are already present between SCAR and CCAMLR, such SOOS, Antarctic Climate Change and the Environment Advisory Group (ACCE) and the Antarctic and Southern Ocean Science Horizon Scan.

10.6 The Scientific Committee congratulated SCAR on the summary, agreed that SCAR collaboration is very beneficial and endorsed the recommendations from the report. Dr Welsford noted that the development of an annual paper between SCAR and the Science Manager should also involve the Scientific Committee Chair. The Scientific Committee noted that SCAR experts could possibly contribute to the work of the Scientific Committee through an expanded e-group process, submissions of unaccompanied papers to working group meetings and *CCAMLR Science*. Whether SCAR experts could attend working group meetings would need to be considered in conjunction with the policy of attendance at those meetings.

## Reports of observers from other international organisations

### COLTO

10.7 COLTO presented a paper (SC-CAMLR-XXXIV/BG/20) on the COLTO and Science Workshop, held in Norway, 25 and 26 July 2015, immediately prior to the WG-SAM-15 meeting. There were 54 participants, of which 38 were COLTO members and 16 scientists. The outputs had been highly successful, and particularly the formation of three working groups of relevance to CCAMLR – WG-Depredation; WG-Science Collaboration; and WG-Education and Marketing. WG-Depredation has established a workshop on depredation, including whale behaviour and fisher behaviour, to be held in Punta Arenas, Chile, from 16 to 18 March 2016. Relevant experts from CCAMLR and other international organisations will be invited to participate and the results will be provided to CCAMLR. WG-Education and Marketing is preparing clear, scientifically based information for use in publicity and education on toothfish fisheries, globally, with input and assistance from scientists. WG-Science Collaboration is developing a trial of oceanographic data collection from several COLTO toothfish longline vessels in 2015/16, for use by CCAMLR and other scientists. If the trial is successful, the intention would be to broaden the oceanographic data collection, and link with organisations such as SOOS and other CCAMLR groups. COLTO thanked Drs Darby, Currey and Welsford for their support and assistance to create the meeting.

10.8 Dr Currey, on behalf of New Zealand, noted that the workshop highlighted the benefits of collaboration with on-water operators. Both depredation and scientific collaboration were very important to CCAMLR, with depredation issues presented at several working group meetings this year.

10.9 COLTO announced the winners of the tag lottery for 2014/15, which had been randomly drawn by the Secretariat from tag returns in new and exploratory fisheries:

- 1st prize: A$400 to *Antarctic Chieftain* (Australia), tag recaptured on 17 January 2015; fish released 16 January 2014 in Subarea 88.2 and had moved only 2.25 km

- 2nd prize: A$350 to *Hong Jin No. 701* (Republic of Korea), tag recaptured on 29 January 2015; fish released on 1 January 2012 in Subarea 88.1 and had moved 11.17 km

- 3rd prize: A$250 to *Argos Froyanes* (UK), tag recaptured on 6 December 2014, fish released on 17 December 2013 in Subarea 88.1 and had moved only 2.07 km.

10.10 COLTO reiterated its support for the tagging program in CCAMLR fisheries, thanked the crews of vessels for their efforts in the tag and release programs, and congratulated the winners. The Scientific Committee thanked COLTO for its continued support of the tagging program and its positive engagement in the work of the Scientific Committee.

### FAO

10.11 The Scientific Committee noted the update on the Areas Beyond National Jurisdiction (ABNJ) Deep-Seas Project which had been submitted jointly by the FAO and CCAMLR Secretariats (SC-CAMLR-XXXIV/BG/25). This project is part of a global initiative to achieve efficient and sustainable management of fisheries resources and biodiversity conservation in ABNJ, and is led by the FAO in partnership with CCAMLR, various deep-sea RFMOs and related organisations and arrangements. CCAMLR has been invited to contribute expertise and information which may be used to improve fisheries management and biodiversity conservation in the deep seas, and this contribution is coordinated by the CCAMLR Secretariat. Project highlights have included:

(i) the implementation of a VME portal and global database which provide information on VMEs and VME-related measures in ABNJ, including areas in the CAMLR Convention Area

(ii) a regional review of current practices for the identification and management of VMEs, including CCAMLR's approach

(iii) a workshop on best practices in VME encounter protocols and impact assessments.

10.12 Dr Constable questioned how CCAMLR might contribute to this work without reviewing its processes for managing VMEs. He also noted that there may be insufficient communication with the Scientific Committee on this issue, especially given that Table 1 in SC-CAMLR-XXXIV/BG/25 is quite extensive; there has been little discussion and planning to date.

10.13 The Scientific Committee further discussed its role in the project under Section 13.

### ACAP

10.14 ACAP thanked the Scientific Committee for the invitation to SC-CAMLR-XXXIV and noted that while ACAP's Advisory Committee and its working groups have not met this year, intersessional work on defining data needs, methodological approaches and reporting requirements for monitoring by-catch of ACAP species across Parties' fisheries has continued. The intersessional group will report back to the 7th meeting of the Seabird Bycatch Working Group (SBWG7) in May next year. ACAP welcomed the news of CCAMLR's ongoing improvement in the reduction of seabird by-catch, and noted that CCAMLR continues to stand as a role model for other high-seas management authorities. ACAP also highlighted that an ID guide for by-caught seabirds, which the ACAP Secretariat produced with the assistance of its Japanese colleagues at the National Research Institute of Far Seas Fisheries, is now available in four languages from the ACAP website, with another four languages to be available shortly.

ARK

10.15 ARK presented its report (SC-CAMLR-XXXIV/BG/35) to the Scientific Committee. It advised it had four members, with two having received Marine Stewardship Council (MSC) certification for their krill fishing operations for the next five years (Aker BioMarine and Olympic Seafood). ARK noted its support for measures to make the system for notification of intent to fish for krill more realistic, including the use of notification fees.

10.16 ARK noted that there were discrepancies between the amount of fish by-catch reported by observers and by vessels, and that it is the responsibility of the vessels to report by-catch on the C1 forms. Members agreed to work towards improving the reporting of fish by-catch to address this issue. ARK reiterated its support for 100% scientific observer coverage in the krill fishery.

10.17 ARK strongly supported proposals for a new biomass survey of Area 48 and its members will assist in whatever way is appropriate.

10.18 ARK noted the Scientific Committee's request for better understanding the fishing strategies used by fishing vessels and proposed a workshop to be held in 2016 that brings together CCAMLR scientists and fishing operators to focus on questions of relevance to the Scientific Committee. It was noted that the Workshop on Feedback Management to be held on 24 October 2015 may be useful in defining such questions. ARK would work with the Convener of WG-EMM to find a suitable date for its workshop which might be in conjunction with WG-EMM-16.

10.19 ARK provided a summary of a meeting held in Qingdao, China, on 15 and 16 September 2015, between the Chinese krill fishing industry and ARK representatives. The meeting contained useful discussions on topics including scientific observer coverage, the use of fishing vessels to conduct science for CCAMLR, the value of ARK's contribution to CCAMLR and the continued sustainable use of the krill resource.

10.20 The Scientific Committee thanked ARK for its reports, and endorsed a workshop to be coordinated by ARK and the WG-EMM Convener.

ASOC

10.21 ASOC provided the following statement:

> 'ASOC submitted background papers relevant to the work of the Scientific Committee on a variety of issues, including marine protected areas, climate change, Article II implementation, krill and CCAMLR's approach to management. ASOC noted the difficulty and complexity of CCAMLR's work but reminded Members that the

CAMLR Convention intended for conservation to be the primary objective of the organisation with any harvesting and associated activities required to comply with several conservation principles.

ASOC noted that in recent years some work has not progressed because it might restrict or limit fishing, most notably the work on MPAs. Since protecting Antarctic marine ecosystems is the main aim of CCAMLR, ASOC urged Members to recommit to fulfilling the conservation requirements of the CAMLR Convention, by designating MPAs in the Ross Sea and East Antarctica and making progress in the management of the krill fishery, including the development of a feedback management system and the expansion of the observer coverage.

ASOC provided an update on the Antarctic Wildlife Research Fund (AWR). AWR was launched in February 2015 to facilitate and promote research on the Antarctic ecosystem. AWR's founding partners are representatives of ASOC, WWF-Norway and Aker BioMarine.

The first call for proposals opened on 16 March and closed on 16 June 2015 with the intention of allocating up to a total sum of US$250 000. The first call resulted in 10 proposals, including from a number of scientists with existing links to CCAMLR.

The Scientific Advisory Group (SAG) of AWR, composed of eight scientists involved in the scientific work of CCAMLR, evaluated and prioritised the scientific research proposals that were submitted to AWR. The first call for proposals was conducted in accordance with the fund's long-term scientific research plan that was developed by SAG and could be consulted in AWR's website: www.antarcticfund.org. The SAG based its evaluation upon a number of criteria to prioritise proposals.

In the evaluation process, all SAG members registered any potential conflict of interest. Vested interest is present when a member is associated or involved in any way with an institution, department or individual that submitted a funding proposal or would otherwise benefit from the decision. The chair of the SAG briefed on vested interests and consequently papers relating to a vested interest were not assessed by the respective member.

In the first call for proposals, each proposal was assessed on a numerical scale (0–10) by the SAG, and the results were presented to the AWR board. The final decision on funding individual proposals was made by the board of AWR.

AWR intends to submit a second call for proposals in mid-March 2016 for a total distribution of US$200 000.'

10.22 The Scientific Committee thanked ASOC for the AWR initiative.

### Oceanites Inc.

10.23 Mr R. Naveen introduced Oceanites Inc. as a new Observer to SC-CAMLR and gave a brief outline of the organisation's aims and its major scientific project, the Antarctic Site Inventory.

## Reports from observers at meetings of other international organisations

### IWC

10.24 Dr Currey presented the CCAMLR Observer's Report (SC-CAMLR-XXXIV/BG/32) on the 67th Meeting of the Scientific Committee of the IWC, held in San Diego, USA, 19 May to 3 June 2015, chaired by Dr T. Kitakado (Japan). In terms of key issues relevant for CCAMLR, there were no large whale catches reported in the Southern Ocean in 2014/15. Discussion of the proposal for a joint IWC–CCAMLR workshop took place, as well as extensive discussion of Japan's proposed New Scientific Whale Research Program in the Antarctic Ocean (NEWREP-A), and reviews of the Southern Ocean Sanctuary (SOS) and the South Atlantic Whale Sanctuary (SAWS) proposals.

10.25 The Scientific Committee thanked Dr Currey for his report on IWC activities.

#### Joint SC-CAMLR and IWC SC Workshop

10.26 Dr Kawaguchi presented the terms of reference for a Joint SC-CAMLR and IWC SC Workshop (SC-CAMLR-XXXIV/BG/33) that was agreed by the workshop steering group. It was concluded that due to another major workshop happening at the same time, it was necessary to defer for one year and hold the workshop during 2017. Additionally, two days was considered insufficient to address a multi-species model, therefore, a proposal is detailed for a larger workshop in 2018.

10.27 The Scientific Committee endorsed the terms of reference for the workshop.

## Future cooperation

10.28 The Secretariat presented a calendar of important events that are relevant to the work of the Scientific Committee (SC-CAMLR-XXXIV/BG/26) and undertook to provide a revised version with additional events detailed by Members.

### Integrating Climate and Ecosystem Dynamics Program

10.29 Dr Constable presented SC-CAMLR-XXXIV/BG/22, which details a proposed conference in April 2018 aimed at assessing status and trends of habitats, key species and ecosystems in the Southern Ocean, and an invitation to Members of SC-CAMLR to participate in working groups on four broad themes. The Scientific Committee noted the relevance of many of its themes that will be of potential benefit to SC-CAMLR.

### Global Environmental Facility

10.30 The Scientific Committee noted the progress with the proposal to approach the Global Environment Facility (GEF) to support a four-year project in the Antarctic to build capacity among GEF-eligible CCAMLR Members to strengthen their engagement in the organisation (SC-CAMLR-XXXIV/BG/24). The Secretariat reported that Chile, Namibia, South Africa and Ukraine had endorsed the proposal, and that India and China were well advanced in internal discussions regarding this project. Noting that the intention was to finalise the proposal for submission to the GEF Council in February 2016, the Scientific Committee encouraged the remaining GEF-eligible CCAMLR Members, including Brazil and Uruguay, to make best efforts to actively engage with the approval process. The Scientific Committee noted that approval of the proposal will lead to a broad consultative process, involving all CCAMLR stakeholders, to support a detailed project design exercise that will include the identification of formal partnerships and collaborative arrangements during project implementation. It is anticipated that this could take 12 months. The Scientific Committee also noted that, in order to secure the US$12.5 million proposed for this project, significant co-financing and funding-in-kind will need to be identified from project collaborators.

10.31 Drs Demianenko, Arata and A. Makhado, on behalf of Ukraine, Chile and South Africa respectively, thanked the Secretariat for coordinating this work and encouraged other GEF-eligible CCAMLR Members to endorse the proposal. Dr Zhao confirmed that the proposal was currently being evaluated by China.

### Proposed exploratory toothfish program for SPRFMO

10.32 Dr Currey, on behalf of New Zealand, presented a proposal for exploratory bottom longlining for toothfish by a New Zealand vessel in the SPRFMO area (SC-CAMLR-XXXIV/BG/36). As the proposed research areas are adjacent to the CCAMLR area, New Zealand will be conducting the work using a consistent approach to that applied in CCAMLR and will undertake to share data and present results to CCAMLR. It was noted that a proposal for cooperative arrangements between both organisations will be considered by the Commission (CCAMLR-XXXIV/16 Rev. 1).

10.33 The Scientific Committee endorsed the use of CCAMLR-consistent methods and the data-sharing offer.

## Budget for 2016

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

11.2 The Scientific Committee agreed to fund one scientific scholarship (paragraph 13.10) of up to A$25 000 over two years under the General Science Capacity Fund.

## Advice to SCIC and SCAF

12.1 The advice to SCAF is summarised in Item 11. On behalf of the Scientific Committee, the Chair and the senior Vice-Chair transmitted the Scientific Committee's advice to SCIC. The advice to SCIC was derived from the Scientific Committee's consideration of VMS data (paragraphs 3.90 and 3.92), discharge of offal (paragraph 3.87), by-catch reporting (paragraphs 3.161 to 3.171), observer coverage in the krill fishery (paragraphs 7.4 to 7.22), the release of untagged toothfish in exploratory fisheries (paragraph 3.85), research fishing in Subareas 48.5 (paragraphs 3.268 to 3.287) and 88.2 (paragraphs 3.198 to 3.211) and IUU fishing (paragraphs 6.5 and 6.9).

## Scientific Committee activities

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

#### Identifying priorities

13.1 In SC-CAMLR-XXXIV/14 the working group conveners presented a summary of the priorities for each of the working groups. The Scientific Committee thanked the conveners for this very useful synthesis and agreed that it was essential to develop a strategy to address a process to prioritise and manage the expectation of delivery of the long list of priorities.

13.2 The Scientific Committee agreed that it was important to identify those issues for which there is a requirement to provide advice to the Commission on an annual basis and to develop a multiyear schedule to deliver longer-term objectives that do not need to be considered each year. The development of a multiyear schedule also recognises the importance of having a clearly defined long-term plan to address key strategic issues as this allows scientists, research institutes and potential collaborators such as SCAR the required lead-time to implement research and deliver results to CCAMLR. The Scientific Committee also acknowledged that having unrealistic or ill-defined timescales, or a lack of clarity on how issues are to be addressed (e.g. the fish-based ecosystem science that has not been addressed in either WG-EMM or WG-FSA), could potentially discourage scientists from engaging.

13.3 The Scientific Committee agreed that while there appeared to be an expectation of a large range of issues on which it was attempting to provide advice that requires the associated supporting science, it was important to focus on ensuring that the essential data and science are in place to deliver the priority advice.

13.4 The Scientific Committee noted that there were three potential ways to manage expectations and address the excessive workload by:

(i) adding capacity in, and increasing the number of, meetings and directing more resources to address the entire list of priority issues listed in SC-CAMLR-XXXIV/14

(ii) prioritising the issues to be addressed, recognising that some issues would not be addressed in the medium term

(iii) maintaining the status quo and accepting that there will be a delay in addressing all issues (regardless of priority).

13.5 The Scientific Committee agreed that it was essential to prioritise its work and that the most effective way to do this was through a risk-based approach where priorities would be identified on an assessment of the risk to the Commission of the Scientific Committee not achieving an objective or not being able to deliver advice at the timescale required. For example, the Scientific Committee noted that CMs 51-06 and 51-07 are time-limited and advice is required in the next two years, and this provides a basis for prioritisation with clearly specified deliverables required.

### Addressing priorities

13.6 The Scientific Committee agreed that, having identified the range of priorities, there was a need to identify a suitable mechanism for addressing priority issues. The Scientific Committee noted that there are currently a number of interrelated issues that are considered in isolation of each other and that linking these themes could provide greater efficiency in delivering coordinated advice. One such mechanism to aggregate topics was to address overarching issues at a regional scale (e.g. the Workshop on Area 48 conducted in 1998 – www.ccamlr.org/en/node/62317) noting that workshops allow a more flexible process for the engagement of a broader participation of relevant expertise.

13.7 In respect of the priorities for 2016, the Scientific Committee agreed the following priorities for the coming year:

- focus topic at WG-EMM on FBM and the review of CMs 51-06 and 51-07
- a one-day forum in either WG-SAM or WG-EMM in 2016 on the Ross Sea ecosystem, given the strong history of research in that region by the Italian hosts of the meetings
- focus topic at WG-FSA on by-catch in finfish and krill fisheries
- Scientific Committee symposium (similar to the CCAMLR symposium held in 2015) during the second half of the week prior to the Scientific Committee meeting (i.e. taking up the last few days of WG-FSA) in 2016 in order to provide more time to review the strategic direction of the Committee and its working groups.

13.8 The Scientific Committee also noted that the work of SG-ASAM should proceed in 2016 to follow the work plan set out in its report and address the methods for analysis of acoustic data collected from krill fishing vessels.

## Intersessional activities

13.9 The Scientific Committee warmly welcomed the offer from Italy and the USA to host the intersessional meetings in 2016 and agreed to the following:

(i) SG-ASAM (La Jolla, USA, 21 to 25 March 2016) (Co-conveners: Drs Zhao and Reiss)

(ii) WG-SAM (Genoa, Italy, 27 June to 1 July 2016) (Convener: Dr Parker)

(iii) WG-EMM (Bologna, Italy, 4 to 15 July) (Convener: Dr Kawaguchi)

(iv) WG-FSA (CCAMLR Headquarters, Hobart, Australia, 3 to 14 October 2016) (Convener: to be confirmed).

### CCAMLR Scientific Scholarship Scheme

13.10 The Chair of the scholarship review panel (Dr Welsford) announced that the recipient of the 2015 CCAMLR scholarship was Ms Fokje Schaafsma from the EU. Ms Schaafsma is studying how living resources are affected by changes in sea-ice habitats through investigations of the distribution, population structure and diet of trophic key species in the under-ice habitat. The review panel had agreed that this was a very relevant area of research for CCAMLR and looked forward to Ms Schaafsma's contribution to WG-EMM and the Scientific Committee.

13.11 The Chair of the scholarship review panel also informed the Scientific Committee that the recipient of the CCAMLR scholarship in 2014 had been unable to participate in the scheme for technical reasons.

13.12 The Scientific Committee agreed that the CCAMLR Scientific Scholarships Scheme was a very successful mechanism for developing capacity in CCAMLR and, in addition to the excellent contributions made in the working groups, there were three previous recipients of scholarships attending the Scientific Committee this year.

13.13 The Scientific Committee agreed that the criteria for early career scientists should be revised to include all suitable postgraduate candidates to be eligible for consideration for the scholarship scheme.

### Invitation of experts and observers to meetings of working groups

13.14 The Scientific Committee agreed that all Observers invited to the 2015 meeting would be invited to participate in SC-CAMLR-XXXV.

13.15 The Scientific Committee noted the request by the New Zealand High Seas Fisheries Group Inc. (HSFG) for observer status at SC-CAMLR-XXXV that was distributed by SC CIRC 15/57. The Scientific Committee agreed that engagement in the meeting of the Scientific Committee by individuals or groups of companies was most appropriately dealt with through the relevant Member delegations rather than through those companies having observer status at the meeting.

13.16 The Scientific Committee recalled issues surrounding the invitation of experts to the meetings of working groups and recommended that SC-CAMLR-XXXII/09 be considered by the Scientific Committee in 2016.

Next meeting

13.17 The next meeting of the Scientific Committee will be held from 17 to 21 October 2016.

## Secretariat-supported activities

14.1 The Scientific Committee reviewed the role of *CCAMLR Science* and considered options for the future which had been developed by the Secretariat (SC-CAMLR-XXXIV/07). Four options were considered:

(i) encourage scientists who contribute to working groups to submit papers to *CCAMLR Science* and encourage those authors who do submit papers to persevere with the review process

(ii) make *CCAMLR Science* more attractive to scientists to publish CCAMLR-related work

(iii) move away from an annual publication cycle to focus on special topics, either (a) published in *CCAMLR Science* as an occasional publication focused on a specific topic, or (b) by sponsoring topic-related special issues in other relevant journals

(iv) retire *CCAMLR Science* and redirect resources to other mechanisms to publicise the science done in CCAMLR and to raise the profile of CCAMLR within the international scientific community.

14.2 The Scientific Committee recognised that *CCAMLR Science* provides a valuable mechanism for promoting the science done in CCAMLR and for raising the profile of CCAMLR within the international scientific community. It was also recognised that the journal's mid-range impact factor may result in some papers being submitted for publication elsewhere; however, the journal's position was also suited to the publication of papers which may not be considered by issue-specific journals. The Scientific Committee also noted that the range of topics published in *CCAMLR Science* has narrowed in recent years, partly as a result of the Scientific Committee's current focus on the development of stock assessments and FBM.

14.3 The Scientific Committee also recalled that funding was available within the existing budget of the journal to provide CCAMLR language editorial assistance to authors but that this had not been accessed in the last five years.

14.4 The Scientific Committee agreed to continue supporting *CCAMLR Science* and endorsed options (i), (ii) and (iiia), noting that these options are not mutually exclusive. It was agreed that progressing option (ii) may include seeking papers addressing specified topics and to be submitted from the broader scientific community, outside working groups. Such papers, once published in *CCAMLR Science*, would be forwarded to the relevant working group for consideration and, where appropriate, inclusion in the work of that working group.

14.5 The Scientific Committee also considered the publication of its meeting reports, or a summary of the reports, in *CCAMLR Science*, noting that this is current practice for some organisations (e.g. IWC).

14.6 The Scientific Committee welcomed the review of the role of *CCAMLR Science* and recognised that the successful implementation of options (i) to (iiia) may require additional budgetary resources and agreed that that the Secretariat should explore these options using available resources in the first instance (paragraphs 16.1 to 16.7).

## Election of the Chair and Vice-Chair

15.1 The Chair notified the Scientific Committee that a new Chair and one of the two Vice-Chair positions for 2016/17 were to be elected at this meeting.

15.2 The Vice-Chair, Dr Welsford, announced that Dr Belchier had been nominated for the position as Chair and Dr Ichii agreed to second the nomination.

15.3 Dr Belchier gratefully accepted the position and thanked the Chair, the Scientific Committee and those who had nominated him for their support. Dr Belchier said that after convening the WG-FSA meeting last week and observing the discussions in the Scientific Committee meeting this week, he was aware of the sheer breadth and scale of the task at hand, but was looking forward to the challenge that lay ahead and was heartened by the support that he would receive from the Secretariat, the Conveners of WG-SAM and WG-EMM and all Members. Dr Belchier thanked Dr Jones for his role in the last four years and said he looked forward to being able to call on him for guidance. Dr Belchier also suggested that some guidelines on chairing the Scientific Committee be drafted to assist newly elected members with transitioning smoothly into this position.

15.4 Dr Grant announced that Mr S. Somhlaba (South Africa) had been nominated for the position of Junior Vice-Chair. It was noted that Mr Somhlaba had coordinated and led subgroups and made substantive contributions to WG-SAM and WG-FSA, and he would continue to make valuable contributions to the working groups in his new role. Dr Watters seconded the nomination. Mr Somhlaba thanked those who had nominated him and expressed that it was a huge honour to be nominated for this position and looked forward to rising to the challenge. The Chair and the Scientific Committee welcomed Mr Somhlaba to this position.

15.5 Dr Grant, who was due to move into the position of Vice-Chair, noted that the Rules of Procedure state that the Scientific Committee Chair and Vice-Chair cannot be from the same Contracting Party, so she graciously resigned from the Vice-Chair position, but thanked the Scientific Committee for its support and expressed that she looked forward to continuing her work with the Committee as an advisor and Co-convener of the Joint CEP–SC-CAMLR Workshop. The Committee noted the sterling job Dr Grant had done in her time as Junior Vice-Chair and thanked her for the valuable contributions she had made in this role.

15.6 Dr Welsford was nominated for one more year in the Vice-Chair position and it was noted by the Scientific Committee that it was important to retain the staggering of years in which the Junior Vice-Chair and Vice-Chair were elected. The nomination was seconded by Dr Watters. Dr Welsford was humbled by the decision and thanked the Scientific Committee for its confidence.

15.7 It was noted by the Scientific Committee that there is some ambiguity on the election process in the current Rules of Procedure and that it may require clarification. The Chair suggested that potential amendments to the Scientific Committee Rules of Procedure (Rule 8) should be made that would clarify the election process and that this should be considered in the intersessional period.

## Other business

Developing a communication strategy with the Commission and wider community

16.1 The Scientific Committee Chair noted the two papers, SC-CAMLR-XXXIV/01 and XXXIV/02, that had been tabled under this agenda item and called on the Delegation of Australia to introduce these papers for further discussion.

16.2 Dr Constable introduced both papers, noting that they emerged from discussions in the meetings last year and at WG-EMM, and that they both related to the development of a communication strategy for the Scientific Committee.

16.3 SC-CAMLR-XXXIV/01 details how reference material for ongoing deliberations in the Commission could be collated and made available on the CCAMLR website. It was noted that last year the Scientific Committee agreed to place reference material on MPAs on the CCAMLR website in the Members-only section so that it could be readily available to the Commission during the meetings (SC-CAMLR-XXXIII, paragraph 5.48). It was further noted that WG-EMM discussed how the mechanism for making this material available on the website was not clear after last year's meeting of the Scientific Committee (Annex 6, paragraphs 3.60 to 3.66) but agreed that the proposal in this paper clarified how it might be achieved. Dr Constable noted that the general repository for reference material illustrated in the paper could also be used to archive maps and a range of other information, including data layers that may be used for a variety of purposes of the Scientific Committee and the Commission.

16.4 The proposal in SC-CAMLR-XXXIV/01 for managing reference material was endorsed by the Scientific Committee.

16.5 The Scientific Committee also considered SC-CAMLR-XXXIV/02 which detailed another part of the Scientific Committee communication strategy that could provide an expanded set of reference documents to the Commission as well as the wider community. It recalled the valuable work, led by Dr Kock and published in 2000, on describing CCAMLR's approach to management that is accessible on CCAMLR's website and available to the wider community but noted that this was now 15 years old and it was time to update this document. The paper suggested that the Scientific Committee could use the excellent meeting server process that is now being used for developing meeting reports. Content could be managed just like an agenda and allow authors to develop and edit text for developing sections of the documents. Once complete, a document could be published and made available with some editorial guidance from the Secretariat.

16.6 The Scientific Committee agreed this would be a useful mechanism for developing documents and materials. It also agreed that such a process may be useful in developing and maintaining Fishery Reports and other parts of reports that could be used in a communication strategy.

16.7 The Scientific Committee recommended that the Commission consider an overarching strategy for communication that included in-house and external skills and could also involve *CCAMLR Science*, wiki-style species identification guides for observers and CCAMLR's approaches to management. It noted that there were a number of common issues with how to best use technical resources that needed to be addressed.

Request to reposition boundaries in Subareas 58.6 and 58.7

16.8 Dr Leslie drew the attention of the Scientific Committee to WG-SAM-15/51 that had been presented to WG-SAM-15 and WG-FSA-15 (Annex 7, paragraph 11.1.) and informed the Committee that South Africa and France intend requesting the Commission to reposition the boundary between Subareas 58.6 and 58.7 to take into account the areas of national jurisdiction of those two Members.

Depredation e-group

16.9 Dr Söffker recalled the discussions on the importance of depredation as a cross-cutting issue that spanned across WG-SAM, WG-FSA and WG-EMM and that it had also been raised in the COLTO workshop. Dr Söffker announced that in response to this, an intersessional small group on depredation had been established to deal with this issue in further detail with focus topics that would address data collection and characterisation, depredation estimation methods, effects of depredation on stock assessment, consequences of depredation on other species and the ecosystem, and mitigation. Dr Söffker also noted that an e-group would be established in the coming weeks and encouraged all interested Members to join and participate in the e-group discussions.

WG-EMM recommendations

16.10 The WG-EMM Convener highlighted the recommendations to the Scientific Committee that were relevant to this agenda item in Annex 6, paragraphs 6.20 and 6.21.

16.11 In Annex 6, paragraph 6.20, the Working Group requested that the Scientific Committee consider whether the inclusion of affiliation on working group papers was necessary. Dr Reid indicated that the omission of affiliations would streamline the work of the Secretariat. The Scientific Committee endorsed this paragraph and agreed that the inclusion of affiliations on working group papers was not necessary.

16.12 The recommendation in Annex 6, paragraph 6.21, noted that on working group papers it would be useful to include the Scientific Committee Representative who was responsible for the submission of the paper. Dr Reid noted that the Secretariat can put this on the cover page and the first author would authorise it. The Scientific Committee endorsed the request that the Scientific Committee Representative responsible for the submission of the paper be named on the cover page.

16.13 The WG-EMM Convener announced that next year will be his last year as convener and he encouraged the potential convener to co-convene the next WG-EMM with him and encouraged all Members to think of suitable candidates to enable a smooth transition.

## Adoption of the report

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

## Close of the meeting

18.1 At the close of the meeting, Dr Jones thanked all participants for their contributions to the deliberations of the Scientific Committee. He also thanked the Conveners of SG-ASAM, WG-SAM, WG-EMM and WG-FSA, the Vice-Chair and Junior Vice-Chair of the Scientific Committee and the subgroup coordinators and rapporteurs for their excellent work. He also thanked all the Secretariat staff for their extensive support. The Scientific Committee undertook a huge amount of work in 2015 and had been able to develop detailed advice on most matters, and Dr Jones looked forward to conveying the Scientific Committee's findings to the Commission.

18.2 Dr Jones expressed that it had been an honour to serve his term as Chair of the Scientific Committee and that he had thoroughly enjoyed it. He thanked all Members for making it a rich and rewarding experience.

18.3 Dr Watters thanked Dr Jones for his four years of exemplary service to the Scientific Committee. On behalf of the Scientific Committee, Dr Welsford, as Senior Vice-Chair, thanked Dr Jones for his patience and guidance through what had been occasionally challenging deliberations of the Scientific Committee. Dr Jones was presented with an engraved gavel to commemorate his time as Scientific Committee Chair. He promptly used the gavel to bring the meeting to a close.

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Table 1: Proposed catch limits in established fisheries in 2015/16 and 2016/17. TOP – *Dissostichus eleginoides*; TOA – *Dissostichus mawsoni*; ANI – *Champsocephalus gunnari*.

| Management area | Species | Catch limit (tonnes) 2015 | Proposed catch limit (tonnes) 2016 | Additional information | SC-CAMLR-XXXIV paragraph reference | Conservation measure containing catch limit |
|---|---|---|---|---|---|---|
| 48.4 | TOP | 42 | 47 | 2016/17 limit 47 tonnes | 3.116 | CM 41-03 |
| 48.4 | TOA | 28 | 39 | | 3.124 | CM 41-03 |
| 48.3 | TOP | 2 400 | 2 750 | 2016/17 limit 2 750 tonnes | 3.133 | CM 41-02 |
| 58.5.2 | TOP | 4 410 | 3 405 | 2016/17 limit 3 405 tonnes | 3.155 | CM 41-08 |
| 48.3 | ANI | 2 695 | 3 461 | 2016/17 limit 2 074 tonnes | 3.103 | CM 42-01 |
| 58.5.2 | ANI | 309 | 482 | 2016/17 limit 357 tonnes | 3.108 | CM 42-02 |

Table 2: Proposed initial allocation and total research catch limits for research plans in Divisions 58.4.1 and 58.4.2 in 2015/16. AUS – Australia; ESP – Spain; FRA – France; KOR – Republic of Korea.

| Division | SSRU | Research block | AUS | ESP | FRA | JPN | KOR | 2015/16 catch limit (tonnes) |
|---|---|---|---|---|---|---|---|---|
| 58.4.1 | C | 5841_1 | - | - | 26 | 26 | 26 | 80 |
| | | 5841_2 | 40[a] | - | 13 | 13 | 13 | 81 |
| | | | - | 42[b] | - | - | - | 42 |
| | D | | - | 42[b] | - | - | - | 42 |
| | E | 5841_3 | 58 | - | 58 | 58 | 58 | 233 |
| | | 5841_4 | - | - | - | - | - | 13 |
| | G | 5841_5 | - | - | - | - | 35 | 35 |
| | | | 50[c] | 42[b] | - | - | - | 92 |
| | H | | - | 42[b] | - | - | - | 42 |
| 58.4.2 | E | 5842_1 | 35 | - | - | - | - | 35 |
| Total from catch limits | | | 133 | - | 97 | 97 | 132 | 459 |
| Total from additional research | | | 50 | 168 | - | - | - | 677 |

[a] Catch proposed by Australia to fish a grid overlapping with the location of a Spanish depletion experiment in SSRU 5841C, research block 5842_2. Uncaught catch will be reallocated as it is part of the existing SSRU catch limit.

[b] Catch proposed by Spain to conduct depletion experiments. Uncaught catch will not be reallocated as it is not part of the existing SSRU catch limits.

[c] Catch proposed by Australia to fish a grid overlapping with the location of a Spanish depletion experiment in SSRU 5841G. Uncaught catch will not be reallocated as it is not part of the existing SSRU catch limits.

Table 3: Advice on research limits for *Dissostichus* spp. fisheries and research fishing in 2015/16. TOP – *Dissostichus eleginoides*; TOA – *Dissostichus mawsoni*. (Refer to Annex 7, Figure 2, for the location of research blocks).

| Subarea/ Division | SSRU | Research block | Species | Research limit (tonnes) 2015 | Proposed research limit (tonnes) 2016 | Additional information | SC-CAMLR-XXXIV paragraph reference | Conservation measure containing research limit |
|---|---|---|---|---|---|---|---|---|
| 48.2 | n/a | 482_1 | TOA + TOP | 75 | 75 | No change in advice of catch limits. 37.5 tonnes for each vessel | 3.261, 3.262 | No CM |
| 48.6 | A and G | 486_1 and 486_2 | TOP | 28 | 28 | No change in advice of catch limits | 3.240 | CM 41-04 |
| 48.6 | A and G | 486_2 | TOA | 170 | 170 | No change in advice of catch limits | 3.240 | CM 41-04 |
| 48.6 | D | 486_3 | TOA + TOP | 50 | 50 | No change in advice of catch limits | 3.240 | CM 41-04 |
| 48.6 | E | 486_4 | TOA + TOP | 100 | 100 | No change in advice of catch limits | 3.240 | CM 41-04 |
| 48.6 | B and C | 486_5 | TOA + TOP | 190 | 190 | No change in advice of catch limits | 3.240 | CM 41-04 |
| 58.4.1 | C | 5841_1 | TOA + TOP | 125 | 80 | Revised on basis of seabed area re-estimation (WG-SAM-15/01) | 3.245 | CM 41-11 |
| 58.4.1 | C | 5841_2 | TOA + TOP | 90 | 81 | Revised on basis of seabed area re-estimation (WG-SAM-15/01) | 3.245 | CM 41-11 |
| 58.4.1 | C | | | 42 | 42 | Spanish depletion experiment only | 3.245 | CM 41-11 |
| 58.4.1 | D | | TOA + TOP | 42 | 42 | Spanish depletion experiment only | 3.245 | CM 41-11 |
| 58.4.1 | E | 5841_3 | TOA + TOP | 280 | 233 | Revised on basis of seabed area re-estimation (WG-SAM-15/01) | 3.245 | CM 41-11 |
| 58.4.1 | E | 5841_4 | TOA + TOP | 35 | 13 | Revised on basis of seabed area re-estimation (WG-SAM-15/01) | 3.245 | CM 41-11 |
| 58.4.1 | G | 5841_5 | TOA + TOP | 26 | 35 | Revised on basis of seabed area re-estimation (WG-SAM-15/01) | 3.245 | CM 41-11 |
| 58.4.1 | G | | TOA + TOP | 42 | 92 | Spanish depletion experiment and Australian research only | 3.245 | CM 41-11 |
| 58.4.1 | H | | TOA + TOP | 42 | 42 | Spanish depletion experiment only | 3.245 | CM 41-11 |
| 58.4.2 | E | 5842_1 | TOA + TOP | 35 | 35 | Revised on basis of seabed area re-estimation (WG-SAM-15/01) | 3.245 | CM 41-05 |
| 58.4.4b | C | 5844b_1 | TOA + TOP | 25 | 25 | No change in advice of catch limits | 3.267 | No CM |
| 58.4.4b | n/a | 5844b_2 | TOA + TOP | 35 | 35 | No change in advice of catch limits | 3.267 | No CM |

(continued)

Table 3 (continued)

| Subarea/ Division | SSRU | Research block | Species | Research limit (tonnes) 2015 | Proposed research limit (tonnes) 2016 | Additional information | SC-CAMLR-XXXIV paragraph reference | Conservation measure containing research limit |
|---|---|---|---|---|---|---|---|---|
| 58.4.3a | n/a | 5843a_1 | TOA + TOP | 32 | 32 | No change in advice of catch limits | 3.251 | CM 41-06 |
| 88.1 | | | | 3 044 | 2 870 | 40 tonnes (shelf) and 100 tonnes for winter survey | 3.190 to 3.192 | CM 41-09 |
| 88.2 | A(N) | 882A_1 to _6 | TOA + TOP | 200 | 150 | 25 tonnes per vessel in each of 6 research blocks in SSRU 882A as shown in CM 41-10, Figure 2 (overall combined limit of 200 tonnes in SSRU 882A–B) | 3.203 | CM 41-10 |
| 88.2 | | 882B_1 to _5 | TOA + TOP | 200 | 125 | 25 tonnes per vessel in each of 5 research blocks in SSRU 882A as shown in CM 41-10, Figure 2 (overall combined limit of 200 tonnes in SSRUs 882A–B) | 3.203 | CM 41-10 |
| 88.2 | A(S) | 882A_7 | | n/a | 60* | Russian research | | CM 41-10 |
| 88.2 | | 882A_8 to _9 | | | 40* | 40 tonnes from one of research blocks 8, 9 or 10 | | CM 41-09 |
| 88.2 | D, E, F, G | 882_1 | TOA + TOP | 200 | 200 | With overall limit of 419 tonnes in SSRUs C, D, E, F, G | 3.197 | CM 41-09 |
| 88.2 | D, E, F, G | 882_2 | TOA + TOP | 200 | 200 | With overall limit of 419 tonnes in SSRUs C, D, E, F, G | 3.197 | CM 41-09 |
| 88.2 | D, E, F, G | 882_3 | TOA + TOP | 200 | 200 | With overall limit of 419 tonnes in SSRUs C, D, E, F, G | 3.197 | CM 41-09 |
| 88.2 | D, E, F, G | 882_4 | TOA + TOP | 200 | 200 | With overall limit of 419 tonnes in SSRUs C, D, E, F, G | 3.197 | CM 41-09 |
| 88.2 | H | | TOA + TOP | 200 | 200 | | 3.197 | CM 41-09 |
| 88.3 | A | 883_1 | TOA + TOP | n/a | 21 | Korean research | 3.290 | No CM |
| 88.3 | A | 883_2 | TOA + TOP | n/a | 29 | Korean research | 3.290 | No CM |
| 88.3 | B | 883_3 | TOA + TOP | n/a | 31 | Korean research | 3.290 | No CM |
| 88.3 | C | 883_4 | TOA + TOP | n/a | 52 | Korean research | 3.290 | No CM |
| 88.3 | D | 883_5 | TOA + TOP | n/a | 38 | Korean research | 3.290 | No CM |

* Research proposal not endorsed (see paragraphs 3.204 to 3.211).

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Annex 2

**List of documents**

## List of documents

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| SC-CAMLR-XXXIV/01 | Proposal for managing scientific reference material to support ongoing discussions in the Commission<br>Delegation of Australia |
| SC-CAMLR-XXXIV/02 | Proposal for developing and editing documents to support the communication of science from the Scientific Committee using the Secretariat's existing report development tool<br>Delegation of Australia |
| SC-CAMLR-XXXIV/03 | Report of the Working Group on Ecosystem Monitoring and Management<br>(Warsaw, Poland, 6 to 17 July 2015) |
| SC-CAMLR-XXXIV/04 | Report of the Working Group on Fish Stock Assessment<br>(Hobart, Australia, 5 to 16 October 2015) |
| SC-CAMLR-XXXIV/05 | Report of the Working Group on Statistics, Assessments and Modelling<br>(Warsaw, Poland, 29 June to 3 July 2015) |
| SC-CAMLR-XXXIV/06 | Report of the Meeting of the Subgroup on Acoustic Survey and Analysis Methods<br>(Busan, Republic of Korea, 9 to 13 March 2015) |
| SC-CAMLR-XXXIV/07 | *CCAMLR Science* – Options for the future<br>Secretariat |
| SC-CAMLR-XXXIV/08 | Information on seasonal and interannual dynamics of ice conditions in the Weddell Sea and a list of candidate sites to be afforded protection<br>Delegation of the Russian Federation |
| SC-CAMLR-XXXIV/09 | Information on biodiversity in candidate areas to be afforded protection based on historical observer data and data from research cruises in the Weddell Sea<br>Delegation of the Russian Federation |
| SC-CAMLR-XXXIV/10 | Proposal by the Russian Federation to change the boundaries of Subarea 88.1 (Ross Sea)<br>Delegation of the Russian Federation |
| SC-CAMLR-XXXIV/11 | Comments and proposals concerning the development of procedures for managing the krill fishery in the CCAMLR Convention Area<br>Delegation of the Russian Federation |

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| SC-CAMLR-XXXIV/12 | Proposal by the Russian Federation for the provision of resources to conduct research in SSRUs of Subareas 88.1 and 88.2 that are closed to fishing<br>Delegation of the Russian Federation |
| SC-CAMLR-XXXIV/13 | Scientific background document in support of the development of a CCAMLR MPA in the Weddell Sea (Antarctica) – Version 2015<br>Delegation of Germany |
| SC-CAMLR-XXXIV/14 | Priorities of the Working Groups and Subgroup for the next four years<br>Conveners of WG-EMM, WG-SAM, WG-FSA and SG-ASAM |

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| SC-CAMLR-XXXIV/BG/01 | Catches in the Convention Area in 2013/14 and 2014/15<br>Secretariat |
| SC-CAMLR-XXXIV/BG/02 | Formulaire de soumission des évaluations préliminaires du risque d'impact négatif significatif des activités de pêche de fond proposées sur les écosystèmes marins vulnérables<br>Délégation française |
| SC-CAMLR-XXXIV/BG/03 | Formulario tipo para las evaluaciones preliminares del riesgo de que las actividades de pesca de fondo propuestas ocasionen graves daños a los ecosistemas marinos vulnerables<br>Delegación de España |
| SC-CAMLR-XXXIV/BG/04 | Preliminary assessment of the potential for proposed bottom-fishing activities to have significant adverse impacts on vulnerable marine ecosystems<br>Delegation of Japan |
| SC-CAMLR-XXXIV/BG/05 | Форма для представления предварительных оценок возможности того, что предложенный донный промысел будет иметь существенное негативное воздействие на уязвимые морские экосистемы<br>[Preliminary assessment of the potential for proposed bottom-fishing activities to have significant adverse impacts on vulnerable marine ecosystems]<br>Делегация Украины<br>[Delegation of Ukraine] |

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| SC-CAMLR-XXXIV/BG/06 | Preliminary assessment of the potential for proposed bottom-fishing activities to have significant adverse impacts on vulnerable marine ecosystems<br>Delegation of Norway |
| SC-CAMLR-XXXIV/BG/07 | Preliminary assessment of the potential for proposed bottom fishing activities to have significant adverse impacts on vulnerable marine ecosystems<br>Delegation of South Africa |
| SC-CAMLR-XXXIV/BG/08 | Preliminary assessment of the potential for proposed bottom fishing activities to have significant adverse impacts on vulnerable marine ecosystems<br>Delegation of Chile |
| SC-CAMLR-XXXIV/BG/09 | Preliminary assessment of the potential for proposed bottom fishing activities to have significant adverse impacts on vulnerable marine ecosystems<br>Delegation of the Republic of Korea |
| SC-CAMLR-XXXIV/BG/10 | Форма для представления предварительных оценок возможности того, что предложенный донный промысел будет иметь существенное негативное воздействие на уязвимые морские экосистемы<br>[Preliminary assessment of the potential for proposed bottom-fishing activities to have significant adverse impacts on vulnerable marine ecosystems]<br>Делегация России<br>[Delegation of Russia] |
| SC-CAMLR-XXXIV/BG/11 | Preliminary assessment of the potential for proposed bottom fishing activities to have significant adverse impacts on vulnerable marine ecosystems<br>Delegation of the United Kingdom |
| SC-CAMLR-XXXIV/BG/12 | Preliminary assessment of the potential for proposed bottom fishing activities to have significant adverse impacts on vulnerable marine ecosystems<br>Delegation of New Zealand |
| SC-CAMLR-XXXIV/BG/13 | Preliminary assessment of the potential for proposed bottom fishing activities to have significant adverse impacts on vulnerable marine ecosystems<br>Delegation of Australia |
| SC-CAMLR-XXXIV/BG/14 | Committee for Environmental Protection: 2015 Annual Report to the Scientific Committee of CCAMLR<br>CEP Observer to SC-CAMLR (Dr P. Penhale, USA) |

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| SC-CAMLR-XXXIV/BG/15 | Scientific background document in support of the development of a CCAMLR MPA in the Weddell Sea (Antarctica) – Version 2015 – Part A: General context of the establishment of MPAs and background information on the Weddell Sea MPA planning area<br>Delegation of Germany |
| SC-CAMLR-XXXIV/BG/16 | Scientific background document in support of the development of a CCAMLR MPA in the Weddell Sea (Antarctica) – Version 2015 – Part B: Description of available spatial data<br>Delegation of Germany |
| SC-CAMLR-XXXIV/BG/17 | Scientific background document in support of the development of a CCAMLR MPA in the Weddell Sea (Antarctica) – Version 2015 – Part C: Data analysis and MPA scenario development<br>Delegation of Germany |
| SC-CAMLR-XXXIV/BG/18 Rev. 1 | The Scientific Committee on Antarctic Research (SCAR) Annual Report 2014/2015<br>Submitted by SCAR |
| SC-CAMLR-XXXIV/BG/19 | Potential for using CCAMLR VMS data for compliance analysis and data quality assurance<br>Secretariat |
| SC-CAMLR-XXXIV/BG/20 | COLTO and Science Workshop<br>Submitted by COLTO |
| SC-CAMLR-XXXIV/BG/21 | Krill Fishery Report 2015<br>Secretariat |
| SC-CAMLR-XXXIV/BG/22 | 2018 International Conference on Assessing Status and Trends of Habitats, Key Species and Ecosystems in the Southern Ocean, Hobart, Tasmania, Australia<br>Delegation of Australia |
| SC-CAMLR-XXXIV/BG/23 | CCAMLR Observer Training Program Accreditation Scheme (COTPAS) Technical Peer Review Group (TPRG) comments on the Australian Observer Program Submission for COTPAS Accreditation<br>Chair of the Scientific Committee |
| SC-CAMLR-XXXIV/BG/24 | GEF proposal – progress report 2<br>Secretariat |

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| SC-CAMLR-XXXIV/BG/25 | Update on the ABNJ Deep Seas Project<br>FAO and CCAMLR Secretariats |
| SC-CAMLR-XXXIV/BG/26 | Calendar of meetings of relevance to the Scientific Committee in 2015/16<br>Secretariat |
| SC-CAMLR-XXXIV/BG/27 | Marine debris and entanglements at Bird Island and King Edward Point, South Georgia, Signy Island, South Orkneys and Goudier Island, Antarctic Peninsula 2014–2015<br>Delegation of the United Kingdom |
| SC-CAMLR-XXXIV/BG/28 | The Chinese national scientific observer program for the krill fishery in the Convention Areas from fishing season 2009/10 to 2014/15<br>Delegation of the People's Republic of China |
| SC-CAMLR-XXXIV/BG/29 | Strengthening the joint work of the CEP and SC-CAMLR on climate change<br>Submitted by ASOC |
| SC-CAMLR-XXXIV/BG/30 | Early announcement of the Third International Krill Symposium<br>Secretariat |
| SC-CAMLR-XXXIV/BG/31 | Sea ice characterisation of the proposed Ross Sea region Marine Protected Area Special Research Zone<br>S. Parker, S. Hoyle, S. Hanchet and R.J.C. Currey<br>(New Zealand) |
| SC-CAMLR-XXXIV/BG/32 | Observer's Report for the 2015 Annual Meeting of the Scientific Committee of the International Whaling Commission<br>(San Diego, CA, USA, 22 May to 3 June 2015)<br>CCAMLR Observer (R. Currey, New Zealand) |
| SC-CAMLR-XXXIV/BG/33 | Joint SC-CAMLR and SC-IWC Workshop, its format and draft Terms of Reference<br>Co-conveners of the Joint SC-CAMLR and SC-IWC Workshop |
| SC-CAMLR-XXXIV/BG/34 | Antarctic sea ice losses drive gains in benthic carbon drawdown<br>Delegation of the UK<br>*Current Biology*, 25, R1–R3 (2015) |

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| SC-CAMLR-XXXIV/BG/35 | Report to the Scientific Committee of CCAMLR by the Association of Responsible Krill Harvesting Companies (ARK)<br>Submitted by ARK |
| SC-CAMLR-XXXIV/BG/36 | Proposal for exploratory bottom longlining for toothfish by New Zealand vessels outside the bottom lining footprint during 2016 and 2017: Description of proposed activities and impact assessment (as submitted to the 3rd Meeting of the Scientific Committee of the South Pacific Regional Fisheries Management Organisation (SPRFMO), Port Vila, Vanuatu, 28 September to 3 October 2015, Document SC-03-DW-01_rev2)<br>Delegation of New Zealand |

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| CCAMLR-XXXIV/01 | Review of the compliance status given by SCIC at CCAMLR-XXXIII to the port inspection of the "*Hong Jin No. 701*" (KOR) conducted by Uruguay<br>Delegation of Uruguay |
| CCAMLR-XXXIV/02 | Vacant |
| CCAMLR-XXXIV/03 | Examination of the audited financial statements for 2014<br>Executive Secretary |
| CCAMLR-XXXIV/04 | Review of the 2015 Budget, Draft 2016 Budget and Forecast Budget for 2017<br>Executive Secretary |
| CCAMLR-XXXIV/05 | Notification fees<br>Secretariat |
| CCAMLR-XXXIV/06 | Trade data analysis proposal<br>Secretariat |
| CCAMLR-XXXIV/07 | Analysis of live untagged toothfish release<br>Secretariat |
| CCAMLR-XXXIV/08 | Climate change implications statements<br>Delegations of the United Kingdom and Norway |
| CCAMLR-XXXIV/09 | Independent Review of CCAMLR's Catch Documentation Scheme (CDS)<br>CDS Implementation Panel |

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| CCAMLR-XXXIV/10 | Review of Conservation Measure 10-04<br>VMS Technical Working Group |
| CCAMLR-XXXIV/11 | Harmonising CCAMLR's financial and conservation objectives in relation to the krill fishery<br>Delegation of the United Kingdom |
| CCAMLR-XXXIV/12 | Consideration of Renewal of the Arrangement between the Commission for the Conservation of Southern Bluefin Tuna (CCSBT) and the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR)<br>Secretariat |
| CCAMLR-XXXIV/13 | Consideration of Renewal of the Memorandum between the Agreement for the Conservation of Albatross and Petrels (ACAP) and the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR)<br>Secretariat |
| CCAMLR-XXXIV/14 | Executive Secretary's Report, 2015 including First Year Implementation Report for the Secretariat's Strategic Plan (2015–2018) and Implementation Report for the Staffing and Salary Strategy<br>Executive Secretary |
| CCAMLR-XXXIV/15 | Summary of action (2010–2015) and options for future work<br>Intersessional Correspondence Group – Sustainable Finance |
| CCAMLR-XXXIV/16 Rev. 1 | Proposal to establish formal cooperative arrangements between the South Pacific Regional Fisheries Management Organisation (SPRFMO) and the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR)<br>Secretariat |
| CCAMLR-XXXIV/17 Rev. 1 | Review of the CCAMLR regulatory framework and recommendations for streamlining fishery status<br>Chair of the Scientific Committee |
| CCAMLR-XXXIV/18 | Recommendation to commence discussions on a way to plan and organise the work of the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR)<br>Delegation of Australia |
| CCAMLR-XXXIV/19 | Updated MPA checklist proposal<br>Delegation of Japan |

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| CCAMLR-XXXIV/20 | Undertaking of a Second Performance Review<br>Delegation of the European Union |
| CCAMLR-XXXIV/21 | 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<br>Delegation of the European Union |
| CCAMLR-XXXIV/22 | Precautionary seasonal restrictions in fisheries for *Euphausia superba* in Area 48<br>Delegation of the European Union |
| CCAMLR-XXXIV/23 | Information on IUU fishing in the French EEZs around Kerguelen and Crozet and in CCAMLR Statistical Area 58<br>Delegation of France |
| CCAMLR-XXXIV/24 Rev. 1 | Prohibition of finning of sharks caught in the CAMLR Convention Area<br>Delegations of Argentina, Australia, Brazil, Chile, the European Union and the USA |
| CCAMLR-XXXIV/25 | Proposal for recording transhipment information in the *Dissostichus* Catch Document<br>Delegation of the USA |
| CCAMLR-XXXIV/26 | Proposal to revise the assessment of bottom fishing procedure in Conservation Measure 22-06<br>Delegation of the USA |
| CCAMLR-XXXIV/27 | Proposal to strengthen monitoring and control of transhipments<br>Delegation of the USA |
| CCAMLR-XXXIV/28 Rev. 2 | CCAMLR Symposium 2015<br>Delegations of Australia, Chile and the USA |
| CCAMLR-XXXIV/29 Rev. 1 | A proposal for the establishment of a Ross Sea Region Marine Protected Area<br>Delegations of New Zealand and the USA |
| CCAMLR-XXXIV/30 | Revisions to the draft East Antarctic Representative System of Marine Protected Areas (EARSMPA) Conservation Measure<br>Delegations of Australia, France and the European Union |

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| CCAMLR-XXXIV/31 | Establishing an Intersessional Correspondence Group (ICG) to consider approaches for appropriately integrating climate change into the work of the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR)<br>Delegations of Australia and Norway |
| CCAMLR-XXXIV/32 | Combatting IUU fishing in the Southern Ocean: international cooperation and information sharing<br>Delegation of New Zealand |
| CCAMLR-XXXIV/33 | Vessel Ice Classification: mandatory notification<br>Delegation of New Zealand |
| CCAMLR-XXXIV/34 | Comments on the final draft of the Conservation Measure on the establishment of an MPA in the East Antarctic System (EARSMPA)<br>Delegation of the Russian Federation |
| CCAMLR-XXXIV/35 Rev. 1 | Modification of Conservation Measure 51-06 proposed in order to increase scientific observation coverage in krill fisheries<br>Delegations of Chile and Norway |
| CCAMLR-XXXIV/36 Rev. 2 | Summary CCAMLR Compliance Report<br>Secretariat |
| CCAMLR-XXXIV/37 | IUU fishing activity and trends in 2014/15 and IUU Vessel Lists<br>Secretariat |
| CCAMLR-XXXIV/38 Rev. 2 | Report of the Standing Committee on Implementation and Compliance (SCIC) |
| CCAMLR-XXXIV/39 | Report of the Standing Committee on Administration and Finance (SCAF) |

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| CCAMLR-XXXIV/BG/01 | Patterns of change in Antarctica<br>Delegation of the United Kingdom |
| CCAMLR-XXXIV/BG/02 | Implementation of conservation measures in 2014/15: fishing and related activities<br>Secretariat |
| CCAMLR-XXXIV/BG/03 | Fishery notifications 2015/16<br>Secretariat |

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| CCAMLR-XXXIV/BG/04 | Description of the General Fund Budget<br>Secretariat |
| CCAMLR-XXXIV/BG/05 | Implementation of Conservation Measure 10-08 – Insurance of the IUU blacklisted vessel FV *Thunder*<br>Delegation of the UK |
| CCAMLR-XXXIV/BG/06 | Report from the CCAMLR Observer (European Union) to the Annual Meeting of the Inter American Tropical Tuna Commission (IATTC) (Guayaquil, Ecuador, 22 June to 3 July 2015)<br>CCAMLR Observer (European Union) |
| CCAMLR-XXXIV/BG/07 | Report from the CCAMLR Observer (European Union) to the International Commission for the Conservation of Atlantic Tunas (ICCAT) Annual Meeting (Genova, Italy, 10 to 17 November 2014)<br>CCAMLR Observer (European Union) |
| CCAMLR-XXXIV/BG/08 | Report from the CCAMLR Observer (European Union) to the Indian Ocean Tuna Commission (IOTC) Annual Meeting (Busan, Republic of Korea, 24 April to 1 May 2015)<br>CCAMLR Observer (European Union) |
| CCAMLR-XXXIV/BG/09 | Summary report<br>Thirty-eighth Antarctic Treaty Consultative Meeting (Sofia, Bulgaria, 1 to 10 June 2015)<br>Executive Secretary |
| CCAMLR-XXXIV/BG/10 | Discharge of offal in the Ross Sea – follow up to COMM CIRC 15/15–SC CIRC 15/06<br>Secretariat |
| CCAMLR-XXXIV/BG/11 Rev. 1 | Withdrawn |
| CCAMLR-XXXIV/BG/12 | Estimates of IUU toothfish catches in the 2014/15 season<br>Submitted by COLTO |
| CCAMLR-XXXIV/BG/13 | Calendar of meetings of relevance to the Commission in 2015/16<br>Secretariat |

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| CCAMLR-XXXIV/BG/14 | Report of the CCAMLR Observer to the Fifth Meeting of the Parties to the Agreement on the Conservation of Albatrosses and Petrels (ACAP), Santa Cruz de Tenerife, Spain, 4 to 8 May 2015<br>CCAMLR Observer (Australia) |
| CCAMLR-XXXIV/BG/15 | Report from the CCAMLR Observer to the Second Meeting of the Parties of the Southern Indian Ocean Fisheries Agreement (SIOFA), Flic en Flac, Mauritius, 17 to 20 March 2015<br>CCAMLR Observer (Australia) |
| CCAMLR-XXXIV/BG/16 | Heard Island and McDonald Islands Exclusive Economic Zone (Statistical Division 58.5.2) 2014–15 IUU catch estimate for Patagonian toothfish<br>Delegation of Australia |
| CCAMLR-XXXIV/BG/17 | Australia's actions and regional cooperation to combat IUU activities in the 2014/15 fishing season<br>Delegation of Australia |
| CCAMLR-XXXIV/BG/18 | Analysis of catch and effort data from the IUU fishing vessel *Kunlun*<br>Delegation of Australia |
| CCAMLR-XXXIV/BG/19 | Status Report – Macquarie Island Toothfish Fishery<br>Delegation of Australia |
| CCAMLR-XXXIV/BG/20 | Options for the sale of seized IUU catch by Non-Contracting Parties in support of the Non-Contracting Party Engagement Strategy – Discussion Paper<br>Delegation of Australia |
| CCAMLR-XXXIV/BG/21 | Monitoring, control and surveillance activities undertaken by New Zealand during 2014/15<br>Delegation of New Zealand |
| CCAMLR-XXXIV/BG/22 | Proposal by the Russian Federation to open Areas of Special Scientific Interest in three sectors of Antarctica in the CCAMLR Convention Area<br>Delegation of the Russian Federation |
| CCAMLR-XXXIV/BG/23 | Collaborating to eliminate Illegal, Unreported and Unregulated fishing in the Southern Ocean<br>Submitted by ASOC and COLTO |

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| CCAMLR-XXXIV/BG/24 | The International Code for Ships Operating in Polar Waters: Step 2 addressing fishing vessels<br>Submitted by ASOC |
| CCAMLR-XXXIV/BG/25 | Implementing Article II of the CAMLR Convention<br>Submitted by ASOC |
| CCAMLR-XXXIV/BG/26 | Revisiting CCAMLR's Approach to Management – A compendium of papers that explores the implementation of the CAMLR Convention<br>Submitted by ASOC |
| CCAMLR-XXXIV/BG/27 | The Ross Sea Region Marine Protected Area: Current proposal and looking forward<br>Submitted by ASOC |
| CCAMLR-XXXIV/BG/28<br>Rev. 1 | Ecosystem conservation and the race to krill<br>Submitted by ASOC |
| CCAMLR-XXXIV/BG/29 | Designation of Marine Protected Areas in Antarctic Waters<br>Delegation of the Russian Federation |
| CCAMLR-XXXIV/BG/30 | Designation of an MPA in East Antarctica<br>Delegation of the Russian Federation |
| CCAMLR-XXXIV/BG/31 | Principal Provisions of the Russian Federation Regarding the Establishment of an MPA in the Ross Sea<br>Delegation of the Russian Federation |
| CCAMLR-XXXIV/BG/32 | MPAs in the area regulated by the Convention on the Conservation of Antarctic Marine Living Resources (background, plans and reality)<br>Delegation of the Russian Federation |
| CCAMLR-XXXIV/BG/33 | The influence of ice conditions on the longline toothfish fishery in the Ross Sea and the likely impact that the introduction of marine protected areas (MPAs) will have on catches<br>Delegation of the Russian Federation |
| CCAMLR-XXXIV/BG/34 | Proposed amendments to Conservation Measure 51-06 (2014) General measure for scientific observation in fisheries for *Euphausia superba*<br>Delegation of Ukraine |

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| CCAMLR-XXXIV/BG/35 | 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<br>Delegation of Ukraine |
| CCAMLR-XXXIV/BG/36 | Implementation of CCAMLR's Vessel Monitoring System (VMS)<br>Secretariat |
| CCAMLR-XXXIV/BG/37 | Reflection Paper on a Proposal for a CCAMLR Weddell Sea Marine Protected Area (WSMPA)<br>Delegation of the European Union and its Member States |
| CCAMLR-XXXIV/BG/38 | Report from the CCAMLR Observer (United States) to the Eleventh Meeting of the Commission for the Conservation and Management of Highly Migratory Fish Stock in the Western and Central Pacific Ocean (WCPFC), Apia, Samoa, 1 to 5 December 2014<br>CCAMLR Observer (USA) |
| CCAMLR-XXXIV/BG/39 | Ross Sea region Marine Protected Area: Reporting, Periodic Review and Period of Designation Elements<br>Delegations of the USA and New Zealand |
| CCAMLR-XXXIV/BG/40 | Trial use of strain gauges to directly measure the green weight of krill caught<br>Delegation of Norway and the CCAMLR Secretariat |
| CCAMLR-XXXIV/BG/41 | Implementation of the Catch Documentation Scheme (CDS)<br>Secretariat |
| CCAMLR-XXXIV/BG/42 | Summary of activities of the Commission during the 2014/15 intersessional period – Report of the Chair<br>Chair of the Commission |
| CCAMLR-XXXIV/BG/43 | Report from the CCAMLR Observer (Norway) to the 37th Annual Meeting of the Northwest Atlantic Fisheries Organization (NAFO), Halifax, Canada, 21 to 25 September 2015<br>CCAMLR Observer (Norway) |
| CCAMLR-XXXIV/BG/44 | Report from the CCAMLR Observer (Norway) to the 2014 Annual Meeting of the North East Atlantic Fisheries Commission (NEAFC), London, UK, 10 to 14 November 2014<br>CCAMLR Observer (Norway) |

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| CCAMLR-XXXIV/BG/45 | Report from the CCAMLR Observer (Namibia) to the 2014 Annual Meeting of the South East Atlantic Fisheries Organisation (SEAFO), Windhoek, Namibia, 1 to 5 December 2014<br>CCAMLR Observer (Namibia) |
| CCAMLR-XXXIV/BG/46 | Actuaciones y compromiso de España para combatir y prevenir la actividad INDNR<br>Delegación de España |
| CCAMLR-XXXIV/BG/47 | Industry–Manager–Science Workshop on Feedback Management<br>Delegation of Norway |
| CCAMLR-XXXIV/BG/48 | Report from the CCAMLR Observer to the Extraordinary Meeting of the Parties of the Southern Indian Ocean Fisheries Agreement (SIOFA), Brussels, Belgium, 12 to 16 October 2015<br>CCAMLR Observer (Australia) |

Annex 3

## Agenda for the Thirty-fourth Meeting of the Scientific Committee

**Agenda for the Thirty-fourth 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 Commission

    3.2 Fish resources
        3.2.1 Status and trends
        3.2.2 Advice from WG-FSA
        3.2.3 Advice to 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 Commission

    3.4 New and exploratory finfish fisheries
        3.4.1 Exploratory fisheries in 2014/15 season
        3.4.2 Notifications for new and exploratory fisheries in 2015/16 season
        3.4.3 Progress towards assessments
        3.4.4 Advice to 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 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 Commission

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

6. IUU fishing in the Convention Area

7. CCAMLR Scheme of International Scientific Observation

   7.1 Scientific observations
   7.2 Advice to 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
      10.2.1 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 2014/15 and forecast budget for 2015/16

12. Advice to SCIC and SCAF

13. Scientific Committee activities

   13.1 Priorities for work of 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 Chair and Vice-Chair

16. Other business

17. Adoption of report of Thirty-fourth Meeting

18. Close of meeting.

Annex 4

**Report of the Meeting of the Subgroup on Acoustic Survey and Analysis Methods**
(Busan, Republic of Korea, 9 to 13 March 2015)

# Contents

**Report of the Meeting of the Subgroup**
**on Acoustic Survey and Analysis Methods**
(Busan, Republic of Korea, 9 to 13 March 2015)

## Introduction

1.1 The 2015 meeting of the Subgroup on Acoustic Survey and Analysis Methods (SG-ASAM) was held at the Haeundae Grand Hotel, Busan, Republic of Korea, 9 to 13 March 2015. The Convener, Dr X. Zhao (People's Republic of China) welcomed the participants (Appendix A). He also thanked Dr S.-G. Choi (Republic of Korea) and colleagues from Korea's National Fisheries Research and Development Institute (NFRDI) and Ministry of Ocean and Fisheries for hosting the meeting. Dr Zhao also thanked Dr R. Kloser for his participation in the meeting as an invited expert.

1.2 Dr Choi extended a very warm welcome to all participants. He stated that it was a great pleasure to host this meeting of SG-ASAM in the harbour city of Busan, the second largest city in Korea. Haeundae Beach, on the doorstep of the meeting, is a most beautiful and famous landmark. He wished all participants a happy stay in Busan and a productive and successful meeting.

1.3 The Subgroup has been considering the use of fishing-vessel-based acoustic data to provide qualitative and quantifiable information on the distribution and relative abundance of Antarctic krill (*Euphausia superba*) (SC-CAMLR-XXX, paragraphs 2.9 and 2.10; SC-CAMLR-XXXI, Annex 4). This meeting continued developing the protocols for collection and analysis of acoustic data collected on board fishing vessels and this work was guided by the following terms of reference (SC-CAMLR-XXXIII, paragraph 2.20):

1. Proof of Concept and Stage 2 (data collected during a range of vessel activities, speeds and weather conditions to assess more fully the quality and utility of acoustic data from commercial fishing vessels)

2. Protocols for data collection and analysis, with emphasis on Simrad echosounders (EK60, ES60/70)

   2.1 Data collection

   - Validation of instrument performance (internal and external reference target, with focus on the role of seabed as reference target for individual and inter-ship calibration, taking into account of inputs from fishing vessel masters)

   - Instructions on instrument setup

   - Work on protocols for data collection with other echosounder/sonars where applicable

2.2 Protocol for data screening and analysis

- Noise removal algorithms (standardized procedures)
- Data analysis (software-specific)
- Uncertainty evaluation methods

3. Analysis of data collected during fishing operations

- Spatial and Statistical treatment
- Potential input into WG-EMM on the use of fishing vessel based acoustic data in the 2015/16 multi-national effort as well as in feedback management (FBM) in general.

1.4 The meeting's provisional agenda was discussed, and the Subgroup agreed to extend the agenda to include an item on 'Other issues and future work'. The meeting agenda is in Appendix B.

1.5 Documents submitted to the meeting are listed in Appendix C. In addition, discussions during the meeting were also guided by presentations which are listed in Appendix C. The Subgroup thanked the authors of papers and presentations for their valuable contributions to the work of the meeting.

1.6 This report was prepared by A. Cossio (USA), O.R. Godø (Norway), D. Ramm and K. Reid (Secretariat), C. Reiss (USA), G. Skaret (Norway) and J. Watkins (UK). Sections of the report dealing with advice to the Scientific Committee are highlighted (see also 'Recommendations to the Scientific Committee').

## Review of proof of concept and stage 2

2.1 Dr Watkins presented an overview of a draft paper entitled 'The use of fishing vessels to provide acoustic data on the distribution and abundance of Antarctic krill and other pelagic species' which had been written by scientists involved in SG-ASAM and submitted recently to a special issue of *Fisheries Research* on 'Fishing vessels as scientific platforms'. This paper summarised the proof of concept study undertaken to date. The Subgroup agreed that this represented a very useful summary and an excellent way of informing a wider audience about the work of CCAMLR.

2.2 In particular, the Subgroup noted that stage 1 data had been submitted from vessels belonging to a large portion of the fleet engaged in krill fishing in the Convention Area.

2.3 The Subgroup agreed that the range of acoustic data submitted from krill fishing vessels to date had met the objectives of the proof of concept study, fully demonstrating the ability to collect acoustic data from fishing vessels to provide data on the abundance and distribution of krill over time and space scales that were not available using conventional research surveys.

2.4 Stage 2 data have not been formally requested as yet although some data had been submitted and various analyses of acoustic data collected from fishing vessels had been submitted by Norway, the Republic of Korea and China. The Subgroup therefore focused its discussion on the actions needed to be undertaken to move to the next stage of the development of protocols and recommendations for data collection, data processing and data analysis as illustrated in the road map shown in Figure 1 of the SG-ASAM-14 report (SC-CAMLR-XXXIII, Annex 4).

2.5 The Subgroup noted that once the system is set up, then logging digital data is simple and low cost. It therefore agreed that the preferred option for stage 2 data and beyond was to log the echosounder continuously during the period the fishing vessel is within the subarea(s) it is licenced to fish for krill.

2.6 The Subgroup agreed that collecting acoustic data in this way from all krill fishing vessels capable of recording digital data would allow the most comprehensive assessment of variation in data quality under different conditions and activities.

2.7 The Subgroup agreed that to facilitate this data collection, the following actions were needed:

(i) define a complete range of metadata required to describe and interpret the acoustic data

(ii) create a complete document of instructions that provides sufficient detail to enable vessels to collect the acoustic data and the appropriate metadata

(iii) provide a listing of nominated transects for collecting acoustic data.

2.8 The Subgroup considered the hierarchy of metadata in the ICES (2013) document on metadata standards and an example of operational acoustic metadata that can be found at http://imos.org.au/badoc.html. The Subgroup noted that the metadata hierarchy comprises the following broad categories of metadata:

(i) metadata compiled for each vessel that can be collected at the time of notification and licensing

(ii) metadata required for instruments (detailing the echosounder for collecting the data being submitted)

(iii) metadata required to describe a particular voyage that can be collected from vessel monitoring system (VMS) and catch data

(iv) metadata generated during the analysis process(es), the details of this will be developed as the analyse protocols are developed.

2.9 The Subgroup agreed that accurate metadata was essential to the use of acoustic data and noted that the hierarchy of metadata was important to identify and minimise the essential elements that needed to be collected at the time the data were collected as there were many elements that could be extracted from information already supplied to CCAMLR, such as in the vessel licensing, notification, catch data and the raw acoustic data. An efficient process for metadata collection and entry should be designed to ensure that information is not duplicated and, once entered, metadata should only need to be entered again if values are changed.

2.10 While the examples referenced in paragraph 2.8 illustrate the potential complexity of a fully operational metadata system, the Subgroup noted that the reality for the metadata collection required from the fishing vessel during fishing was limited to recording the start and end times of nominated transects.

2.11 The Subgroup agreed that ancillary data, such as sea state or wind force, were essentially a proxy measure for vessel motion. Information about ship motion might help explain changes in the quality of acoustic data, but the same weather conditions might have very different effects on the quality of acoustic data from different ships. It was noted that ship motion logging is used in the Integrated Marine Observation System (IMOS) bioacoustics to correct the data as it has important implications for acoustic estimation at mesopelagic depths (200–1 000 m).

2.12 The Subgroup agreed that the main determination of whether particular acoustic data were suitable to be used for a particular purpose would be based on the quality of the acoustic data itself, rather than a particular value in the ancillary data. Therefore, the collection of specific ancillary data was not obligatory at this stage.

2.13 The Subgroup agreed that determining when a vessel was fishing was possible using the catch and effort (C1) data that is already submitted to CCAMLR. Other activities, such as searching or relocating, were difficult to determine, however, they could be determined in the analysis stage on the basis of speed and course.

2.14 The Subgroup noted that there would also be metadata that would be required for particular methods of processing and analysis of the submitted acoustic data and that these metadata requirements would need to be specified as those detailed processing steps were agreed at future meetings.

2.15 The Subgroup prepared an instruction manual for the collection of fishing-vessel-based acoustic data, based on discussion at this and previous meetings (2012 and 2014). This manual facilitates the collection of data to provide qualitative and quantifiable information on the distribution and relative abundance of krill (Appendix D).

2.16 The Subgroup agreed that collecting acoustic data on CCAMLR transects (SC-CAMLR-XXXIII, Annex 4, Table 2) was a priority activity. Recognising that there is a large number of such transects, the Subgroup selected a subset of these from each subarea on the basis of their biological and oceanographic interest. The Subgroup agreed that, in order to use the data collected along these nominated transects to investigate temporal variation in krill abundance, the transects should be sampled as frequently as possible during fishing (Table 1).

2.17 To facilitate the detection of these nominated transect data within the acoustic data collected continuously during the period the fishing vessel is within the subarea(s) it is licenced to fish, it was agreed that nominated transect metadata (subarea, transect numbers, start and end times) should be recorded during the voyage.

## Protocols for data collection and analysis

Protocols for data collection and analysis, with emphasis
on Simrad echosounders (EK60, ES60/70)

3.1 The Subgroup recalled from the SG-ASAM-14 meeting that work to establish data collection protocols for Simrad echosounders had started, but that some elements of the protocols needed evaluation and others required further exploration and development subsequent to intersessional work on the issues.

Data collection

3.2 The Subgroup welcomed Dr Kloser who described the acoustic data components of the Australian IMOS as an example of how scientific data from vessels of opportunity can be collected, stored and distributed. The Subgroup agreed on the importance of benefitting from the knowledge base generated by IMOS to more efficiently develop the collection of acoustic data from the krill fishing fleet in CCAMLR.

3.3 The IMOS program uses vessels of opportunity to acquire high-quality basin-scale data with focus on the mid-trophic level.

3.4 The development of the program included a proof-of-concept phase which showed that the data collected had the potential to provide valuable information about different aspects of ecosystem state at several temporal and spatial scales. A required part of the implementation of the program was also the development and documentation of protocols for calibration, data collection, processing, metadata and indicators.

3.5 At present, 23 vessels are providing acoustic data for the program, collecting data on various numbers of echosounder frequencies. The selection of vessels is based on their ability to carry out annual sphere calibrations, conducting repeated transects, ease of interaction with the vessels and the cost of processing the data.

3.6 Dr Kloser highlighted the amount of work invested in the data processing at various levels. Automated correction for absorption and sound velocity with depth as well as motion corrections are added to the data for each frequency. Evaluation and removal of noise is also an essential part of the processing and algorithms are run for removing spike noise, intermittent noise, background noise and handling attenuation. The algorithms need to be tuned to suit the data and the output needs to be monitored. In addition, there are macro data issues, including loss of GPS signal, incorrect clocks (i.e. vessel time), limitations to the spike filters and limitations due to attenuation. Presently, eight of the 23 vessels collect 70% of the data which are used, and some vessels are not able to produce reliable acoustic data for use in the program.

3.7 Systems for data storage and making data available have been developed in IMOS and the data are now open for free use by the scientific community.

3.8 Dr Watkins presented an update on the status of the Southern Ocean Network of Acoustics (SONA) project, which aims at implementing a self-sustaining, long-term acoustic observing strategy of the mid-trophic level (krill, zooplankton and other pelagic organisms) in the Southern Ocean. This international project has several of the same goals as IMOS, including developing common standards and methodologies for acoustic data collection and processing, and creating an open-access database of acoustic observations of the mid-trophic level. Several international partners involved in SG-ASAM are also involved in SONA, and the minimum requirement to enter the SONA partnership is to share the data with the other partners.

3.9 SONA has developed techniques for extraction of metadata from EK60 raw data, and the project holds a database with calibrated $S_v$ data stored in 5 m vertical × 500 m horizontal resolution which allows for different techniques to be used for target identification. SONA has also adopted several of the IMOS techniques for noise removal, but some of them require tuning to work consistently on the data which have been tested so far.

3.10 The Subgroup noted that since several initiatives for large-scale data collection existed, common conventions for metadata formats should be encouraged. The Subgroup also agreed on the importance of the metadata, the processing history and the processing algorithms being available to the users for all the data.

3.11 The Subgroup agreed that CCAMLR's existing rules for data access and use applied to data collected on krill fishing vessels and that the application of these rules to acoustic data should be formally clarified with data owners and providers.

3.12 Three potential storage locations of the data were discussed: the CCAMLR Secretariat, national institutions and data collection programs like SONA and IMOS. The Subgroup agreed that, although the Secretariat might be one of the storage locations of raw acoustic data, it may be more appropriate to give the Secretariat access to these data from other storage locations. It further agreed that instead of developing its own framework for storage, searching and distribution of data, CCAMLR should draw on the development taking place in IMOS and SONA.

## Validation of instrument performance

3.13 The Subgroup recalled from last year's meeting that it was recommended to study alternative calibration methods to standard sphere calibration. Even though such methods might be less accurate than sphere calibration, they should be simpler to carry out and, thereby, allow more fishing vessels to be calibrated and provide CCAMLR with more acoustic data suitable for a greater range of analyses.

3.14 In particular, the Subgroup requested studies using seabed as reference target and encouraged Members to collect such data for further development of the method.

3.15 Dr Skaret presented a study on using the seabed for acoustic calibration with reference to data collected on the Norwegian-flagged krill fishing vessel *Juvel* in the South Orkney Islands krill surveying area, as well as on board the RV *G.O. Sars* in a Norwegian fjord. The data from the Southern Ocean were collected using a sphere-calibrated ES60 echosounder system running 38, 70 and 120 kHz transducers. Two different reference stretches at about 100 m and 300 m depth were used, and data from 2012 and 2015 were compared. The results showed high consistency within experiments, but were not consistent when compared between years.

3.16 The Subgroup noted that the integrated backscatter was generally lower in 2015 than in 2012, even though the echosounders had undergone a standard sphere calibration prior to both experiments. At present, it is not known whether the difference is caused by instrument performance or changes in bottom reflection. Also, it was noted that there was a larger difference between 38 kHz and 70 kHz at location 2 (300 m) compared to location 1 (100 m), which is probably caused by depth.

3.17 Dr Skaret noted that there have been some problems with the sensitivity of the 38 kHz transducer, which were discovered during the sphere calibration in 2012. This has impacted the results from the seabed calibration. He further noted that this work is at present inconclusive and in progress and will be continued during upcoming surveys.

3.18 Dr Kloser suggested using area backscattering instead of volume backscattering of the bottom echo as the data then would be independent of depth. He further indicated that, instead of using median, comparing mean values might be more appropriate and the Subgroup agreed that reanalysing the data taking this into account would be useful.

3.19 The Subgroup discussed various properties of the candidate seabed calibration location to be considered:

- depth should not be so great that the background noise is a problem in the analysis. The depth at which background noise interferes with seabed calibration will be frequency specific

- the bottom signal is impacted by the movement of the vessel and this could be monitored by recording the motion of the vessel or analysing the phase angle of the bottom signal

- it would be useful to know the bottom type along the reference stretch as this might explain variation in backscattering

- each calibration site should be characterised according to its acoustic backscattering properties.

3.20 The Subgroup also discussed using a fixed location versus transects for seabed calibration and agreed that both approaches might be valuable and welcomed contributions from Members to elucidate the issue.

3.21 The Subgroup emphasised that the sphere calibration still represents the benchmark method for validation of echosounder data. However, the Subgroup noted that the seabed calibration method had the potential to be very valuable as:

(i) a quick system check of acoustic system performance for vessels which have already had their echosounders sphere calibrated earlier in the season or in previous seasons

(ii) an alternative calibration method for uncalibrated vessels through inter-vessel comparisons

accepting that the results from (ii) will have uncertainties associated with them and would not be appropriate for stock assessment but could be used for distributional and other studies.

3.22 Recognising that the desirability of having acoustic data from vessels that have undertaken a standard sphere calibration, the Subgroup discussed the potential for designating a list of preferred calibration sites in each subarea that could be used by fishing vessels to undertake such a calibration.

3.23 The Subgroup requested the Secretariat to investigate the potential to provide sets of calibration equipment that could be kept at research bases near each calibration site at Cumberland Bay, South Georgia; Scotia Bay, South Orkney Islands; and Admiralty Bay, South Shetland Islands.

3.24 Dr M. Kang (Republic of Korea) described two challenges associated with standard sphere calibrations of Simrad ES60 echosounders:

- ES60 echosounders add a triangular wave noise function in the transceiver to degrade the signal. While such a noise function has no overall effect on echo-integration at the survey level, it can cause a problem during calibration. Dr Kloser noted that software available from CSIRO can be used to remove this systematic noise.

- Although angle information from the sphere is visible on the screen, there is no calibration procedure in the ES60 software. Data therefore have to be logged and post-processed in software such as Echoview before the calibration coefficients can be estimated.

### Instructions on instrument setup

3.25 The Subgroup recognised that the requirement of instrument setup on board fishing vessels might differ for both nominated transects and periods of fishing operations and reviewed the recommendations for instrument settings given in Table 5 and Appendix D of the SG-ASAM-14 report (SC-CAMLR-XXXIII, Annex 4). The Subgroup agreed that the maximum data collection range should be increased from 1 000 to 1 100 m to enable more efficient noise removal without decreasing the ping rate interval set at 2 seconds (see Appendix D, Table 2, for nominated transects).

3.26 The Subgroup encouraged all Members to use the instruction manual (Appendix D), including, where possible, translation into the language used on the vessel, and to implement the data-collection procedures in the manual in their krill fishing fleet in the present season. The experience from such an exercise would provide useful guidance for possible future modifications.

### Data screening and analyses

#### Noise removal algorithms (standardised procedures)

3.27 The Subgroup recalled last year's discussion recommending the study of noise removal methods in relation to data collected from the fishery which were considered more likely to be contaminated by noise than data from scientific vessels.

3.28 Dr Zhao presented the work carried out in SG-ASAM-15/02. The work was presented in a generalised framework (see presentation, Appendix C) which served as an example for documenting and reporting noise removal.

3.29 Dr Kang presented the application of a noise removal technique on a very noisy example of acoustic data of a dense aggregation.

3.30 The Subgroup welcomed both presentations and acknowledged that there was a principle difference between removing noise in contaminated data, and filling in data gaps using adjacent mean values, which was presented as part of the noise-removal algorithms. While the mean value is likely to be similar, the variability is reduced when data-filling methods are used. The Subgroup therefore advised Members to report how much of the data has been removed or filled in.

3.31 The Subgroup recognised that filling in discarded pings could be useful and may be necessary for estimating swarm geometry and behaviour. However, the Subgroup agreed that the statistical implications of this process need to be factored into analyses using such data.

3.32 The Subgroup agreed that information on background noise is very useful to record, and is important information for noise-removal algorithms to work properly and for reviewing data quality in general. Procedures developed by Simrad to evaluate background noise based on data collected with the echosounder in passive mode are available and the Subgroup encouraged the submission of such information for evaluation.

3.33 The Subgroup encouraged further work on noise removal, but agreed that the ideal solution is to identify the source of the noise and eliminate it. The Subgroup noted that interference from other acoustic instruments could be a major source of noise and that synchronising such instruments could eliminate this noise.

3.34 The Subgroup welcomed the range of approaches presented and recognised the desirability for a standard set of protocols for noise removal. Members were encouraged to compare and evaluate the performance of their algorithms.

3.45 Dr Kloser noted that the experience from the IMOS project had revealed that uncertainty in data output from vessels of opportunity is typically difficult to quantify appropriately, and that both negative bias can be introduced due to a low signal-to-noise ratio and positive bias due to, for instance, contaminating signals from interfering instruments. A ‘traffic light approach’ where data from each vessel is categorised according to simple quality criteria could be a useful approach in such a case to address the uncertainty.

3.36 The Subgroup welcomed the presentation from Dr Godø of a software program developed at the Institute of Marine Research (IMR) in LabView for synchronising signal triggering between two Simrad sonars, Simrad EK60 echosounders and a Furuno sonar. The software is available upon request from IMR.

Data analysis (software-specific)

3.37 Dr Skaret presented SG-ASAM-15/01, where the R-package EchoviewR (Harrison et al., 2015) allows for efficient automated acoustic data processing in Echoview via the

Echoview COM protocol. The package presently contains 46 functions and is freely available for download. The automated procedure considerably reduces the manual and supervised part of the processing time and decreases the risk of subjective errors in the processing. As an example, the package allows for automation of several key processing steps for obtaining a biomass estimate from an acoustic krill biomass estimation survey, including the krill identification through the dB-difference method. The package presently does not allow for automatic noise removal.

3.38 The Subgroup welcomed the method of automated processing and agreed that it was useful, in particular, that open-source processing tools would increase the ability for different groups to make use of the tools, including the Secretariat.

3.39 The Subgroup recognised that a full model implementation of the stochastic distorted-wave Born approximation (SDWBA) for target strength (TS) estimation, as recommended in the CCAMLR protocol for krill biomass estimation, is at present only implemented and available on the Matlab platform, and encouraged Members to work on a version of the package to be available in open-source software.

## Analysis of data collected during fishing operations

4.1 Dr H. Lee (Republic of Korea) presented examples of acoustic data from two Korean fishing vessels: the *Sejong* running Simrad ES70 38 and 200 kHz and the *Kwang Jae Ho* running ES70 38 and 120 kHz, which had been fishing in the South Orkney Islands and Bransfield area in 2013/14. The data were collected using the settings of SC-CAMLR-XXXIII, Annex 4, Table 5. The presentation included an example of noise removal on 200 kHz data following the noise-removal scheme described in SG-ASAM-15/02.

4.2 The Subgroup thanked Dr Lee for the presentation and in particular noted that the quality of the example data was very good given the sampling range and the frequency. Dr Lee noted that the whole dataset will be processed and analysed as part of future work.

4.3 The Subgroup noted that high-quality data had been collected by a national observer and encouraged all Members to include appropriate training in their observer training programs to ensure that observers can include acoustic data collection in their tasks when on the vessel.

4.4 Dr Reiss noted that the vessels had been transiting the Bransfield Strait on several occasions along lines of similar length and direction as the transect lines comprised in designed surveys. The information from the acoustic recording along such lines could be used to evaluate krill density, and if repeated several times through a season, the temporal development of krill density, which is highly relevant information for the krill management. The Subgroup agreed that this demonstrates the high relevance and applicability of data collected by the fishing fleet.

4.5 SG-ASAM-15/03 summarised an analysis that simulated the use of data that might be available from the commercial fishery (using single-frequency acoustic data and varying length-frequency distributions of krill) on estimates of krill biomass in the South Shetland Islands. The analysis showed that significant variability in relative biomass estimates can be obtained when length-frequency data are truncated and used in different survey areas and with different acoustic frequencies. The authors showed that models developed using a wide length-frequency distribution (Elephant Island) could be used to estimate biomass from other areas where the length frequency of animals is skewed towards larger animals, but differed considerably when length frequencies were skewed towards smaller animals that the commercial fishery might not sample efficiently. They emphasised that it is possible to develop semi-empirical models of krill biomass at 120 kHz frequency that can be used to augment research acoustic surveys if proper survey design and calibration of transducers is maintained and if time series are sufficiently long to average out differences among years.

4.6 The Subgroup thanked the authors of SG-ASAM-15/03 and noted that acoustic properties of the 38 kHz or 70 kHz transducers may provide more stable estimates for these single-frequency applications. The Subgroup also noted that it may be necessary to revisit the automated dB differencing approach in order to ensure high-quality data.

4.7 Dr Godø presented preliminary analyses from acoustic data collected during the 2011 fishing season by the Norwegian fishing vessels around the South Orkney Islands. He provided a variety of results highlighting the wide utility of commercial acoustic data for understanding spatio–temporal variability in krill on the fishing grounds and its potential use in developing ideas for FBM. The Subgroup concluded that the breadth of analyses demonstrated the richness and utility of krill acoustic data collected by the fishery. The Subgroup encouraged further exploration of the data and its combination with data from a range of sources to better understand how to reflect local fishing conditions and/or broader spatial patterns of krill behaviour and incorporation into statistical models and operational procedures and analyses for FBM.

4.8 Dr Godø also presented an alternative use of acoustic data from the fisheries, where the dB-difference technique had been used to filter krill out of the echogram and visual inspection of the remaining echo traces was used to quantify diving activity of penguins. He noted that, while the method and analysis was still at an exploratory stage, it held promise and could potentially provide a link between krill monitoring and land-based predator monitoring.

4.9 The Subgroup welcomed the work examining predator foraging using acoustic data and noted that the analysis was carried out on raw data. While aggregated data are still appropriate to use for biomass estimation, the present work would not have been possible to be carried out using aggregated data. This illustrated the requirement for data to be archived at a level of resolution which suited their intended use.

Spatial and statistical treatment

4.10 There were no papers submitted under this agenda item. The Subgroup discussed the recent increase in publications that could provide insights into novel analysis techniques for incorporating commercially acquired acoustic data into the assessment and management process. Dr Kloser provided a bibliography of recent literature on this topic which will be placed on the SG-ASAM e-group for participants to update.

4.11 The Subgroup agreed that data exploration and research analyses benefit from a range of statistical and analytical approaches. However, analyses that provide outcomes for use in management would need to follow pre-agreed analytical procedures, and insight from other working groups (WG-EMM, WG-SAM, WG-FSA) could provide useful input into the development of appropriate statistical analyses.

Potential input into WG-EMM on the use of fishing vessel-based acoustic data in the 2015/16 multinational effort

4.12 The Subgroup reviewed the status of preparations for the 2015/16 multinational survey with respect to acoustic data collection and agreed that repeat occupation of nominated transects lines in different fishing areas should be a priority for participating fishing vessels, as repeated sampling of those transects would provide comparability with existing data.

4.13 The Subgroup noted that China, the Republic of Korea, Norway and the UK will all conduct coordinated research, including using commercial fishing vessels, in 2015/16.

4.14 The Subgroup strongly supported the proposed research by these nations and encouraged the exchange of ideas and relevant information (such as planned cruise dates for research vessels) to all interested Members through WG-EMM and through the 2016 Multi-Member Research e-group on the CCAMLR website.

## Other issues and future work

Instruction manual

5.1 The Subgroup agreed that the manual (Appendix D) should be made available as a stand-alone document on the CCAMLR website in order that it can be trialled in the current fishing season. The Subgroup also encouraged feedback from users which may improve the instructions.

Future work

5.2 The Subgroup recalled Figure 1 of SC-CAMLR-XXXIII, Annex 4, which set out its future work program. The next task identified in that program was the development of a protocol for data analysis. The Subgroup agreed that this would consist of:

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

5.3 The Subgroup recognised that other issues may arise due to feedback from data collection and analyses in the current fishing season, noting that this process for collection and use of data from the krill fishery is still in a developmental phase.

## 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 to communicate the outcomes of the Subgroup meeting, especially the manual in Appendix D (see paragraphs 3.26 and 5.1) and the desirability of training scientific observers to collect acoustic data (paragraph 4.3).

6.2 Advice to the Scientific Committee on how acoustic data collected by fishing vessels might contribute to the 2015/16 multinational research effort and 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 the extensive intersessional activities which had advanced the development of protocols for using fishing-vessel-based acoustic data. Dr Zhao also thanked Dr Choi and his team for the excellent support and generous hospitality during the meeting. The Subgroup thanked Dr Zhao for convening the meeting.

## References

Harrison, L.-M.K., M.J. Cox, G. Skaret and R. Harcourt. 2015. The R package EchoviewR for automated processing of active acoustic data using Echoview. *Front. Mar. Sci.*, 2:15, doi: 10.3389/fmars.2015.00015.

ICES. 2013. A metadata convention for processed acoustic data from active acoustic systems. SISP 3 TG-AcMeta, ICES WGFAST Topic Group, TG-AcMeta. 35 pp.

Table 1: Way points for the nominated transects for the collection of acoustic data in Subareas 48.1, 48.2 and 48.3.

| Subarea | Transect | Waypoint 1 | | Waypoint 2 | |
|---|---|---|---|---|---|
| | | Longitude | Latitude | Longitude | Latitude |
| 48.1 | T2 | 62°30.00'W | 62°00.00'S | 61°30.00'W | 62°30.00'S |
| | T3 | 62°00.00'W | 61°45.00'S | 61°00.00'W | 62°15.00'S |
| | T13 | 54°30.00'W | 60°00.00'S | 54°30.00'W | 61°45.00'S |
| | T14 | 54°00.00'W | 60°00.00'S | 54°00.00'W | 61°03.00'S |
| | T16 | 60°30.00'W | 63°00.00'S | 59°30.00'W | 63°30.00'S |
| | T17 | 60°00.00'W | 62°45.00'S | 59°00.00'W | 63°15.00'S |
| 48.2 | T3 | 46°30.00'W | 59°40.20'S | 46°30.00'W | 60°28.80'S* |
| | T4 | 45°45.00'W | 59°40.20'S | 45°45.00'W | 60°28.80'S |
| 48.3 | T5 | 38°26.94'W | 53°13.25'S | 38°13.22'W | 53°55.61'S |
| | T6 | 38°08.42'W | 53°11.11'S | 37°54.40'W | 53°53.42'S |
| | T9 | 36°15.62'W | 54°05.73'S | 35°15.19'W | 53°41.49'S |
| | T10 | 36°10.50'W | 54°10.35'S | 35°09.80'W | 53°46.26'S |

* Northern section only.

Appendix A

## List of Participants

Subgroup on Acoustic Survey and Analysis Methods
(Busan, Republic of Korea, 9 to 13 March 2015)

| | |
|---|---|
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Appendix B

# Agenda

Subgroup on Acoustic Survey and Analysis Methods
(Busan, Republic of Korea, 9 to 13 March 2015)

1. Introduction

    1.1 Opening of the meeting
    1.2 Adoption of the agenda
    1.3 Modification/adoption of meeting agenda

2. Review proof of concept: stage 2

3. Protocols for data collection and analysis, with emphasis on Simrad echosounders (EK60, ES60/70)

    3.1 Data collection
        3.1.1 Validation of instrument performance
        3.1.2 Instructions on instrument setup
        3.1.3 Work on protocols for data collection with other echosounder/sonars where applicable

    3.2 Data screening and analysis
        3.2.1 Noise removal algorithms (standardised procedures)
        3.2.2 Data analysis (software-specific)
        3.2.3 Uncertainty evaluation methods, including data quality/data loss

4. Analysis of data collected during fishing operations

    4.1 Spatial and statistical treatment
    4.2 Potential input into WG-EMM on the use of fishing vessel-based acoustic data in the 2015/16 multinational effort as well as in FBM in general

5. Other issues and future work

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
(Busan, Republic of Korea, 9 to 13 March 2015)

| | |
|---|---|
| SG-ASAM-15/01 | Automated data processing using Echoview<br>M.J. Cox (Australia), G. Skaret (Norway), L.-M.K. Harrison and R. Harcourt (Australia) |
| SG-ASAM-15/02 | A noise removal algorithm for acoustic data with strong interference based on post-processing techniques<br>X. Wang, X. Zhao and J. Zhang (People's Republic of China) |
| SG-ASAM-15/03 | Semi-empirical acoustic estimates of krill biomass derived from simulated commercial fishery data based on single-frequency acoustics<br>A.M. Cossio, G.W. Watters, C.S. Reiss, J. Hinke and D. Kinzey (USA) |
| | *************** |
| Presentations | Acoustic and catch data collected by the fleet – relevance for Feedback Management<br>O.R. Godø, G. Skaret and T. Klevjer (Norway) |
| | Quantitative assessment of diving birds in fishing locations using vessel acoustics<br>T. Klevjer, O.R. Godø, G. Skaret and B. Krafft (Norway) |
| | Overview of IMOS bioacoustic program using ships of opportunity<br>R. Kloser, T. Ryan, G. Keith and R. Downie (Australia) |
| | Procedures for removing noises and strong interferences in acoustic data based on Echoview post processing software<br>X. Wang, X. Zhao and J. Zhang (People's Republic of China) |
| | Software developed at IMR for synchronising pinging of various acoustic instruments<br>O.R. Godø (Norway) |

Southern Ocean Network of Acoustics
S. Fielding, A. Tate (UK), M. Cox, R. Kloser, T. Ryan (Australia), P. Brehmer, N. Behagle (France), G. Skaret, R. Korneliussen (Norway), R. O'Driscoll, A. Dunford (New Zealand), C. Reiss, A. Cossio (USA) and J. Thomas (SONA data manager) (presented by J. Watkins)

ES60/70 center calibration using Echoview
M. Kang (Republic of Korea)

Interference noise removal method
M. Kang (Republic of Korea)

Acoustic data from Korean krill fishing vessels
H. Lee (Republic of Korea)

Appendix D

**Instruction manual for the collection of fishing-vessel-based acoustic data Version 1.0 16 March 2015**

**Preface**

This manual is to be used by the person(s) who are responsible for the collection of raw acoustic data on board krill fishing vessels operating in the CAMLR Convention Area. The specific instruments covered by this manual are limited to Simrad ES60, Simrad ES70 and Simrad EK60 echosounders.

The data collected according to this manual, whether during specially designed surveys along nominated transits or during fishing operation (including searching for suitable fishing aggregation and steaming to another fishing area), are potentially very valuable and may be used to provide qualitative and quantifiable information on the distribution and relative abundance of Antarctic krill (*Euphausia superba*). This information is fundamental to CCAMLR's approach to management.

The manual consists of:

Chapter 1: A brief overview of what data should be collected, where and when it should be collected and finally how it should be collected

Chapter 2: Validation of instrument performance.

For further details please contact your national technical coordinator or Scientific Committee Representative or contact the CCAMLR Secretariat (ccamlr@ccamlr.org).

Thank you for taking the time to record these important data.

# Chapter 1

## A brief overview of recommendations for data collection

**What data should be collected**: raw acoustic data and supporting metadata describing the acoustic data and cruise should be collected. The actual acoustic data needs to have the correct metadata (the data about the data) in order to be useable. In many cases the required metadata is already available in other details submitted to CCAMLR and the need for additional data has been minimised to make the task easier.

**Where data should be collected:** Acoustic data, together with supporting metadata, should be collected in all of the areas for which the vessel has been licenced to fish for krill. The acoustic data collected along the nominated transects (in Table 1), as well as in the areas in which fishing actually occurs, are seen as a high priority.

**When data should be collected:** Acoustic data collection should begin as the vessel enters the Convention Area and be continued until the vessel leaves. Collecting data throughout the entire fishing trip is required to build up a picture of temporal variability and change in krill abundance and distribution. In particular, given the importance of the nominated transects in building up patterns of temporal variability, repeating these nominated transects as often as possible during the cruise is recommended.

**How data should be collected:** Raw acoustic data should be logged to a hard drive. The echosounder should be configured using the key settings detailed in Table 2.

Table 1: Waypoints for the nominated transects for the collection of acoustic data in Subareas 48.1, 48.2 and 48.3. Maps showing the location of the nominated transects are in Figure 1. Note that transects T5 and T6 could be run as a transect pair, running up one transect and down the other. Similarly, T9 and T10 could be run as a transect pair.

| Subarea | Transect | Waypoint 1 | | Waypoint 2 | |
|---|---|---|---|---|---|
| | | Longitude | Latitude | Longitude | Latitude |
| 48.1 | T2 | 62°30.00'W | 62°00.00'S | 61°30.00'W | 62°30.00'S |
| | T3 | 62°00.00'W | 61°45.00'S | 61°00.00'W | 62°15.00'S |
| | T13 | 54°30.00'W | 60°00.00'S | 54°30.00'W | 61°45.00'S |
| | T14 | 54°00.00'W | 60°00.00'S | 54°00.00'W | 61°03.00'S |
| | T16 | 60°30.00'W | 63°00.00'S | 59°30.00'W | 63°30.00'S |
| | T17 | 60°00.00'W | 62°45.00'S | 59°00.00'W | 63°15.00'S |
| 48.2 | T3 | 46°30.00'W | 59°40.20'S | 46°30.00'W | 60°28.80'S* |
| | T4 | 45°45.00'W | 59°40.20'S | 45°45.00'W | 60°28.80'S |
| 48.3 | T5 | 38°26.94'W | 53°13.25'S | 38°13.22'W | 53°55.61'S |
| | T6 | 38°08.42'W | 53°11.11'S | 37°54.40'W | 53°53.42'S |
| | T9 | 36°15.62'W | 54°05.73'S | 35°15.19'W | 53°41.49'S |
| | T10 | 36°10.50'W | 54°10.35'S | 35°09.80'W | 53°46.26'S |

* Northern section only.

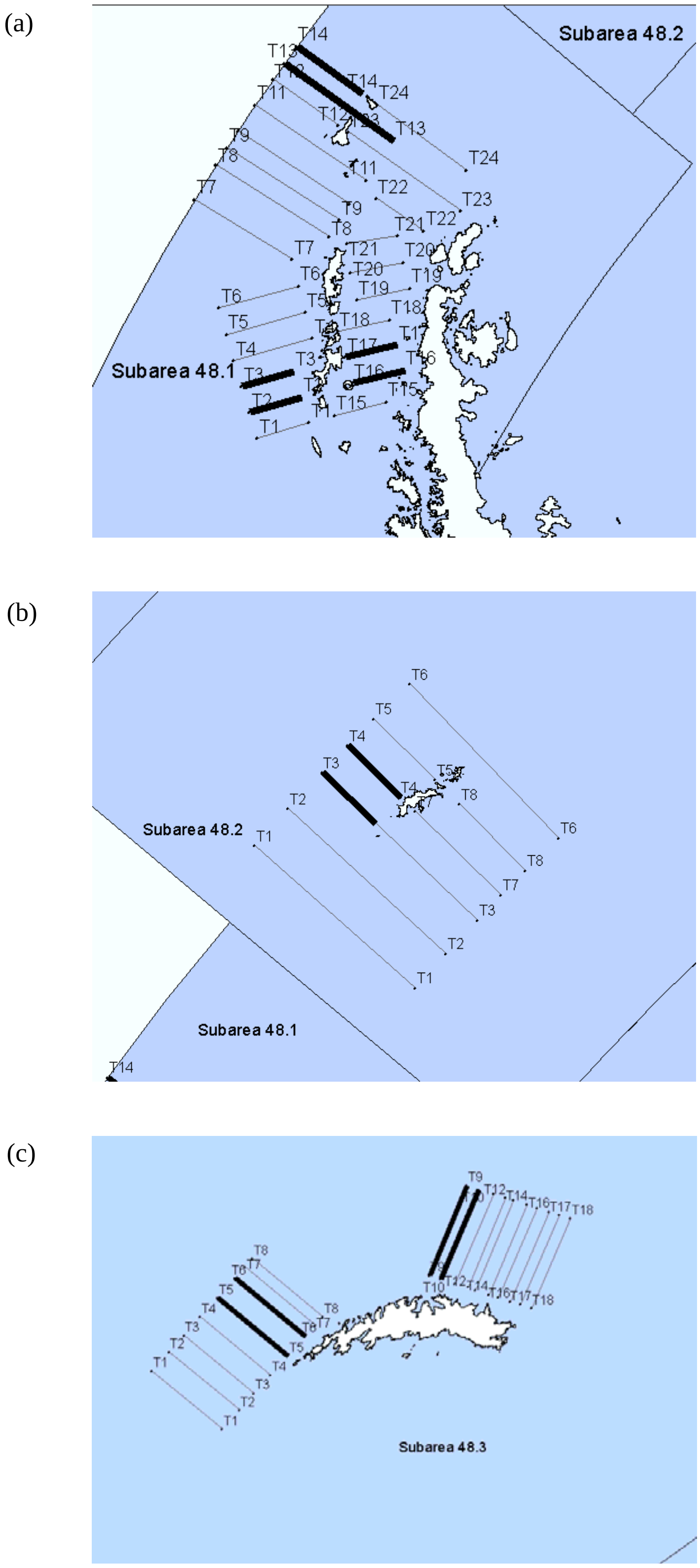



Figure 1: Location of nominated transects (thick black lines) and existing research transects for the collection of acoustic data in: (a) Subarea 48.1, (b) Subarea 48.2 and (c) Subarea 48.3.

# Data Logging Instructions

## 1. System requirements

### 1.1 Echosounder

A properly functional Simrad ES60, Simrad ES70 or Simrad EK60.

### 1.2 Data logging device

An external hard drive with a minimum data storage capacity of 2 Tb. The actual volume of data stored depends on the number of frequencies used and the duration of the time in the Convention Area. The external hard drive is to be used both for data backup and for data delivery. It is advisable to have two hard drives in order to have a backup in case of failure of one drive.

### 1.3 Navigation device

A global positioning system (GPS) (with data output) connected to the echosounder.

## 2. Instrument parameter settings

The instrument parameters should be set according to Table 2, and should not be changed, except the display range.

Table 2: Instrument setting for data collection (modified from SC-CAMLR-XXXIII, Annex 4, Table 5).

| **Parameter** | Unit | Setting | | | |
|---|---|---|---|---|---|
| Frequency | kHz: | 38 | 70 | 120 | 200 |
| Power* | W | 2000 | 700 | 250 | 110 |
| Pulse duration | microsecond | 1024 | 1024 | 1024 | 1024 |
| Ping interval | second | 2 | 2 | 2 | 2 |
| Data collection range (min.–max.) | m | 0–1100 | 0–1100 | 0–1100 | 0–1100 |
| Bottom detection range (min.–max.) | m | 5–1100 | 5–1100 | 5–1100 | 5–1100 |
| Display range (min.–max.) | m | 0–1100 | 0–1100 | 0–1100 | 0–1100 |

* based on Korneliussen et al., 2008

## 3. Operational instruction

This set of instructions describes how to set up the echosounder for data collection. While the descriptions are primarily referring to Simrad ES60, they are similarly applicable to Simrad ES70 and Simrad EK60. Where differences do exist, please refer to the instruction manual of the specific echosounder used.

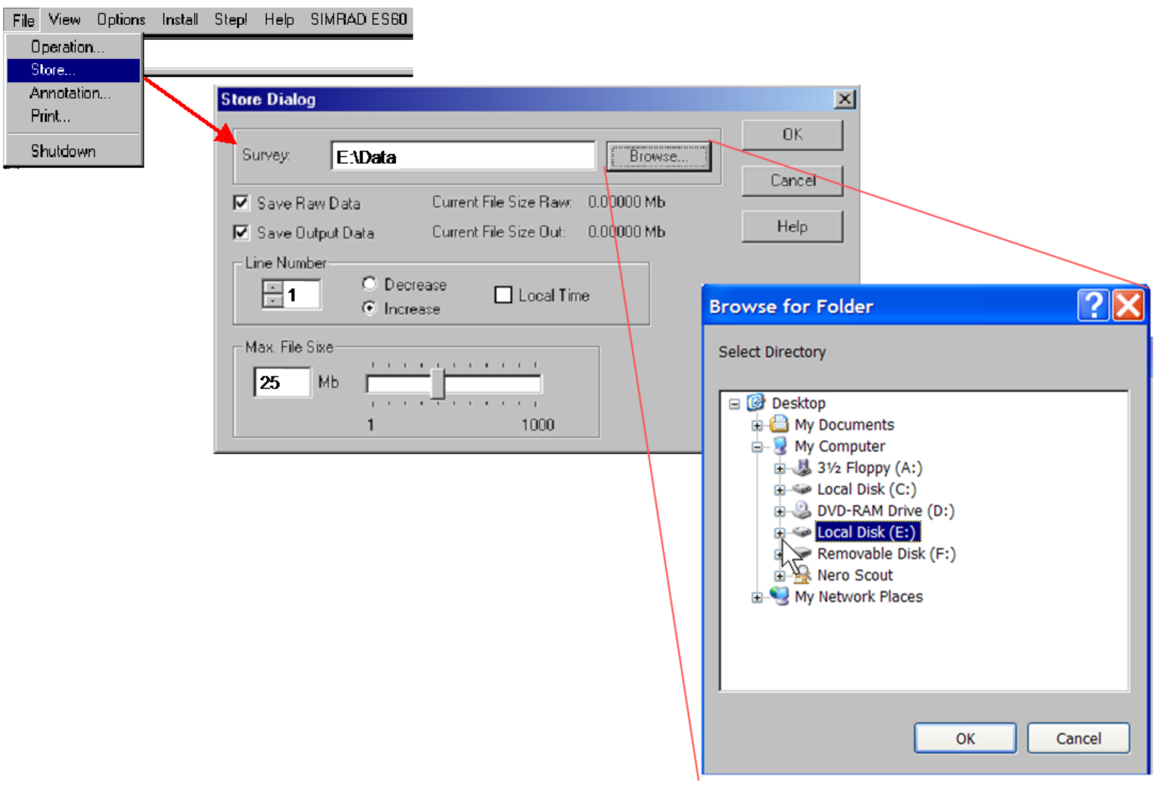
### System settings

- Set data to log to a folder on the external USB hard drive
- Set ES60 PC clock to UTC and reset against GPS time source
- Log data while you are in the Convention Area.

Details on how to set up and adjust these settings are given below in steps 1 to 6.

1) Set logging directory

On the very top left-hand side of the ES60 screen, click File/Store and then the Browse button to navigate to the externally attached hard drive and select a suitable folder for the logged data. Set the file size to 25 MB and uncheck the box that says 'Local time'.




**Tip:** USB drive letter will not be C and is unlikely to be D, and is probably E on most installations. Supplied drives will most likely have a folder \Data. If so, log to this folder, i.e. E:\Data*.

**Tip:** If you need to set up a logging directory, hold down the Windows key on the keyboard ( ) and press E. This will bring up Windows Explorer. You can then find your way to the USB hard drive and create a folder to log to.

**Tip:** Hold down the Alt key and press the Tab key. This will take you back to the ES60 software.

* For ES70 and EK60 recommend that the vessel uses the call sign as file suffix to the recorded data.

2) Set echosounder power and pulse duration for each frequency available

On the top of the ES60 screen, right-click on the text ‘38 kHz’, ‘120 kHz’ or ‘200 kHz’ to bring up the transceiver settings dialog. Set the power to 2 000 W (38 kHz), 700 W (70 kHz)**,** 250 W (120 kHz) or 110 W (200 kHz), ping interval to 2.0 s and the pulse length to 1 024 microseconds and click OK.

3) Set display range

Set the display range from 0 to 1 100 m by right-clicking on the right-hand side of the ES60 screen.

4) Set bottom detection range

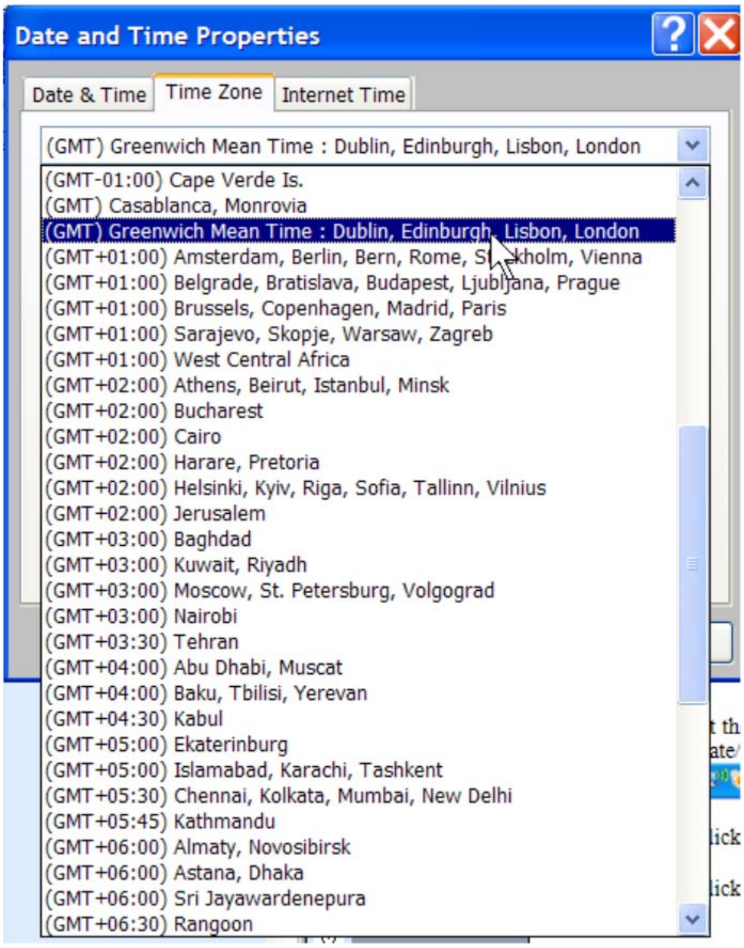
Set the bottom detection to start at 5 m and finish at 1 100 m. **Note**: if this reading is needed for navigational purposes, the depth setting should be reset.

5) Set the ES60 PC clock to UTC

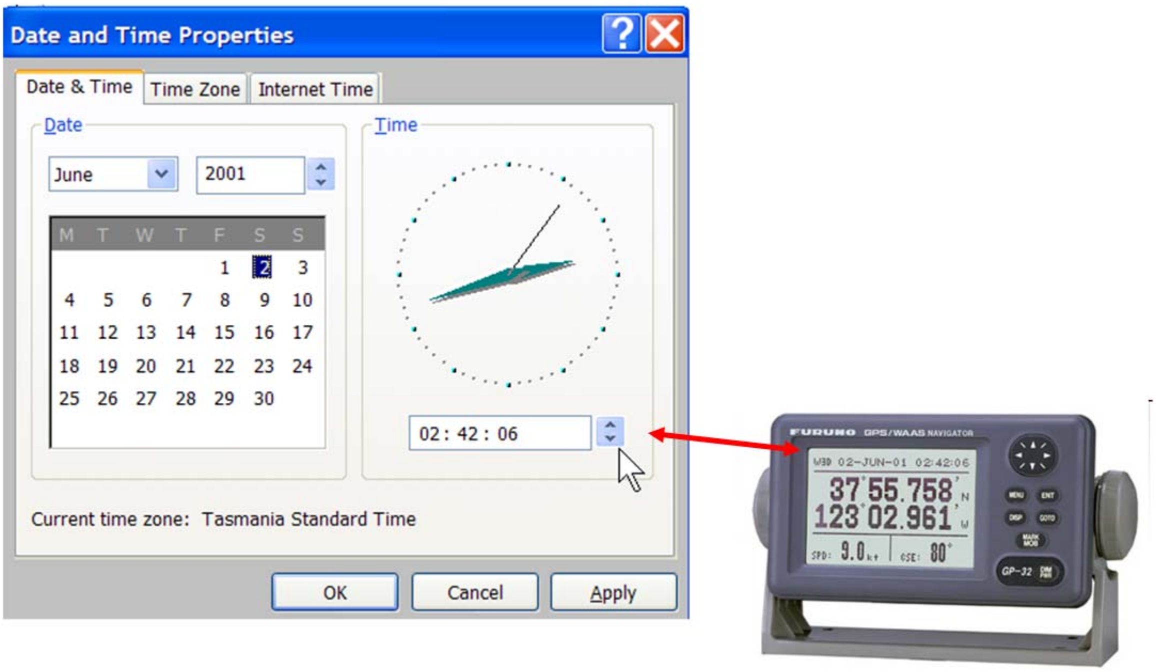
Hold the Windows key ( ) and press M to get to the ES60 PC’s desktop.

At the bottom right-hand side of the screen, double-click on the time readout to bring up the Date/Time dialog.


Click on the Time Zone tab. Select GMT from the pick list and click OK.

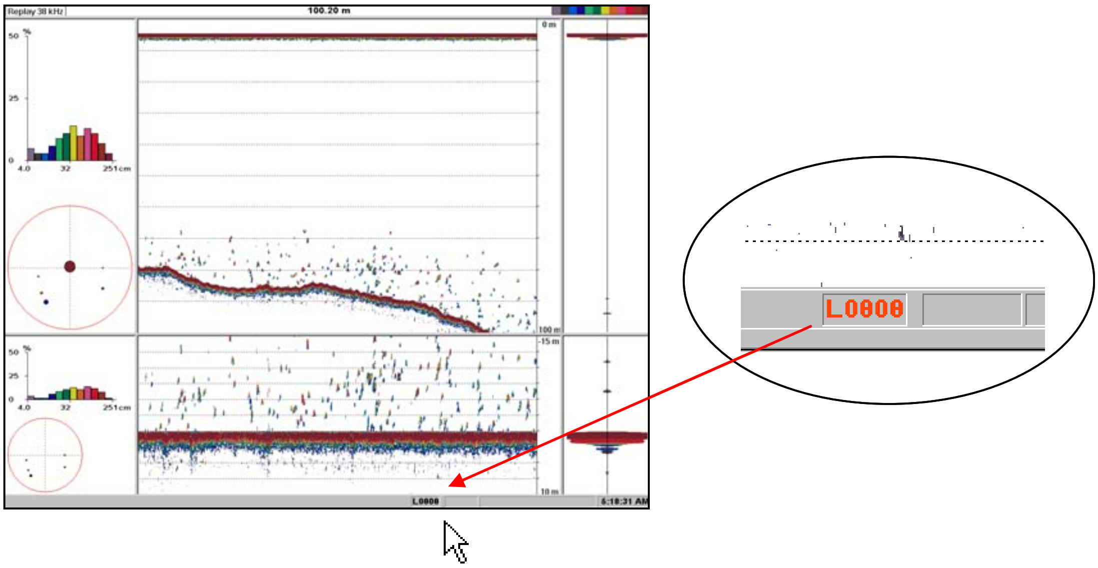



Click on the Date & Time tab. Reset the time to match the UTC time from a GPS readout.



6) Commence logging

Alt-Tab back to the ES60 software. At the bottom right-hand side, click on the text ‘L000..’. This should turn from black to red to indicate logging has commenced.




<u>**Tip:** Turn off other sounders when logging in transects to avoid unwanted interference.</u>

## 4. Metadata requirements

Metadata contains important information that is an essential element of the data logged and should be delivered together with the data collected.

Please fill in Table 3 at the beginning and the end of data collection. When data has been collected along nominated transects as listed in Table 1 and shown in Figure 1, please fill in the relevant metadata also. The location and waypoints for all existing acoustic transects are given in SC-CAMLR-XXXIII, Annex 4, Figure 2, and are included here (as Figure 2 and Table 4) for reference.

Table 3: Metadata required during cruise and running nominated transects.

| | | | |
|---|---|---|---|
| Vessel name | | | |
| Vessel call sign | | | |
| Cruise start date (dd/mm/yy) | | | |
| Cruise end date (dd/mm/yy) | | | |
| Subarea | Transect number (ID) | Start datetime (UTC) | End datetime (UTC) |
| | | | |
| | | | |

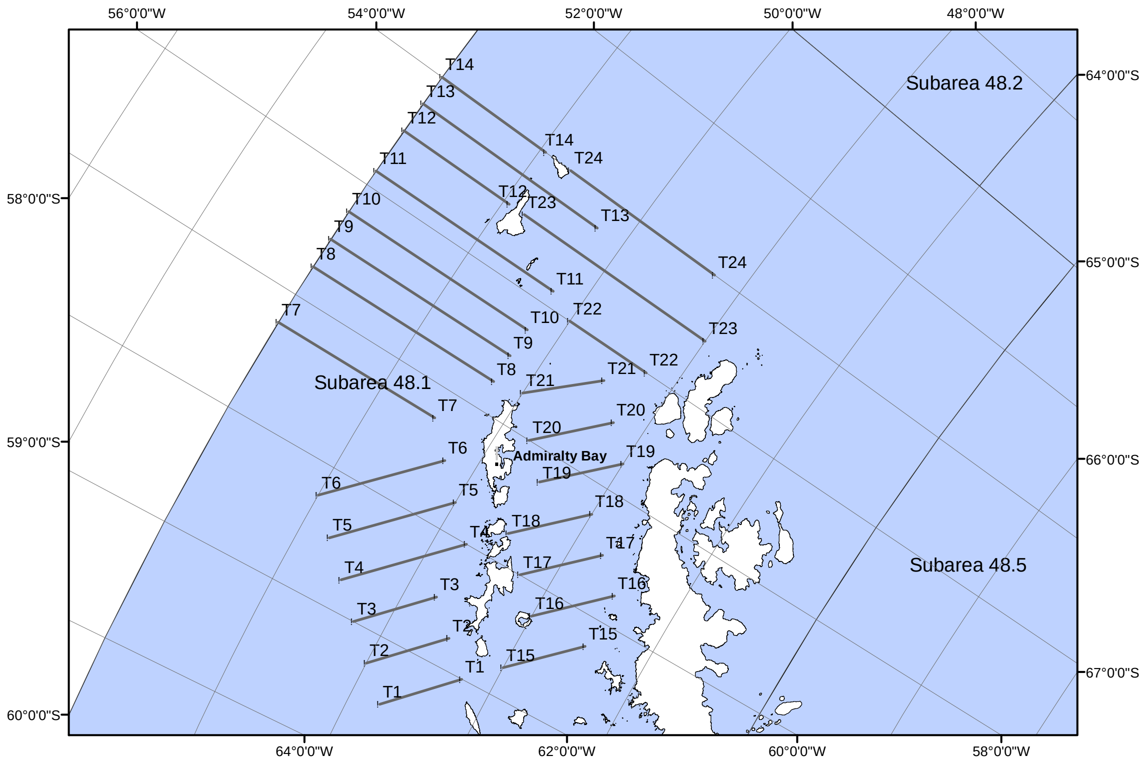



Figure 2(a): Location of acoustic transects (T1 to T24) and the calibration site (Admiralty Bay) at the South Shetland Islands (Subarea 48.1). The positions of the start and end of the transects are listed in Table 1 (copied from SC-CAMLR-XXXIII, Annex 4).

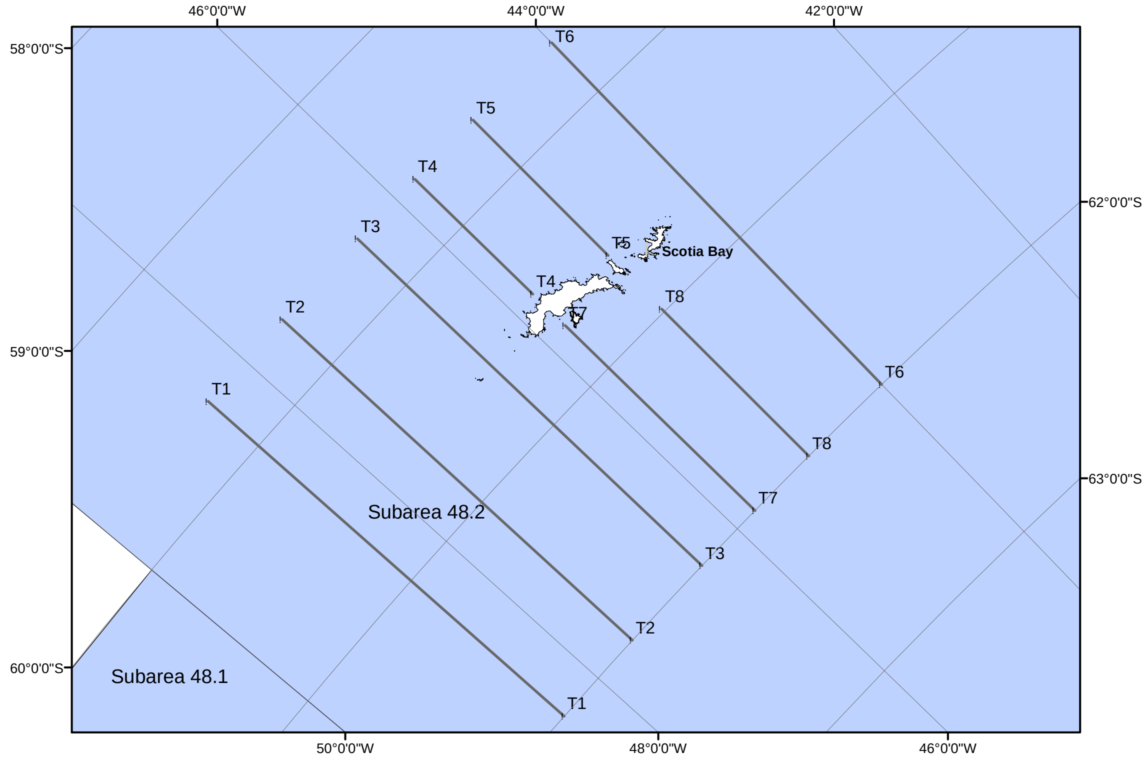



Figure 2(b): Location of acoustic transects (T1 to T8) and the calibration site (Scotia Bay) at the South Orkney Islands (Subarea 48.2). The positions of the start and end of the transects are listed in Table 1 (copied from SC-CAMLR-XXXIII, Annex 4).

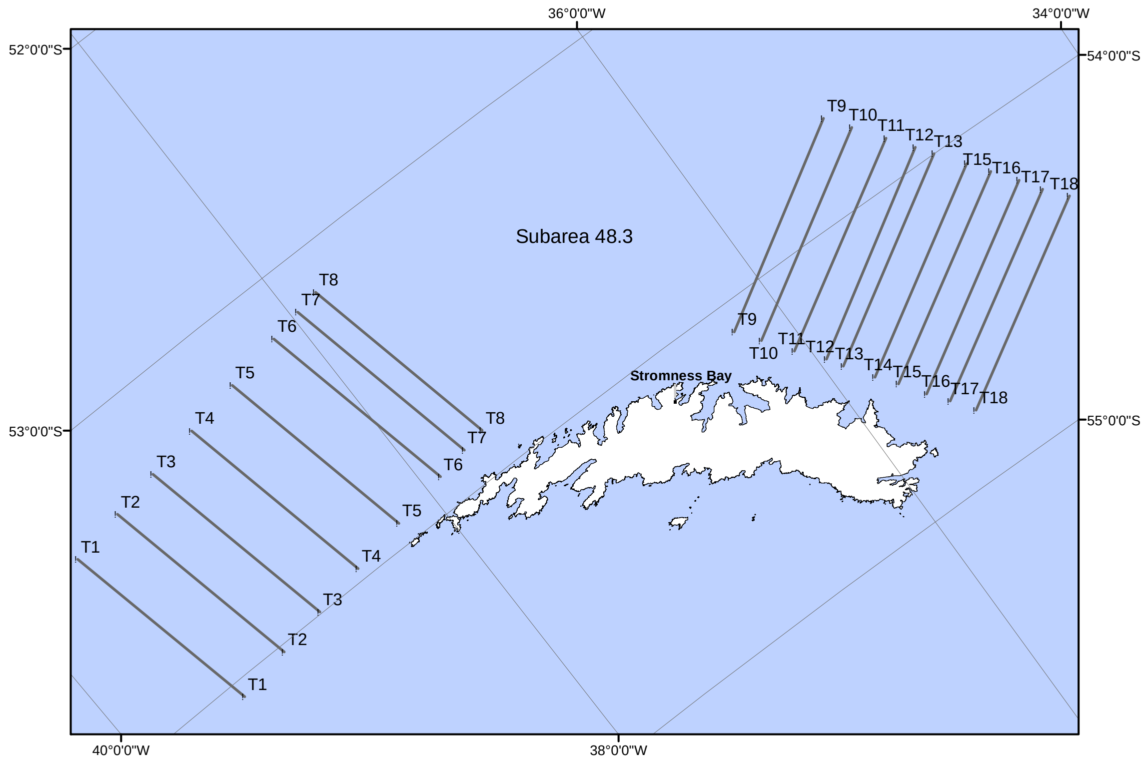



Figure 2(c): Location of acoustic transects (T1 to T18) and the calibration site (Stromness Bay) at South Georgia (Subarea 48.3). The positions of the start and end of the transects are listed in Table 1 (copied from SC-CAMLR-XXXIII, Annex 4).

Table 4: Waypoints (dd mm.00) of the acoustic transects that are part of existing krill acoustic surveys in Subareas 48.1, 48.2 and 48.3 (copied from SC-CAMLR-XXXIII, Annex 4). See also Figure 2.

| Subarea | Transect | Waypoint 1 | | Waypoint 2 | |
|---|---|---|---|---|---|
| | | Longitude | Latitude | Longitude | Latitude |
| 48.1 | T1 | 63°00.00'W | 62°15.00'S | 62°00.00'W | 62°45.00'S |
| | T2 | 62°30.00'W | 62°00.00'S | 61°30.00'W | 62°30.00'S |
| | T3 | 62°00.00'W | 61°45.00'S | 61°00.00'W | 62°15.00'S |
| | T4 | 61°30.00'W | 61°30.00'S | 60°00.00'W | 62°15.00'S |
| | T5 | 61°00.00'W | 61°15.00'S | 59°30.00'W | 62°00.00'S |
| | T6 | 60°30.00'W | 61°00.00'S | 59°00.00'W | 61°45.00'S |
| | T7 | 58°30.00'W | 60°00.00'S | 58°30.00'W | 61°30.00'S |
| | T8 | 57°30.00'W | 60°00.00'S | 57°30.00'W | 61°45.00'S |
| | T9 | 57°00.00'W | 60°00.00'S | 57°00.00'W | 61°45.00'S |
| | T10 | 56°30.00'W | 60°00.00'S | 56°30.00'W | 61°45.00'S |
| | T11 | 55°45.00'W | 60°00.00'S | 55°45.00'W | 61°45.00'S |
| | T12 | 55°00.00'W | 60°00.00'S | 55°00.00'W | 61°03.00'S |
| | T13 | 54°30.00'W | 60°00.00'S | 54°30.00'W | 61°45.00'S |
| | T14 | 54°00.00'W | 60°00.00'S | 54°00.00'W | 61°03.00'S |
| | T15 | 61°30.00'W | 63°00.00'S | 60°30.00'W | 63°30.00'S |
| | T16 | 60°30.00'W | 63°00.00'S | 59°30.00'W | 63°30.00'S |
| | T17 | 60°00.00'W | 62°45.00'S | 59°00.00'W | 63°15.00'S |
| | T18 | 59°30.00'W | 62°30.00'S | 58°30.00'W | 63°00.00'S |
| | T19 | 58°30.00'W | 62°30.00'S | 57°30.00'W | 63°00.00'S |
| | T20 | 58°00.00'W | 62°15.00'S | 57°00.00'W | 62°45.00'S |
| | T21 | 57°24.00'W | 62°00.00'S | 56°30.00'W | 62°30.00'S |
| | T22 | 56°00.00'W | 62°00.00'S | 56°00.00'W | 62°45.00'S |
| | T23 | 55°00.00'W | 61°12.00'S | 55°00.00'W | 63°00.00'S |
| | T24 | 54°00.00'W | 61°18.00'S | 54°00.00'W | 62°45.00'S |
| 48.2 | T1 | 48°30.00'W | 59°40.20'S | 48°30.00'W | 62°00.00'S |
| | T2 | 47°30.00'W | 59°40.20'S | 47°30.00'W | 62°00.00'S |
| | T3 | 46°30.00'W | 59°40.20'S | 46°30.00'W | 62°00.00'S |
| | T4 | 45°45.00'W | 59°40.20'S | 45°45.00'W | 60°28.80'S |
| | T5 | 45°00.00'W | 59°40.20'S | 45°00.00'W | 60°36.60'S |
| | T6 | 44°00.00'W | 59°40.20'S | 44°00.00'W | 62°00.00'S |
| | T7 | 45°45.00'W | 60°42.00'S | 45°45.00'W | 62°00.00'S |
| | T8 | 45°00.00'W | 60°58.80'S | 45°00.00'W | 62°00.00'S |
| 48.3 | T1 | 39°36.14'W | 53°20.83'S | 39°23.51'W | 54°03.32'S |
| | T2 | 39°18.25'W | 53°18.94'S | 39°05.34'W | 54°01.40'S |
| | T3 | 39°02.29'W | 53°17.22'S | 38°49.14'W | 53°59.64'S |
| | T4 | 38°45.05'W | 53°15.31'S | 38°31.61'W | 53°57.70'S |
| | T5 | 38°26.94'W | 53°13.25'S | 38°13.22'W | 53°55.61'S |
| | T6 | 38°08.42'W | 53°11.11'S | 37°54.40'W | 53°53.42'S |
| | T7 | 37°57.86'W | 53°09.85'S | 37°43.67'W | 53°52.15'S |
| | T8 | 37°49.93'W | 53°08.90'S | 37°35.62'W | 53°51.19'S |
| | T9 | 36°15.62'W | 54°05.73'S | 35°15.19'W | 53°41.49'S |
| | T10 | 36°10.50'W | 54°10.35'S | 35°09.80'W | 53°46.26'S |
| | T11 | 36°04.15'W | 54°15.94'S | 35°03.05'W | 53°51.92'S |
| | T12 | 35°57.60'W | 54°21.02'S | 34°57.42'W | 53°56.79'S |
| | T13 | 35°54.68'W | 54°24.11'S | 34°53.74'W | 53°59.99'S |
| | T14 | 35°48.65'W | 54°29.60'S | 34°47.35'W | 54°05.35'S |
| | T15 | 35°43.98'W | 54°33.43'S | 34°42.54'W | 54°09.38'S |
| | T16 | 35°38.65'W | 54°38.34'S | 34°36.98'W | 54°14.02'S |
| | T17 | 35°33.94'W | 54°42.22'S | 34°32.50'W | 54°18.15'S |
| | T18 | 35°29.00'W | 54°46.67'S | 34°26.85'W | 54°22.33'S |

## Chapter 2

## Validation of Instrument Performance

1) External assessment of echosounder performance

Standard sphere calibration

If possible, a standard sphere calibration utilising the techniques described in Foote et al. (1987) should be carried out. Locations where regular calibrations have been carried out previously are given in Table 5.

Table 5: Positions (dd mm.00) of regularly used calibration sites in Subareas 48.1, 48.2 and 48.3. See also Figure 2.

| Subarea | Calibration site | Position | |
|---|---|---|---|
| | | Longitude | Latitude |
| 48.1 | Admiralty Bay | 58°26.58'W | 62°08.10'S |
| 48.2 | Scotia Bay | 44°40.86'W | 60°44.88'S |
| 48.3 | Stromness Bay | 36°40.02'W | 54°09.30'S |

2) Seabed reflection calibration

CCAMLR is currently investigating the use of seabed reflection as another way of externally assessing echosounder performance. A protocol for such assessments will be added to this part of the document once it becomes available.

3) Internal assessments of echosounder performance

Internal validation procedures to monitor basic system performance are being developed or documented and will be added here once available.

### References

Korneliussen, R.J., N. Diner, E. Ona, L. Berger and P.G. Fernandes. 2008. Proposals for the collection of multifrequency acoustic data. *ICES J. Mar. Sci.*, 65: 982–994.

Foote, K.G., H.P. Knudsen, G. Vestnes, D.N. MacLennan and E.J. Simmonds. 1987. Calibration of acoustic instruments for fish density estimation: a practical guide. *ICES Coop. Res. Rep.*, 144: 69 pp.

Annex 5

**Report of the Working Group on**
**Statistics, Assessments and Modelling**
(Warsaw, Poland, 29 June to 3 July 2015)

## Contents

**Report of the Working Group on**
**Statistics, Assessments and Modelling**
(Warsaw, Poland, 29 June to 3 July 2015)

## Opening of the meeting

1.1 The 2015 meeting of WG-SAM was held at the Ministry of Agriculture and Rural Development, Warsaw, Poland, from 29 June to 3 July 2015. The meeting was convened by Dr S. Parker (New Zealand).

1.2 Mr L. Dybiec (Ministry of Agriculture and Rural Development and former Chair of the Commission), Dr M. Kaniewska-Krolak (Ministry of Agriculture and Rural Development) and Dr M. Korczak-Abshire (Institute of Biochemistry and Biophysics of the Polish Academy of Sciences) welcomed the Working Group and outlined local arrangements.

1.3 Dr Parker welcomed participants (Appendix A) and noted the large number of papers received this year and the large workload that had been directed to the Working Group.

### Adoption of the agenda and organisation of the meeting

1.4 WG-SAM discussed the agenda and agreed to include an item on Future work (Item 6). The revised agenda was adopted (Appendix B).

1.5 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.

1.6 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.

1.7 The report was prepared by M. Belchier (UK), A. Constable (Australia), R. Currey (New Zealand), C. Darby (UK), A. Dunn (New Zealand), T. Earl (UK), C. Jones (USA), D. Ramm, K. Reid and L. Robinson (Secretariat), M. Söffker (UK), D. Welsford and P. Ziegler (Australia).

## Methods for assessing stocks in established fisheries

### A review of progress towards updated integrated assessments of toothfish

2.1 WG-SAM-15/24 presented a CASAL assessment of research block 5843a_1 that included tag-release and recapture data from 2005 to 2014 and the sensitivity analyses recommended by WG-FSA-14.

2.2 The Working Group noted that the relatively high number of fish tagged in 2012 and the subsequent recaptures of those fish strongly influenced the model conclusions and, as a consequence, these data had been excluded from some model runs. However, the Working Group agreed that models that included all the tag data were preferred and requested that consideration be given to additional data analyses that may lead to an understanding of the high level of tag recaptures from 2012.

2.3 The Working Group noted that the model should include stock-specific life-history parameters and age data, when these are available, and requested that model sensitivities be considered that included available age and growth data (e.g. as described in WG-SAM-15/11). Further, the Working Group requested additional model sensitivity analyses that considered the impact on results if the future depth distribution of fisheries were to change.

2.4 WG-SAM-15/25 presented a CASAL assessment for research block 5844b_1 in Division 58.4.4b. The analysis included five model runs, including alternative choices of the catch-per-unit-effort (CPUE) and tag datasets and alternative choices of selectivity for illegal, unreported and unregulated (IUU) fishing. The paper suggested excluding the 2008 tag and CPUE data. The Working Group noted the additional analyses recommended by WG-FSA-14.

2.5 The Working Group noted that IUU catch had been estimated in the model, and these estimates indicated that IUU catch much greater than the research catch had occurred over recent years. The Working Group requested that WG-FSA consider these results and other sources of information on IUU activity in the region to determine the best estimate of IUU catch to include in this assessment.

2.6 The Working Group agreed that the CPUE from 2008 was likely to reflect learning behaviour of the fishery and hence may not be an index of abundance. However, it also noted that the tag data from 2008 should be retained within the assessment model. It requested that model runs be carried out that examine the sensitivity to the 2008 tag data, along with the IUU selectivity modelled as a double-normal function.

2.7 The Working Group noted that the assessment model did not include any consideration of potential impacts on the stock from depredation, and methods to incorporate this into the assessment of toothfish in this division should be explored.

2.8 The Working Group inferred from results presented in WG-SAM-15/25 that it was possible that the catch limit calculated from the CCAMLR decision rule would lead to this stock being below 50% of initial biomass for a large number of years before recovering. The Working Group requested that projections be presented to WG-FSA for this assessment that examine the consequences of different harvest levels for the time to recovery to the target level.

2.9 The Working Group requested that Members provide analyses for discussion on the question of how to provide management advice for stocks that are expected to fall below target levels during the 35-year projection period to WG-SAM-16.

2.10 WG-SAM-15/34 presented analyses that considered potential biases in the calculation of priors for survey catchability coefficients ($q$) using abundance estimates from a random trawl survey and tag-recapture data. The Working Group concluded that estimates of $q$ from such methods using these data were likely to be biased. The Working Group thanked the authors and noted that such simulation experiments were a valuable method for informing advice from WG-SAM.

2.11 The Working Group noted that WG-SAM-15/34 recommended the use of a uniform prior but also noted that it may be possible to calculate a prior for $q$ based on priors of the components of catchability (i.e. vulnerability, vertical availability and spatial availability) from first principles. However, it also noted that determination of such priors may be confounded by the assumptions in the model and the spatial extent of different parts of the stock available to the survey.

2.12 WG-SAM-15/37 outlined a research plan and initial progress towards the evaluation of the stock structure and spatial distribution of toothfish between Divisions 58.5.1 and 58.5.2, along with simulation studies to evaluate potential bias in spatially distributed tag-release and recapture data, and presented initial work towards the development of methods to use spatially stratified tag-recapture data in an integrated stock assessment model.

2.13 The Working Group welcomed the research outlined by the authors. The Working Group noted that the analyses proposed in the paper would be a valuable contribution to understanding the stock structure spatial distribution and relationship of toothfish between Divisions 58.5.1 and 58.5.2. The Working Group also noted that consideration of how the assessments from Divisions 58.5.1 and 58.5.2 may be harmonised was an important outcome and that this work would lead to a better understanding of how this could be achieved.

2.14 WG-SAM-15/43 presented an investigation of the impact of including different subsets of tag data in the CASAL assessment of toothfish in Division 58.5.1. Previous analyses have indicated a poor fit to tag recaptures in the first recapture season that had a time of liberty of at least 12 months. The paper found that by reducing the minimum time at liberty to six months resolved the systematic lack of fit to recaptures in the first recapture season and resulted in a substantial improvement of the overall model fits to the tag data. The authors also noted that they had undertaken some sensitivity analyses on the choice of time at liberty and that small changes in the number of months at liberty were not influential on the results.

2.15 The Working Group noted that the substantial improvement in the fit of the model to tag data by the change in the time at liberty could be explained by the annual pattern of fishing. Vessels tend to return to similar fishing locations at similar times of the year and fish generally move only short distances, and thus the vessels tend to recover higher numbers of tagged fish after around 12 month of liberty. However, many recaptures were excluded in the model by limiting it to fish with a minimum time at liberty of exactly 12 months, and this pattern led to the poor fits in the original model fits.

2.16 The Working Group discussed whether the pattern of movement of vessels may be related to targeting pre-spawning aggregations or in response to sea conditions during the winter and encouraged additional analyses be undertaken that may allow an understanding of both the vessel and fish patterns of movement.

2.17 The Working Group noted that the likelihood profiles presented suggested that the POKER survey indicated a larger biomass than the tag data and suggested considering raising the upper bound for $q$, which currently is estimated at the upper boundary of 1, so that it did not unduly constrain the model estimates.

2.18 WG-SAM-15/49 presented additional analyses to the Amundsen Sea region CASAL two stock assessment models. The models had been revised following suggestions made at WG-FSA-14. The paper showed that a two-area model with sex- and age-specific migrations from small-scale research units (SSRUs) 882C–G to SSRU 882H and back provided the best fits to the age and tag data, but that there were still some unexplained patterns in the residuals of the fit to the tag data.

2.19 The paper considered models that included a resident population in SSRU 882H that was combined with a migrating population from the south, annually varying or density-dependent migration and the choice of subsets of the tag data that excluded small fish. However, none of these provided any improvements to the fits to the tag data.

2.20 The authors noted that this model would be further developed over the intersessional period once additional data had been obtained from the fishery. Dr Welsford noted that otoliths collected by Australian vessels were currently being analysed and toothfish ages would be available for this area in the near future.

2.21 The Working Group welcomed the analyses and developments for the CASAL two-area model and encouraged its development using the additional data, including all available age data.

### General

2.22 The Working Group noted different default values being used between assessments where no stock-specific data was present. For example, some assessments used a default value of steepness in the stock-recruit relationships of $h$ = 0.8 while others use $h$ = 0.75. It recommended that consideration by authors be given to standardising default parameter values, where appropriate, across species-specific assessments for use until there were data available that may allow a more informed approach.

2.23 The Working Group noted that the choice of priors for assessments was an important consideration and that choices of how priors were obtained or assumed should be clearly documented in both the assessment submissions from Members and CCAMLR's Fishery Reports.

2.24 The Working Group encouraged the development of analyses (including, for example, power analyses and simulation experiments) that would allow a better understanding of how much data is necessary for the production of a robust assessment and how long such data collection may take.

## A review of stock assessment methodologies used in CCAMLR's integrated assessments

2.25 WG-SAM-15/23 presented an analysis of by-catch in CCAMLR longline fisheries undertaken by the Secretariat, which examined the proportion of target fish species in the total catch in the commercial C2 data and the CCAMLR Scheme of International Scientific Observation (SISO) data from 2008 to 2014 in the Ross Sea. The target catch to by-catch ratio results from the C2 data showed not only differences due to gear and fishing locations, but also a clear distinction into two groups according to Flag State of vessels, with one group having nearly double the ratio of the other. The differences were also apparent in the data reported through SISO.

2.26 The Working Group noted that the requirement to collect both target and by-catch data is the same for all CCAMLR longline fisheries and discussed potential reasons for the observed differences in the by-catch proportions in C2 data between Members.

2.27 Following discussion of WG-SAM-15/23, the Working Group requested that the Secretariat correspond with those Members that have participated in that fishery to obtain information in order to develop a better understanding of how by-catch data are collected and reported on the C2 forms. This correspondence should include a request to:

(i) provide details, including examples where possible, of instructions provided to vessels on how the C2 data forms should be completed, in particular, how and what target and non-target catch data should be collected and submitted on those forms

(ii) provide a description of how the data on target and non-target catch are actually collected and reported at-sea (this could be, if available, detailed instructions provided to vessels on methods for estimating catches), including, for example, whether:

(a) the crew records the number and weight of all target and non-target catch for each haul

(b) the international scientific observer records the number and weight of all catch and reports this to the vessel for inclusion in the C2 form

(c) the international scientific observer makes detailed observations of (by-)catch on a sample of the line and the data is scaled up from this sample to complete the C2 form.

2.28 The Working Group recalled CPUE standardisation undertaken in the 1990s and considered that generalised linear mixed models (GLMM) or a case-control approach as used in the Ross Sea (WG-SAM-13/34) could be applied as an alternative to the method used in WG-SAM-15/23. However, the need for data from vessels using the same gear type and configuration (including the same bait type etc.) fishing in close proximity to each other may limit the use of these approaches.

2.29 In response to a request from the Working Group, the Secretariat provided a generalised linear model (GLM) analysis that included gear type, fishing location at 1 degree by 1 degree cells in the Ross Sea and Flag State as covariates. This analysis indicated that a significant effect of Flag State remained even when the spatial distribution of fishing and gear type were taken into consideration.

2.30 Dr S. Kasatkina (Russia) highlighted the significant spatial–temporal variability of the target catch ratio as well as variability for different longline gear types and between Flag States. This variability may be a specific characteristic of by-catch in the Ross Sea exploratory fishery and fish distribution patterns. She proposed to use GLMM for analysis of by-catch data. It will provide a possibility to investigate specific and dynamic by-catch as functions of different variables across various spatial units in the Ross Sea. She proposed to undertake this analysis for WG-SAM-16.

2.31 The Working Group recalled that a number of issues related to differences in the reporting of observer data have already been highlighted in the SISO review in 2013 and in discussion of the rationale for the CCAMLR Observer Training Program Accreditation Scheme (COTPAS). The Working Group recommended a review of the training and instructions provided to observers on by-catch reporting.

2.32 The Working Group agreed that it was important to distinguish between differences in by-catch reporting by Members and through SISO, noting that these would be issues for the Commission and Scientific Committee respectively.

2.33 WG-SAM-15/26 described progress towards the development of a set of standard diagnostic principles and tools used to characterise toothfish stock assessment models and evaluate whether a model is well specified and fits the data adequately.

2.34 The Working Group noted the large and increasing number of toothfish stock assessments that are being evaluated by WG-SAM and WG-FSA. It noted that a standard set of diagnostics and model output would help the working groups to provide adequate advice, and could also serve as a teaching aide for scientists with relatively less experience in integrated assessments.

2.35 The Working Group set out to develop a minimum set of diagnostic tools for integrated assessments to evaluate if a model is well specified and fits the data adequately. It also noted that there is a need to determine what tools can be used to assess whether a stock assessment model is sufficiently robust to provide management advice.

2.36 The Working Group developed an initial set of diagnostics that includes two types of information, firstly a description of model structure and baseline data, and secondly a set of model diagnostics. It recommended that as many of this initial set of diagnostics be used in stock assessments presented to WG-FSA-15 as is possible in the given timeframe.

2.37 For each stepwise change in a preliminary stock assessment, diagnostics shown in Appendix D should be submitted with the assessment as an attachment, and the description should include information on:

(i) model structure, including catch equations

(ii) fixed parameters and what qualitative or quantitative data was used to justify their choice (e.g. growth curve assumption where not estimated, choice of recruitment function)

(iii) estimated parameters, their priors, associated distributions and bounds, and for each prior what qualitative or quantitative data was used to justify their choice

(iv) all observations (including their values, variances and justification of choice) that the model was fitted to.

2.38 In addition, copies of the following files should be submitted for the candidate model runs for preliminary stock assessments presented to the Secretariat together with documents describing the assessment (SC-CAMLR-XXXI, Annex 7, paragraph 12.5):

(i) the model input files associated with each candidate model run (e.g. for CASAL models, this includes the population.csl, estimation.csl and the output.csl)

(ii) maximum of the posterior density (MPD) point estimates

(iii) Markov chain Monte Carlo (MCMC) samples and objectives file (if MCMC sampling has been conducted).

2.39 The Working Group recalled that the Secretariat routinely conducts model validation runs and reports on these to WG-FSA (WG-FSA-06/06, paragraphs 6.1 and 6.2; SC-CAMLR-XXXII, Annex 6, paragraph 4.93).

2.40 The Working Group noted that in addition to this information, a table with the stepwise changes from the model recommended in the previous year to the recommended model in the current year should be presented.

2.41 The model diagnostics relate to the MPD fits, likelihood profiles, MCMC sampling and derived parameters from the model. MPD fits should be used to evaluate candidate models, and the most promising candidate model or models will then be taken forward to MCMC sampling. The management advice should be based on these MCMC estimates.

2.42 Appendix D summarises the recommended diagnostics which include:

(i) table of process error weighting
(ii) table of the MPD components
(iii) plots on age- and length-frequency and abundance data and mean age
(iv) plots on indices of abundance (e.g. from survey or catch rates)
(v) plots on tagging data
(vi) likelihood profiles
(vii) MCMC model convergence
(viii) MCMC parameter estimates with MCMC credible intervals
(ix) model-derived estimates with MCMC credible intervals for e.g. selectivity functions, spawning and total biomass, stock status, year-class strength, stock biomass projections and risk profiles.

2.43 The Working Group recommended that model diagnostics should be developed further and welcomed future developments into how to incorporate structural model and parameter uncertainty into management advice. These issues should be regularly reviewed at future WG-SAM meetings. It further recommended to develop common R code that can be deposited at the Secretariat and be made available when preparing stock assessments. The established Toothfish Assessment Diagnostics e-group was tasked with developing common R code prior to WG-FSA-15.

2.44 WG-SAM-15/29 reviewed the fishery and tagging data for Patagonian toothfish (*Dissostichus eleginoides*) in Subarea 48.3 in order to characterise the fishery selectionpattern. The paper provided several metrics to identify whether a cryptic biomass is present outside the fishing range and suggested that the distribution of tag age with depth indicated that a dome-shaped selection pattern is unlikely in this fishery.

2.45 The Working Group agreed that the results from the metrics used in this paper were consistent with the way the stock assessment model was fitted and results from the stock assessment model in Subarea 48.3. Both analyses support the conclusion that the fish in the deeper waters in Subarea 48.3 mix with the fish at target fishing depth and thus the assumption of a flat-topped selectivity model is appropriate in the stock assessment for Subarea 48.3.

2.46 WG-SAM-15/30 discussed a potential link between the *D. eleginoides* stocks of Subareas 48.3 and 48.4. Different growth rates and maturity suggested that there is no regular exchange between the two areas, but tag-recapture data clearly show a small number of toothfish moving from Subarea 48.4 to Subarea 48.3 and genetic analyses indicate that both stocks belong mostly to the same genetic population. The two areas are currently assessed separately, as this is the most precautionary approach given the limited knowledge.

2.47 The Working Group discussed potential implications of fish movement for the stock assessments of *D. eleginoides* in Subareas 48.3 and 48.4 and the potential for a two-area stock assessment model covering both subareas. The Working Group considered that a two-area stock assessment would pose considerable difficulties, as it would require strong assumptions about movement rates. Currently, there is evidence for movement of some fish from Subarea 48.4 to Subarea 48.3, but only one fish tagged in Subarea 48.3 has been recaptured in Subarea 48.4.

2.48 The Working Group welcomed a proposed workshop that Australia intends to organise in 2016 on complex spatial stock structures and how to represent them in stock assessments. Such a workshop could address stock assessment questions related to the fish movement, stock structures and stock assessment approaches as used in e.g. Subareas 48.3 and 48.4, Divisions 58.5.1 and 58.5.2 and Subareas 88.1 and 88.2.

2.49 WG-SAM-15/33 presented an update on the major overhaul of the CCAMLR database and supporting infrastructure. The new structure follows the Enterprise Data Model and is intended to simplify the database architecture, improve data-quality assurance and modernise the workflow. As a result, data quality and database documentation should substantially improve for users from late 2015 onwards.

2.50 The Working Group welcomed these database developments to improve integration of fishery and observer data from different sources. The Working Group requested that the Secretariat provide sufficient documentation on workflow, data quality control, metadata and changes to the database structure, as well as summaries of any changes to data. The Working Group agreed that a summary log of changes would be useful for each extraction. The Working Group also recalled that an example for data extraction has been documented in WG-FSA-13/56.

2.51 The Working Group requested that the roll-out of the new database structure not be carried out prior to WG-FSA-15. Even with substantial testing and system evaluation conducted by the Secretariat prior to the roll-out, data users will still need to conduct comparisons between the old and new data extracts and such an evaluation may delay any stock assessment work for WG-FSA-15.

2.52 WG-SAM-15/P01 presented an approach to standardise fishing power between vessels fishing in the same area at the same time, whereby the vessel power is calculated relative to a standard vessel that is particularly active and would allow many within-fleet comparisons over the time period of the analysis.

### Seabed area

2.53 WG-SAM-15/01 examined differences in (i) planimetric seabed area within fishable depth ranges based on the General Bathymetric Chart of the Oceans (GEBCO) 2008 and GEBCO 2014 datasets, and (ii) planimetric and surface area estimates for the same areas using the most up-to-date global bathymetry dataset provided in GEBCO 2014. Differences between the GEBCO datasets varied between 0% and 62% depending on the research block examined in the fishable depth range. Results from the comparison of total surface and planimetric area within the fishable depth range of a research block showed differences of less than 2% and, therefore, the use of surface area was unlikely to affect calculations of toothfish density using the CPUE analogy method. However, at finer scales, including those used in habitat models, these differences would be important.

2.54 The Working Group thanked the Secretariat for its work to compare the different datasets and agreed that using the most up-to-date dataset (which in this analysis was GEBCO 2014 rather than GEBCO 2008) is the best practice. It recognised that the latest dataset is likely to improve calculations of seabed area, particularly on the continental shelf.

2.55 The Working Group also noted that fishing vessels could provide useful sources of bathymetric data but noted that the data from the vessels' plotters were likely to be more reliable than the depths reported in haul-by-haul records. Calibration of vessel data will be an important part of the process for contributing these data to bathymetric modelling such as, for example, the process being undertaken by the SCAR Expert Group on the International Bathymetric Chart of the Southern Ocean (IBCSO). The Working Group suggested that, where the collection of bathymetric data has been identified in a research plan, consideration will need to be given to how that data will be turned into suitable products within the time frame specified in the research plan.

### Depredation

2.56 WG-SAM-15/27 and 15/28 reviewed methods used within the CAMLR Convention Area for reducing depredation of toothfish on longlines by large marine predators and summarised depredation activity within the CCAMLR area. In some subareas, depredation is well studied and included in stock assessments, and these areas have trialled a range of mitigation methods and developed approaches to minimise fishery–mammal interactions. Acoustic methods currently in circulation to mitigate depredation have been found to be ineffective. The most effective method to date uses move-on provisions that minimise interactions with odontocetes together with using shorter lines and faster hauling rates. Inclusion of depredation in stock assessments will be important in those areas with exploratory fisheries where the issue is regularly observed.

2.57 The Working Group agreed that this was an important issue to be resolved urgently. It noted that the issue involves three parts: (i) mitigation, (ii) impacts on stock assessments, including removals and the effects on tagging programs, and (iii) ecosystem effects of altered foraging ecology and the provision of food resources to odontocete populations.

2.58 Dr Welsford noted that this subject was also a high priority at the recent Coalition of Legal Toothfish Operators (COLTO) meeting of industry and scientists. A working group had been formed by COLTO to address different aspects of the issue.

2.59 Drs K.-H. Kock (Germany) and Currey indicated that the Scientific Committee for the International Whaling Commission (IWC SC) was considering killer whale population studies and that there are synergies between the work needed by CCAMLR and the IWC.

2.60 The Working Group suggested that WG-EMM and WG-FSA consider the process by which the three parts of the depredation issue might be addressed so that recommendations can be made to the Scientific Committee. For example, establishing a group to work on mitigation of depredation may be similar to the approach taken by the Scientific Committee in establishing WG-IMAF to address a specific issue within CCAMLR. The Working Group noted that further discussion on this issue would benefit from coordination with COLTO and the IWC.

2.61 The Working Group recommended that intersessional discussions be initiated to begin work on the first of the three priorities and consider issues around odontocete depredation, including killer whale behaviours and the use of mitigation measures that are effective and easy to put into place to reduce depredation. Drs Belchier, Söffker and Mr N. Gasco (France) agreed to coordinate these discussions.

### Management strategy evaluation (MSE)

2.62 WG-SAM-15/48 described the development of a management strategy evaluation (MSE) for the Ross Sea toothfish fishery. It used some example parameters and parameter values to assist in prioritising further MSE analyses on the performance of the feedback mechanisms that the CCAMLR decision rules provide. It noted that different assessment models may be sensitive to different parameters and parameter values, and may require different approaches to MSE. It also noted the importance of simulation studies for testing the sensitivities of assessment models to different parameters and, where possible, developing and maintaining data collections that can contribute to more accurate parameter specifications for any parameters identified as priorities through the MSE process.

2.63 The Working Group noted that the evaluation of management strategies involves testing of assessment scenarios, including the effects of misspecification of parameters, as well as examining the performance of the management strategy in the long term, which could result in biases in assessments that may have long-lasting inadvertent impacts on stocks. Evaluations will be able to help identify whether errors in assessments in one or more years may result in long-term issues.

2.64 The Working Group noted that MSE was also being undertaken in a number of areas, including through the International Council for the Exploration of the Sea (ICES), and in the FRDC project relating to toothfish stock assessments in Divisions 58.5.1 and 58.5.2 (WG-SAM-15/37). It recommended that intersessional correspondence be initiated to progress MSE for toothfish fisheries, including evaluating the performance of data collection methods, assessments and harvest control rules, led by Mr Dunn. The outcomes from this group could be initially reported to WG-SAM-16.

### Research plans for data-poor exploratory fisheries

3.1 The Working Group undertook to develop a report card style summary of the progress of each research plan submitted under Conservation Measure (CM) 21-02 and each research proposal submitted under CM 24-01. The criteria consisted of the original research plan evaluation criteria developed by WG-SAM in 2012 (SC-CAMLR-XXXI, Annex 5, Table 6), the requirements for sampling dependent species in CM 22-01 and new criteria to summarise the progress towards an assessment. The Working Group noted that several of the criteria have become irrelevant since the 2012 reviews and that a more structured review process and summary of progress could be developed for the future under Agenda Item 6 (Future work). To provide more detailed information from the self-assessments of research plans and proposals, Drs Parker and Darby, along with the Secretariat, offered to annotate the table and describe how the review process developed under Future work could be further developed by WG-FSA to promote the development of stock assessments.

#### Subarea 48.6

3.2 The Working Group recalled that South Africa and Japan had been conducting research fishing for *Dissostichus* spp. in Subarea 48.6 under a research plan established in 2012, with the aim of collecting data that would lead to an assessment within 3–5 years. WG-SAM-15/50, jointly authored by South African and Japanese scientists, presented the progress towards the development of a robust stock assessment of *Dissostichus* spp. in this subarea. The Working Group noted that in 2013/14, tagged Antarctic toothfish (*D. mawsoni*) had been recaptured in research block 486_4, which indicated potential to include tagging data for this area in stock assessments in the near future. The Working Group further noted that considerable data on the reproductive biology of *D. mawsoni* had been collected showing a clear pattern of gonadosomatic index peaking during May and June (WG-SAM-15/06), confirming the hypothesis that peak spawning of this species occurs during the austral winter, and spawning fish seem to occur over seamounts in the north of the subarea.

3.3 The Working Group noted that a large amount of data had been collected over the duration of the research plan and requested that a summary of data be submitted to WG-FSA-15. It encouraged the development of a preliminary stock assessment model for research block 486_2 where a sufficient time series of tag recaptures may exist. The Working Group also noted that age data had not yet been developed. It noted that age data were now being prepared and encouraged South Africa and Japan to expedite this work for inclusion in stock assessments.

3.4 WG-SAM-15/06 and 15/39 provided proposed work plans by Japan and South Africa respectively for 2015/16. The Working Group noted that the details of the proposal were similar to those in previous years. It further noted that Japan proposed to add two additional research blocks along the slope of the continent either side of research block 486_4, which would substitute research block 486_5 in case the block is under adverse ice conditions, but that no research had been conducted in research block 486_5 due to persistent sea-ice.

3.5 The Working Group recalled the Commission's request that the Scientific Committee and relevant working groups examine the scientific implications of additional flexibility, such as extending research activities to areas outside the designated research blocks when they are inaccessible due to ice condition (CCAMLR-XXXIII, paragraph 5.43). The Working Group also recalled its discussion last year on developing new research blocks (SC-CAMLR-XXXIII, Annex 5, paragraph 3.14) and the importance of focussing fishing in the existing research blocks to obtain the data required for a robust assessment. Dr T. Ichii (Japan) indicated that Japan will submit a revised proposal on the design of research block 486_4 to WG-FSA-15.

Subarea 58.4

3.6 WG-SAM-15/02 presented a proposal by Spain to complete the third year of the depletion fishing experimental approach that it is conducting in Divisions 58.4.1 and 58.4.2. During 2014/15, the vessel had not been able to conduct its planned research due to a technical problem. Spain noted that it had initiated an ageing program and an age–length key (ALK) from the previous surveys would now be available for the subarea.

3.7 The Working Group welcomed the progress on developing an ageing program by Spain, and requested it submit a paper describing it to WG-FSA-15. It noted that the proposal included modifications in response to recommendations by the Scientific Committee, in particular that the lines during the depletion experiments would be laid closer together. It further noted that the proposal stated that the vessel would complete the research in Division 58.4.1, after fishing in the Ross Sea (Subarea 88.1) exploratory fishery, if sufficient fuel was available. Therefore, there was a risk that the vessel would not be able to complete the proposed research in 2015/16. The Working Group agreed that while the research plan was appropriate, it requested that Spain consider how to maximise the likelihood that the vessel could undertake its research commitments in a revised proposal for review by WG-FSA-15.

3.8 WG-SAM-15/10 presented a proposal by Australia to undertake a dedicated research fishing in Divisions 58.4.1 and 58.4.2 for the next three years. The vessel planned to visit each of the existing research blocks and deploy spatially separated fishing sets to determine relative density of toothfish and by-catch species, release tagged fish and attempt to recover tagged fish released in the locations where Spain had conducted depletion experiments. Cameras and conductivity temperature depth probes (CTDs) will be attached to longlines to collect data on the habitat and environmental conditions across the research areas.

3.9 The Working Group noted that the research design was appropriate to achieve the stated objectives and progress towards a stock assessment for the exploratory fisheries in Divisions 58.4.1 and 58.4.2.

3.10 The Working Group noted that while the proposal would operate within the existing catch limits for the research areas, there was no information provided as to how much catch the vessel is expected to take to allow comparison with other proposals in the same area such that advice can be provided on research priorities in the area if catches exceed the advised levels. It further noted that the survey would fish in the area that Spain had notified for its three-year research plan (WG-SAM-15/02) and that the research could impact the results of that program depending on the sequence that the Australian and Spanish vessels visited those locations. It agreed that the research program using a dedicated vessel with no other commitments was an advantage to completing the work. However, it also agreed that there needed to be collaboration and coordination with other Members' research programs to ensure that their objectives would not be impacted.

3.11 WG-SAM-15/04 and 15/05 presented the results of the most recent analysis of data collected by Japan in Divisions 58.4.1 and 58.4.2 and a proposal for a further three years of research using the previously agreed research design. The current season (2014/15) is the final of the three-season research plan in these data-poor fisheries. Catch, effort and biological data were analysed in relation to the development of stock assessments within each research block and stock sizes were estimated using the modified Petersen estimator and the CPUE by seabed analogy. The proposal would include an enhanced tagging program, as well as collection and analysis of biological data, including otoliths and gonads to clarify migration routes and associated life stages of toothfish.

3.12 The Working Group recalled hypotheses regarding stock structure in this region based on exploratory fisheries data (Agnew et al., 2009; WG-FSA-11/35) which indicate that recruitment is likely to occur near Prydz Bay. The gonadosomatic indices (GSIs) during the austral summer tend to be more progressed in SSRU 5842A, suggesting that aggregations of mature fish may move to BANZARE Bank to spawn.

3.13 The Working Group noted that during the previous three-year research plan, very little fishing effort had occurred due to the strong seasonal pattern of sea-ice and prioritisation of research fishing in other areas during the summer when the research blocks are most likely to be open. The Working Group noted that as the vessel proposed by Japan to conduct research in this region was also planning to conduct research in Subarea 48.6 as a priority, there was a risk that it may not be able to conduct research in Divisions 58.4.1 and 58.4.2 in the coming years.

3.14 WG-SAM-15/35 presented the results of the first year of the five-year research plan conducted by the Republic of Korea in Divisions 58.4.1 and 58.4.2 in 2014/15. Korea collected and analysed the catch, effort and biological data (length, weight, gonadal development) and samples of stomach contents and muscle tissue, which it intends to analyse to construct food-web models. Korea also presented a notification (WG-SAM-15/07) to conduct research fishing in Divisions 58.4.1 and 58.4.2 in 2015/16 to collect the catch and effort, CTD, biological and tagging information, including the deployment of pop-up archival tags.

3.15 The research fishing had caught a total of nine species; 706 *D. mawsoni* were tagged at a rate of over 5 fish per tonne and an 80% overlap statistic was achieved. CTD casts were also performed and satellite archival tags had been released, however, not all planned research sets could be completed due to weather and ice conditions.

3.16 WG-SAM-15/15 and 15/16 presented notifications by France to conduct research fishing for toothfish (*Dissostichus* spp.) in Divisions 58.4.1 and 58.4.2. The fishery in these regions had been limited to relatively few vessels with limited fishing activity. France notified its wish to collaborate in the research fisheries with other Members over the coming years in order to participate in the tagging program and achieve a robust stock assessment. The papers presented proposals for a research fishing plan for 2015/16 developed under CM 41-01.

3.17 The Working Group noted 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 the area. It suggested that a correspondence group be set up to progress this prior to WG-FSA-15.

3.18 The Working Group noted that the authors of WG-SAM-15/03 referred to large inconsistencies between the C2 and the observer data from 2005/06, and that the observer data had been used as the basis for the tagging information. The Secretariat confirmed that during the initial period of reporting tagging data in the C2 forms (2005/06) there were some differences between the vessel and observer data, but in subsequent years there was good agreement. The Working Group noted that recaptures of tagged fish released early in the development of this fishery may not provide any useful information on stock abundance due to issues with fish condition and tag overlap. It, therefore, requested that sensitivity tests be conducted to evaluate the impact of exclusion of these tags on the stock assessment be presented to WG-FSA-15.

3.19 It also requested that WG-FSA-15 consider developing principles for dealing with tagging data originating prior to the requirements for tagging to occur in proportion to fish length and the development of fish condition assessment criteria.

Division 58.4.3a

3.20 WG-SAM-15/03 presented a proposal by Japan to continue its research fishing in Division 58.4.3a for a further three years using the previously agreed research design. The research would continue the tagging program, as well as collection and analysis of biological data, including otoliths and gonads, to document migration routes and associated life stages of the fish.

3.21 The Working Group noted that the authors of WG-SAM-15/03 suggested that the stock is a closed unit. However, the Working Group recalled that genetic studies indicated that a metapopulation was likely to exist across the Indian Ocean sector (WG-FSA-03/72). Furthermore, evidence of spawning activity and juvenile recruitment would be required to confirm that Elan Bank supported a self-sustaining population.

3.22 WG-SAM-15/11 presented the results of research fishing and assessment analysis in Division 58.4.3a since 2012 by two vessels from Japan and France. France also notified its intention to continue the multi-Member research fishing over the coming years in order to achieve a robust stock assessment that would provide advice on a catch limit according to CCAMLR decision rules.

3.23 The Working Group noted that a CASAL assessment was being developed for the stock by France and Japan, but that this had been associated with data that had high concentrations of fishing effort and in the most recent year an increasingly high catch rate of tagged fish. It noted that the CASAL models had shown substantial uncertainty, but could still be used to integrate the various sources of data to provide an evaluation of the trends in the stock, identify critical data gaps and the level of risk associated with the current level of removals.

Generic

3.24 The Working Group noted that there was a need to agree time frames that were realistic to the objectives of research proposals in developing assessments that can be used to provide management advice. However, there was also a need to provide a review process such that research in each fishery could be prioritised and coordinated between Members and reviewed to ensure the Scientific Committee is satisfied with progress towards CCAMLR's objectives. Such a review process could also guide proponents in adapting their research plans.

3.25 The Working Group noted that with the increase in the number of research proposals in Subarea 58.4 there was a possibility that conducting research fishing under the conditions of an Olympic fishery may impact the quality of, and ability to successfully complete, each individual research program and delay reaching the overall objective of developing a stock assessment. The Working Group agreed that there needed to be a review of the proposals in each area relative to their progress in developing assessments for each region such that the Scientific Committee can advise the Commission on priorities for future research. Areas in which multiple Members have applied to conduct research need to be coordinated among proponents – as some areas were not being visited while others had potentially competing proposals. It was agreed that further consideration of combined coordinated proposals should be brought forward to WG-FSA-15.

## Research proposals in other areas (closed areas, areas with zero catch limits, Subareas 88.1 and 88.2)

Subarea 48.2

4.1 The Working Group reviewed WG-SAM-15/38 which described the preliminary results obtained from a research survey for toothfish undertaken by Ukraine in Subarea 48.2 in 2015. This was the first year of a three-year program of research carried out using trotlines.

4.2 The Working Group thanked Ukraine for the report and noted that it would be developed further for consideration at WG-FSA. The Working Group requested that more detailed information regarding the distribution of the two species of toothfish in the survey area be provided to WG-FSA. It noted that there are marked spatial and bathymetric differences in the distribution and abundance of the two species across the banks and seamounts in the research area. The Working Group noted that there had been difficulties in tagging large fish during the research but this had been resolved by modifying the method by which fish were brought on board (using a net mounted in a frame as described in WG-FSA-07/36).

4.3 The Working Group was informed that ageing of the sampled catch would be undertaken by Ukraine and that fish tissue samples had been provided to the UK which, subject to funding, will be used as part of a genetic study to investigate stock linkages.

4.4 The Working Group considered WG-SAM-15/40 which summarised the plan for continuing the Ukrainian toothfish research in Subarea 48.2 in 2016. The Working Group noted the proposal to stratify the survey by area by dividing the survey region into the northern bank and the southern seamount area. The Working Group also noted that a reduction of the tagging rate to 3 fish per tonne was proposed in the southern seamount stratum as a result of the density of longline sets in this area being higher than in the northern banks region.

4.5 WG-SAM-15/53 described a proposal by Chile to undertake a three-year program of toothfish research fishing in Subarea 48.2 using cachalotera trotline gear. The Working Group noted the marked similarity in the survey design, station location and area presented in the proposal with that currently being carried out by Ukraine (paragraphs 4.1 to 4.4) and recommended that Chile coordinate its research program with Ukraine's, noting that it is effort limited not catch limited, in the first instance. The Working Group also noted that the Chilean research would be a year behind that of Ukraine and the proponents should consider how this work could be better coordinated in view of the common aim of an integrated stock assessment for the area. The Working Group also noted that no precautionary catch limit had been provided in the proposal.

4.6 The Working Group agreed that the use of the cachalotera nets on the trotlines was considered unnecessary for this planned research as whale depredation has not previously been observed in the area and was unlikely to occur in Subarea 48.2. The use of cachaloteras was also considered more likely to cause damage to the catch which could reduce the availability of fish suitable for tagging.

4.7 WG-SAM-15/12 summarised a research proposal by Chile to conduct a trawl survey of finfish resources on the shelf areas of Subareas 48.1 and 48.2. The Working Group noted that this research had previously been approved by the Scientific Committee (SC-CAMLR-XXXII, paragraphs 9.1 and 9.2).

Subarea 48.5

4.8 WG-SAM-15/22 presented a reanalysis by Russia of data collected during the 2012/13 Russian research program in the Weddell Sea (Subarea 48.5). In the paper, C2 and logbook data collected by the vessel *Yantar 35* from Subareas 88.1 and 88.2 were compared with that obtained from the same season in Subarea 48.5. Vessel monitoring system (VMS) positional data were also presented.

4.9 Dr Kasatkina noted that WG-SAM-15/22 reported on data from of the Russian research program in Subarea 48.5 (Weddell Sea) in 2012/13. In her view, the data were analysed in accordance with the Scientific Committee recommendations (SC-CAMLR-XXXIII, paragraphs 3.230 to 3.234). Catches, positioning the vessel, tagging program and recommended fishing indices in Subareas 88.1, 88.2 and 48.5 were analysed and compared. The paper reported that CPUE (kg/thousand hooks; daily catch) in the Weddell Sea was higher in comparison with the Ross Sea and Amundsen Sea in 2012/13. Dr Kasatkina highlighted that the Russian Federal Agency for Fisheries established a special group and identified responsible persons for the purpose of completing analysis of research fishing data from the Russian program in the Weddell Sea in 2012–2014. She indicated that the analysis will include contact with the captain of the vessel and the international observer on board the Russian vessel. The report will be submitted when finalised.

4.10 The Working Group thanked Russia for the analysis of the 2012/13 data but recalled the advice of the Scientific Committee (SC-CAMLR-XXXIII, paragraph 3.232) that Russia had been requested to provide a finalised analysis of data obtained by the *Yantar 35* in Subarea 48.5 for both the 2012/13 and 2013/14 seasons for consideration by WG-SAM-15. As WG-SAM-15/22 reported only on the data reanalysis from the 2012/13 season, the Working Group was unable to provide any further assessment of the analyses and recommended that the data concerned remain quarantined until such time that the complete analysis has been undertaken and submitted for consideration by WG-SAM.

4.11 The Working Group sought further analysis and explanation of the VMS-derived vessel track data presented in WG-SAM-15/22, Figure 7, which appeared to show inconsistencies between fishing locations and vessel movements within research blocks. The vessel VMS showed consistent tracks in positions where no lines had been deployed according to the report. There were also two tracks presented of the vessel entering and leaving the area. The Working Group noted that this report from the Russian Federation should therefore be brought to the attention of the Standing Committee on Implementation and Compliance (SCIC).

4.12 Dr Kasatkina presented in WG-SAM-15/18 a proposal based on the original research program approved in 2012 with some modifications that, in her opinion, were consistent with the original research objectives approved in 2012 (SC-CAMLR-XXXIII, paragraph 3.233) for implementation in 2015/16. She noted that:

(i) the proposed program would be conducted with a new fishing company and fishing vessels and scientific observers

(ii) a scientist from another Member country will be invited to take part in the cruise

(iii) implementation of the Russian research program will provide information about toothfish distribution and biological parameters to estimate stock status in the future

(iv) values of CPUE were four times higher than in the Ross Sea and concluded that the Weddell Sea is a prospective area for an exploratory fishery.

4.13 The Working Group considered the proposal by Russia (WG-SAM-15/18) to revise the original research fishing proposal submitted in 2012 (WG-FSA-12/12). It was noted that this proposal was based on an assumption that there was no information originally available for the area. During 2012/13, Russia fished in the area and was only able to deploy eight lines before the quota was exhausted. The revised proposal detailed two vessels fishing in the area in which the catch rates, if consistent with those noted in WG-SAM-15/22, would imply that only a very small number of lines would be deployed by each vessel providing very limited information for analysis. The Working Group also concluded that once the analysis of the quarantined data was complete, the strategy recommended to achieve the research objectives may change and, therefore, the proposed design cannot be considered appropriate at this time to reach the original objectives agreed by the Scientific Committee (SC-CAMLR-XXXIII, paragraphs 3.232 and 3.233).

4.14 The Working Group also noted that the area of option 3 of the proposal had not been free of ice in recent years and, therefore, the proposal for this area was unlikely to be achieved. The Working Group also recalled the concerns expressed regarding the ability to carry out research safely in Subarea 48.5 in locations that were frequently ice covered.

4.15 The Working Group agreed that, as a result of the uncertainty created by the incomplete analysis conducted by Russia, the Russian revised research plan for Subarea 48.5 did not meet the CCAMLR objectives and could thus not be recommended. The Working Group noted the request by Russia to conduct collaborative research in the area. The Working Group will be able to revisit proposals for this area when the data reanalysis requested by the Scientific Committee in 2014 has been fully evaluated.

4.16 The Working Group considered WG-SAM-15/08, a proposal by the Republic of Korea to conduct a three-year program of toothfish research fishing in Subarea 48.5. The Working Group noted that the planned research is based on the preliminary results of the Russian research conducted in Subarea 48.5 from 2012 to 2014 for which the data are currently quarantined (paragraph 4.10). Given the uncertainty surrounding these data, Korea withdrew the proposal for 2015/16 and indicated that it would consider resubmission subject to the outcomes of the reanalysis of the Russian data.

### *Dissostichus* spp. Divisions 58.4.4a and 58.4.4b (Ob and Lena Banks)

4.17 WG-SAM-15/14 described progress with the program of toothfish research undertaken by Japan in Divisions 58.4.4a and 58.4.4b. The Working Group noted the high tag-overlap statistic achieved in 2014 and thanked Japan for the considerable amount of biological information provided in the report. The Working Group also noted that nine lines had been affected by killer whale depredation and encouraged Japan to consider how levels of depredation could be assessed and incorporated into future assessments. The Working Group recalled that France had presented a paper in which relative proportions of target and by-catch had been used to assess levels of killer whale depredation (WG-FSA-14/10) and such an analysis may be informative in this division. The Working Group encouraged the participation of cetacean scientists on future research cruises. The Working Group recommended that Japan starts to collect photographic identification data for killer whales in the region in collaboration with France and noted that a comprehensive online database has already been developed by Mr Gasco (Tixier et al., 2014a, 2014b; Labadie et al., 2014; WG-FSA-13/08).

4.18 WG-SAM-15/13 described a research plan for toothfish in Division 58.4.4b in 2015/16 by Japan. The Working Group discussed whether the difference in biomass estimates derived by CPUE and Petersen methods presented in the paper could result from killer whale depredation. The Working Group recommended that confidence intervals be provided with estimates of expected tag returns that are provided in proposals and this was relevant across all research fishery areas.

4.19 A proposal for a program of French toothfish research in Division 58.4.4 for 2015/16 was presented in WG-SAM-15/52. The Working Group recommended that France also consider the issue of whale depredation and to collect photographic identification data for killer whales in the region in collaboration with Japan.

Subarea 88.3

4.20 WG-SAM-15/09 presented the three-year Korean research plan for dedicated research cruises to study *Dissostichus* spp. in Subarea 88.3. In the first year, the research would focus on exploring and locating fishable habitat, biological sampling of toothfish and environmental data collection in the northern slope and southern shelf of SSRUs 883A–D. The Working Group noted the need for a robust sampling design within each of the research blocks and requested that details on locations of research sets and stratification and research block prioritisation be included in the updated research proposal for WG-FSA.

4.21 The Working Group discussed the potential constraints of sea-ice along the continental margin on returning to recapture tagged fish in future years. It noted the low levels of historic catch from research fishing in this subarea and the importance of completing the research even in the event of low catch rates. It highlighted the importance of returning to previously fished areas to recapture tagged fish and the value of supplementary information to characterise populations and inform stock structure that might be obtained by fishing in research blocks adjacent to SSRU 882G. The Working Group requested that these objectives be incorporated in the research proposal for Subarea 88.3.

Subarea 88.1

Ross Sea shelf survey

4.22 WG-SAM-15/44 presented the results of the fourth CCAMLR-sponsored research survey to monitor abundance of sub-adult Antarctic toothfish in the southern Ross Sea. The original objectives of this research were to: (i) detect changes in relative abundance of recruitment over time, and (ii) estimate variability and autocorrelation in recruitment (WG-SAM-14/25). The survey successfully completed 44 sets in the core survey strata and 15 sets in Terra Nova Bay, detecting a decline in catch rates of sub-adult fish in the core strata and high catch rates and larger fish in Terra Nova Bay. Age composition during the four surveys completed provided clear evidence of modes representing a strong year class progressing through the surveyed population. This information will be incorporated in the upcoming Ross Sea assessment model to help inform recruitment variability and change.

4.23 WG-SAM-15/45 presented a two-year proposal to continue the time series of research surveys to monitor abundance of Antarctic toothfish in the southern Ross Sea. The survey proposal had two key objectives: (i) to monitor toothfish recruitment in the core strata, and (ii) to monitor trends in abundance of larger (large sub-adult and adult) toothfish in two areas of importance to predators: McMurdo Sound and Terra Nova Bay. This second objective was intended to complement existing sea-ice research fishing and predator studies (killer whales and Weddell seals) from Scott Base and Mario Zucchelli Station (e.g. WG-EMM-14/52, WG-EMM-15/52).

4.24 The Working Group noted the importance of estimating trends in sub-adult abundance and recruitment for input to stock assessment models. It recalled that the Scientific Committee agreed that the survey is necessary to collect information on future recruitment (SC-CAMLR-XXXIII, paragraph 3.215).

4.25 The Working Group recommended that the next Ross Sea stock assessment should consider data weighting of survey and commercial data and sensitivities to incorporate the results of the survey series in the model. It further recommended that the priority for ongoing survey effort should be the monitoring of toothfish recruitment in the core strata. The Working Group requested an updated proposal be submitted to WG-FSA to provide further details associated with the objective of monitoring trends in abundance of larger toothfish in McMurdo Sound and Terra Nova Bay.

4.26 In discussion of the forthcoming Ross Sea stock assessment, the Working Group requested that WG-FSA review the mechanism of subdividing the long-term precautionary yield into SSRUs in the Ross Sea region.

### Ross Sea winter survey

4.27 WG-SAM-15/47 presented a proposal for a dedicated winter longline survey of Antarctic toothfish in SSRUs 881B–C in 2016. This survey was identified as a priority in the CCAMLR-endorsed medium-term research plan for the Ross Sea (CCAMLR-XXXIII, paragraph 5.52) and proposals have been requested by the Scientific Committee (SC-CAMLR-XXXII, paragraph 3.76iv). The survey is proposed to: (i) investigate spawning time and location in the northern Ross Sea region; (ii) refine the developmental cycle and likely residence time on the spawning grounds; (iii) investigate the potential dispersion areas of eggs and larvae; and (iv) investigate the timing of movement to and from the spawning grounds.

4.28 The Working Group discussed WG-SAM-15/47 and noted that:

(i) the research blocks were designed to account for variable ice conditions in winter while ensuring broad spatial coverage of sampling locations

(ii) research on what fish are found under the ice will be needed to help interpret the data arising from this survey

(iii) while the proposal was for a single season, it provided a template for additional survey proposals in subsequent seasons by any Member, to enable sampling over the necessary spatial and temporal scales to characterise spawning.

In addition, the Working Group recommended that standard protocols and methods be established for this research, in order that any vessels undertaking this research will provide consistent and compatible data.

4.29 The Working Group noted that the proponents would require the vessel to prepare a risk management plan to ensure vessel safety. In discussion of the proposed catch limit, the Working Group noted that the survey proposal was intended to be CCAMLR-sponsored research with the proposed survey catch limit taken from the Ross Sea catch limit to address CCAMLR-agreed priorities. Further discussion of the catch limit was referred to the Commission.

Subarea 88.2

SSRUs 882A–B north survey

4.30 WG-SAM-15/17, 15/31, 15/42 and 15/46 reported the results of the longline survey for toothfish conducted by Russia, the UK, Norway and New Zealand respectively in the northern Ross Sea region (SSRUs 882A–B). Three of four vessels were able to undertake research sets in the research blocks, with two of four vessels reaching their catch limit and undertaking the full seven days bathymetric mapping identified in the original research proposal (WG-FSA-14/61). Catch rates were high and similar to those observed in the adjacent SSRU 881C. Toothfish were large in both areas, consistent with the hypothetical life history of toothfish in the Ross Sea region.

4.31 Dr Kasatkina considered that results of the longline surveys for toothfish in the northern Ross Sea region (SSRU 882A–B) in 2015 showed unexpectedly high values of CPUE (kg/thousand hooks) which amounted to 5 000 kg/thousand hooks and with considerable variation in catches (WG-SAM-15/31 and 15/46). She suggested that this CPUE was four-times higher than in the Weddell Sea and indicated that it is very important to analyse the data to understand fish distribution patterns and the source of the high CPUE.

4.32 Dr Kasatkina made the following statement at report adoption:

> ‘It was proposed to analyse relationship between haul duration and haul speed and CPUE.’

4.33 The Working Group noted the high CPUE and the importance of such data in assessing fish distribution. It noted that despite operational difficulties for two of the four vessels, the survey still collected valuable data in a little studied area and that these data could be utilised for updated analyses in the Ross Sea region spatial population model. It recalled the longstanding recommendation for research collaboration and noted that this survey provided a model for how such collaboration can be achieved.

4.34 The Working Group requested that the biological and bathymetric data from all four survey vessels be combined in a single report for WG-FSA and requested clarification on the acoustic calibration of vessels’ echosounders. It requested that the proponents identify a strategy for sampling research blocks for the coming season and include that in their report to WG-FSA.

4.35 The Working Group noted that, while the notification process for this survey was ambiguous, New Zealand (WG-SAM-15/46), Norway (WG-SAM-15/41) and the UK (WG-SAM-15/32) had notified their intention to continue the research using vessels with the same gear configuration as specified in CM 41-10. Dr Kasatkina confirmed that Russia intended to take part in the survey this coming season, using a vessel with the same gear configuration as specified in CM 41-10.

4.36 The Working Group noted that the notification process for this research survey is unclear and recommended that WG-FSA consider how to clarify the process for this research survey. It further recommended that contingency plans be developed for research survey proposals this year to enable alternative vessels with appropriate gear configurations to be substituted to ensure necessary data collection and continuity of CCAMLR-sponsored research survey programs.

SSRU 882A south survey

4.37 WG-SAM-15/21 described a research program on the resource potential and life cycle of *Dissostichus* species from SSRU 882A from 2015 to 2018 and presented an updated version of the survey proposal from 2014 to incorporate recommendations from the Scientific Committee (SC-CAMLR-XXXIII, paragraph 3.226). The Working Group noted the proposal used auto lines to enable comparison of CPUE with the SSRUs 882A–B north survey, consistent with the advice of WG-SAM last year (SC-CAMLR-XXXIII, Annex 5, paragraph 4.20).

4.38 Dr Kasatkina noted that it is important to understand fish distribution patterns by combining data from surveys in the northern part of SSRUs 882A–B and a survey in the southern part of SSRU 882A, planned by Russia.

4.39 The Working Group agreed that the catch for this research should be subtracted from the Ross Sea catch limit.

4.40 Noting the ongoing investigation of the *Yantar 35*, the quarantine in place for all data collected by that vessel in CCAMLR waters, and the fact the vessel had not notified to fish in Subareas 88.1 or 88.2, clarification was sought as to the availability of alternative vessels with appropriate gear configuration. It was noted that alternative vessels may be available.

4.41 The Working Group concluded that it was unable to complete the review of the investigation of the *Yantar 35* data from 2012/13 and 2013/14 (paragraph 4.10). It agreed that the review needs to be complete and approved by the Scientific Committee prior to that vessel being considered for any further surveys in the CCAMLR area.

4.42 Dr Kasatkina assured the Working Group that the *Yantar 35*, notified in the research proposal for the southern part SSRU 882A, will be replaced by an alternative vessel with appropriate gear configuration.

## Other business

5.1 The Working Group noted that WG-SAM-15/19, 15/20 and 15/51 were not directly related to other WG-SAM agenda items. These papers dealt with positioning some statistical boundaries in the Convention Area and opening currently closed SSRUs in Subareas 88.1 and 88.2. Given that these topics are outside the remit of WG-SAM, the Working Group recommended that these papers be forwarded to the Scientific Committee for further consideration.

5.2 Dr R. Leslie (South Africa) acknowledged that repositioning of the boundaries of statistical areas was outside the remit of WG-SAM and noted that WG-SAM-15/51 was tabled to inform the Working Group that South Africa and France intend making a formal submission to the Commission requesting that the boundary between Subareas 58.6 and 58.7 be repositioned taking cognisance of the areas under national jurisdiction.

*CCAMLR Science*

5.3 The Science Manager, as Editor of *CCAMLR Science*, described the reduction in the number of papers submitted to, and published in, *CCAMLR Science* in recent years and sought the views of the Working Group on whether there was a future for the journal. In recalling the rationale for *CCAMLR Science* to provide a mechanism to publicise the science done in CCAMLR, the Science Manager also noted that many working group papers in the past few years had been published in high-ranking peer-reviewed journals and that this might actually provide a more effective mechanism for CCAMLR to reach a wider scientific audience than via an in-house journal.

5.4 The Working Group noted that the mechanisms available for 'publishing' science have changed considerably since *CCAMLR Science* was launched in 1994 and that continuing the journal in its current form was a considerable overhead for the Secretariat. The Working Group acknowledged the proliferation of science journals and the challenges of maintaining an in-house journal like *CCAMLR Science* and suggested that it may be useful to consider different options for promoting the science contributions to CCAMLR, such as for example, sponsoring occasional 'special issues' in other appropriate journals, and that this should be examined by the Secretariat.

5.5 The Science Manager thanked the Working Group for its comments and advice and undertook to prepare a paper to the Scientific Committee on the future options for *CCAMLR Science*.

## Future work discussions

6.1 The Working Group noted that CM 21-02, paragraph 6(iii), requires that all notifications for exploratory fisheries in Subarea 48.6 and Divisions 58.4.1, 58.4.2 and 58.4.3a are submitted before 1 June and that these should include a research plan (that follows the format of CM 24-01, Annex 24-01/A, format 2). This means that each Member that submits a notification is required to submit a research plan each year (and these plans are required to be submitted to WG-SAM for review by 1 June).

6.2 The Working Group agreed that the requirements of the notification process were not consistent with the desire to have multiyear multi-Member research proposals that do not necessarily require an annual presentation and review. The Working Group also recognised that there were several occasions during the Working Group meeting that highlighted an apparent lack of clarity in the process of notifications for research conducted under CMs 21-02, 24-01 and 41-10, Annex 41-10/A. The Working Group requested that the Scientific Committee consider this matter.

6.3 The Working Group also agreed that the research undertaken in CCAMLR with the aim of developing an assessed fishery should be grouped according to the objectives of the research rather than the conservation measure under which the research was proposed.

6.4 The Working Group agreed that there are several key types of information that should be compiled for each fishery in order to help develop a strategy for research toward an assessment:

(i) Research phase (prospecting/biomass estimation/assessment) –

(a) method of biomass estimation in use
(b) catch level
(c) define stock area
(d) Member(s) developing assessment.

(ii) Characterisation of the fishery –

(a) catch and CPUE
(b) tag releases and recaptures
(c) inventory of age data
(d) model parameters available – maturity, growth, tagging-related mortality etc.
(e) other sources of mortality.

(iii) Data collection plan for the fishery.

(iv) Development of long-term assessments –

(a) timeline for developing assessments
(b) identify information needed to improve assessment
(c) key research questions and priorities
(d) MSE.

(v) Reporting of progress –

(a) data available for assessments by vessel, year etc. (see characterisation)
(b) performance of the research plan (given sea-ice etc.)
(c) check appropriate catch levels based on local data
(d) submitted progress reports by Members participating in the plan.

6.5 The Working Group agreed that this information should be available prior to WG-FSA to assist it in reviewing proposals. It also agreed that the Secretariat be asked to assist in preparing a summary table of the elements of the characterisation of the fishery (ii) with data that are routinely submitted to the Secretariat (with the current exception of age data). The Working Group requested that information on the availability of, and/or the age data itself, be made available to the Secretariat and the Secretariat indicated that the structure for an age database currently existed and could be used to store age information and metadata.

6.6 The Working Group noted the value of having a standardised system for plotting research set locations and research blocks. It recommended that all those providing research proposals use the CCAMLR GIS system to display spatial data or to submit spatial data with their research proposals to the CCAMLR Secretariat so that spatial information could be displayed consistently for all proposals.

6.7 The Working Group agreed that the increasing number of multiyear multi-Member research proposals aimed at producing a stock assessment would necessitate greater collaboration among Members, and that it may be beneficial to identify common research themes when developing these proposals. It recalled the success of the focused science, research and assessment activities undertaken with the development of the *Dissostichus* fishery in Subareas 88.1 and 88.2.

6.8 The Working Group agreed that future progress reports that summarise multiyear research efforts should be comprehensive and efforts should be made within progress reports to more formally evaluate whether the objectives of the research are being met.

6.9 The Working Group agreed that the Fishery Report for individual fisheries should include a research annex that describes the status of the research designed to lead to an assessment, and if an assessment has been developed, an assessment annex that describes the status of the stock assessment in a standardised way. For those fisheries with assessments, the research plan would be designed to improve the assessment and could also be included as an annex to the Fishery Report.

6.10 The Working Group recognised that the agenda for its meetings had changed considerably over the past three years and that, along with the other working groups of the Scientific Committee, there was a need for an overview of the priorities that the Scientific Committee had identified for its working groups. The Working Group welcomed the indication that a paper was being prepared for discussion at the Scientific Committee this year on possible options for streamlining the work of the Scientific Committee.

## 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) Integrated assessments of toothfish –

  (a) estimation of IUU fishing (paragraphs 2.5 and 2.6)

  (b) retention of tag data (paragraphs 2.5 and 2.6)

  (c) consistency of stock projections with CCAMLR decision rule (paragraph 2.9).

(ii) Review of stock assessment methods –

  (a) review of by-catch data and SISO observer training on by-catch reporting (paragraphs 2.27, 2.31 and 2.32)

  (b) development of stock assessment model diagnostics (paragraph 2.43)

  (c) CCAMLR database redevelopment (paragraph 2.51)

  (d) depredation (paragraphs 2.60 and 2.61)

  (e) MSE (paragraph 2.64).

(iii) Research plans –

  (a) Subarea 88.1 Ross Sea surveys and stock assessments (paragraphs 4.26, 4.29 and 4.36)

(b) replacement of the *Yantar 35* (paragraph 4.41)

(c) historical tagging data (paragraph 3.19).

(iv) Other business –

(a) boundary positions in Subarea 88.1 (paragraph 5.1).

(v) Future work –

(a) notifications (paragraph 6.2)

(b) conservation measures (paragraph 6.3).

## 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 the meeting hosts for the excellent facilities and very kind hospitality. He also thanked participants for their goodwill and contributions to the work of WG-SAM, and the subgroup coordinators, rapporteurs and Secretariat for facilitating discussions and preparation of the report.

8.3 Dr Jones, on behalf of WG-SAM and the Scientific Committee, thanked Dr Parker for successfully leading his first meeting as Convener of WG-SAM. The Working Group had been able to give due consideration to the large number of papers submitted to the meeting and make further progress in developing assessment methods.

## References

Agnew, D.J., C. Edwards, R. Hillary, R. Mitchell and L.J. López Abellán. 2009. Status of the coastal stocks of *Dissostichus* spp. in East Antarctica (Divisions 58.4.1 and 58.4.2). *CCAMLR Science*, 16: 71–100.

Labadie, G., P. Tixier, L. Trudelle, J. Vacquie-Garcia, N. Gasco and C. Guinet. 2014. Sperm whales of the Crozet and Kerguelen Islands, photo-identification catalogue 2014. doi: 10.6084/m9.figshare.1414472

Tixier, P., N. Gasco and C. Guinet. 2014a. Killer whales of the Crozet Islands, photo-identification catalogue 2014. doi: 10.6084/m9.figshare.1060247.

Tixier, P., N. Gasco, T. Poupart and C. Guinet. 2014b. Type-D killer whales of the Crozet Islands, photo-identification catalogue 2014. doi: 10.6084/m9.figshare.1060259.

Appendix A

## List of Participants

Working Group on Statistics, Assessments and Modelling
(Warsaw, Poland, 29 June to 3 July 2015)

| | |
|---|---|
| **Convener** | Dr Steve Parker<br>National Institute of Water and Atmospheric Research (NIWA)<br>steve.parker@niwa.co.nz |
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Appendix B

# Agenda

Working Group on Statistics, Assessments and Modelling
(Warsaw, Poland, 29 June to 3 July 2015)

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 A review of progress towards updated integrated assessments of toothfish
    2.2 A review of stock assessment methodologies used in CCAMLR's integrated assessments
    2.3 Other work

3. Review of research plans from Members notifying to fish in exploratory fisheries in Subareas 48.6 and 58.4

4. Review of scientific research proposals for other areas (e.g. closed areas, areas with zero catch limits, Subareas 88.1 and 88.2)

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
(Warsaw, Poland, 29 June to 3 July 2015)

| | |
|---|---|
| WG-SAM-15/01 | Comparing surface and planimetric area across multiple scales and assessing the impact of different data sources on seabed area estimation in research blocks in the CAMLR Convention Area<br>CCAMLR Secretariat |
| WG-SAM-15/02 | Continuation in the 2015/16 season of the research plan initiated in 2012/13 for stocks of *Dissostichus* spp. in Divisions 58.4.1 and 58.4.2<br>Delegation of Spain |
| WG-SAM-15/03 | Research plan for the 2015/16 exploratory longline fishery of *Dissostichus* spp. in Division 58.4.3a<br>Delegation of Japan |
| WG-SAM-15/04 | Research plan for the 2015/16 exploratory longline fishery of *Dissostichus* spp. in Division 58.4.2<br>Delegation of Japan |
| WG-SAM-15/05 | Research plan for the 2015/16 exploratory longline fishery of *Dissostichus* spp. in Division 58.4.1<br>Delegation of Japan |
| WG-SAM-15/06 | Research plan for the 2015/16 exploratory longline fishery of *Dissostichus* spp. in Subarea 48.6<br>Delegation of Japan |
| WG-SAM-15/07 | Research plan for the exploratory longline fishery for *Dissostichus* spp. in Divisions 58.4.1 and 58.4.2 in 2015/16<br>Delegation of the Republic of Korea |
| WG-SAM-15/08 | Korean research plan for *Dissostichus* spp. in Subarea 48.5 in 2015/16<br>Delegation of the Republic of Korea |
| WG-SAM-15/09 | Korean research plan for *Dissostichus* spp. in Subarea 88.3 in 2015/16<br>Delegation of the Republic of Korea |
| WG-SAM-15/10 | Research plan for exploratory fishing for toothfish (*Dissostichus* spp.) in East Antarctica (Divisions 58.4.1 and 58.4.2) by Australia<br>Delegation of Australia |

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|---|---|
| WG-SAM-15/11 | Revised research plan for the exploratory longline fishery for *Dissostichus* spp. in 2015/16 in Division 58.4.3a<br>Delegation of France |
| WG-SAM-15/12 | Finfish Research Proposal: Finfish distribution and abundance in Subareas 48.1 and 48.2<br>Delegation of Chile |
| WG-SAM-15/13 | Research plan for toothfish in Division 58.4.4 b by *Shinsei Maru No. 3* in 2015/16<br>Delegation of Japan |
| WG-SAM-15/14 | Reports on abundance and biological information of toothfish in Division 58.4.4 a & b by *Shinsei Maru No. 3* in 2013/14 season<br>Delegation of Japan |
| WG-SAM-15/15 | Research plan for exploratory fishing for toothfish (*Dissostichus* spp.) in 2015/16 in Division 58.4.2<br>Delegation of France |
| WG-SAM-15/16 | Research plan for exploratory fishing for toothfish (*Dissostichus* spp.) in 2015/16 in Division 58.4.1<br>Delegation of France |
| WG-SAM-15/17 | Implementation of the research program for characterisation of the local toothfish population distribution and quantity in the SSRUs 882 A and B. Marine studies to assess the resource potential of the Subarea within the framework of the Ross Sea MPA proposed by the NZ and USA<br>Delegation of the Russian Federation |
| WG-SAM-15/18 | Plan of research program of the Russian Federation in Subarea 48.5<br>Delegation of the Russian Federation |
| WG-SAM-15/19 | Proposal of the Russian Federation to amend the borders of the Subarea 88.1 (Ross Sea)<br>Delegation of the Russian Federation |
| WG-SAM-15/20 | Proposal of the Russian Federation to establish research TAC for closed SSRU in Subareas 88.1 and 88.2<br>Delegation of the Russian Federation |
| WG-SAM-15/21 | Research program on resource potential and life cycle of *Dissostichus* species from the Subarea 88.2 A in 2015–2018<br>Delegation of the Russian Federation |

| | |
|---|---|
| WG-SAM-15/22 | Analysis of the scientific data obtained during Russian research program in the Weddell Sea (Subarea 48.5) in 2012–2013<br>Delegation of the Russian Federation |
| WG-SAM-15/23 | A meta-analysis of by-catch in the Ross Sea toothfish fishery<br>CCAMLR Secretariat |
| WG-SAM-15/24 | Assessment models for Patagonian toothfish in research block 58.4.3a_1 of Division 58.4.3a, Elan Bank for the years 2005–2014<br>K. Taki (Japan), S. Mormede (New Zealand) and T. Ichii (Japan) |
| WG-SAM-15/25 | Assessment models for Patagonian toothfish in research block 58.4.4b_1 (SSRU 58.4.4bC) for the years 1990–2014<br>K. Taki (Japan), S. Mormede (New Zealand) and T. Ichii (Japan) |
| WG-SAM-15/26 | Towards developing diagnostics tools for fishery stock assessments<br>P. Ziegler, P. Burch, A. Constable (Australia), C. Darby (United Kingdom), A. Dunn (New Zealand), C. Jones, D. Kinzey (USA), S. Mormede (New Zealand) and D. Welsford (Australia) |
| WG-SAM-15/27 | Review of cetacean depredation in CCAMLR statistical subareas<br>M. Söffker (United Kingdom) and P. Tixier (France) |
| WG-SAM-15/28 | Review of depredation mitigation methods applied within the CCAMLR Statistical Area<br>R. Faulkner, N. Edmonds and M. Söffker (United Kingdom) |
| WG-SAM-15/29 | Fishery selection for Patagonian toothfish in CCAMLR Subarea 48.3, asymptotic or dome shaped?<br>C. Darby, V. Laptikhovsky and M. Söffker (United Kingdom) |
| WG-SAM-15/30 | A potential link between the *D. eleginoides* stocks of Statistical Subareas 48.3 and 48.4<br>M. Söffker, M. Belchier and V. Laptikhovsky (United Kingdom) |
| WG-SAM-15/31 | Results of the longline survey for toothfish in the northern Ross Sea region (SSRU 88.2A) by the FV *Argos Froyanes*, United Kingdom<br>M. Söffker, J. Clark, J.M.G. Rebollo and C. Darby (United Kingdom) |
| WG-SAM-15/32 | Proposal to continue participation in the second year of the joint CCAMLR research survey to collect spatially stratified longline and bathymetric data in 88.2_A and 88.2_B in 2015/16<br>Delegation of the United Kingdom |

| | |
|---|---|
| WG-SAM-15/33 | Vacant |
| WG-SAM-15/34 | Using tag-recapture data to estimate catchability of a series of random stratified trawl surveys<br>W. de la Mare, P. Ziegler and D. Welsford (Australia) |
| WG-SAM-15/35 | Progress report on the Korean exploratory longline fishery for *Dissostichus* spp. in Divisions 58.4.1 and 58.4.2 in 2014/15<br>Delegation of the Republic of Korea |
| WG-SAM-15/36 | Vacant |
| WG-SAM-15/37 | Progress report on the Australian Fisheries Research and Development Corporation project to develop robust assessment methods and harvest strategies for spatially complex, multi-jurisdictional toothfish fisheries in the Southern Ocean<br>P. Burch, C. Péron, D. Welsford, P. Ziegler, T. Lamb, T. Robertson (Australia), G. Duhamel, N. Gasco, P. Pruvost, C. Chazeau and R. Sinègre (France) |
| WG-SAM-15/38 | The preliminary report on the survey in Subarea 48.2 in 2015 (the first year of the planned 3-year-old investigations)<br>Delegation of Ukraine |
| WG-SAM-15/39 | South African work plan for 2015/16 for the joint Japan/South Africa research on *Dissostichus* spp. in Subarea 48.6<br>Delegation of South Africa |
| WG-SAM-15/40 | Plan of research program of the Ukraine in Subarea 48.2 in 2016 (second season)<br>Delegation of Ukraine |
| WG-SAM-15/41 | Proposal to continue participation in the second year of the joint CCAMLR research survey to collect spatially stratified longline and bathymetric data in 88.2_A and 88.2_B in 2015/16<br>Delegation of Norway |
| WG-SAM-15/42 | Results of the longline survey for toothfish in the northern Ross Sea region (SSRU 88.2A) by the FV *Seljevær*, Norway<br>Delegation of Norway |
| WG-SAM-15/43 | Investigations on tagging data in the Kerguelen Islands Patagonian toothfish fishery (Division 58.5.1)<br>R. Sinegre and G. Duhamel (France) |

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| WG-SAM-15/44 | Results of the fourth CCAMLR sponsored research survey to monitor abundance of sub-adult Antarctic toothfish in the southern Ross Sea, February 2015 and further development of the time series<br>S.M. Hanchet, B.R. Sharp, S. Mormede, S.J. Parker (New Zealand) and M. Vacchi (Italy) |
| WG-SAM-15/45 | Proposal to continue the time series of research surveys to monitor abundance of Antarctic toothfish in the southern Ross Sea, 2016−2017<br>S.M. Hanchet, S.J. Parker, S. Mormede and R.J.C. Currey (New Zealand) |
| WG-SAM-15/46 | Results of the longline survey for toothfish in the northern Ross Sea region (Subarea 88.2 SSRUs A–B) by the FV *Janas*, New Zealand<br>S.J. Parker, R.J.C. Currey and S. Mormede (New Zealand) |
| WG-SAM-15/47 | Proposal for a winter longline survey of Antarctic toothfish in Subarea 88.1 SSRUs B–C in 2016<br>S.J. Parker, S.M. Hanchet and R.J.C. Currey (New Zealand) |
| WG-SAM-15/48 | Progress in the evaluation of management strategies for the Antarctic toothfish (*Dissostichus mawsoni*) in the Ross Sea region<br>S. Mormede, A. Dunn, S.J. Parker and S.M. Hanchet (New Zealand) |
| WG-SAM-15/49 | Potential modelling structures for a two-area stock assessment model for Antarctic toothfish (*Dissostichus mawsoni*) in the Amundsen Sea Region<br>S. Mormede, S.J. Parker, A. Dunn and S.M. Hanchet (New Zealand) |
| WG-SAM-15/50 | Progress report for the third year of the research fishery for *Dissostichus* spp. in Subarea 48.6 being jointly undertaken by Japan and South Africa: 2013–2015<br>R.W. Leslie (South Africa), K. Taki, T. Ichii (Japan) and S. Somhlaba (South Africa) |
| WG-SAM-15/51 | Proposal to reposition the boundary between CCAMLR Statistical Subareas 58.6 and 58.7<br>R.W. Leslie (South Africa) and G. Duhamel (France) |
| WG-SAM-15/52 | 2015–16 Research plan in Division 58.4.4 for *Dissostichus* spp.<br>Delegation of France |

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| WG-SAM-15/53 | Exploratory longline fishing proposal for *Dissostichus* spp. in Subarea 48.2<br>Delegation of Chile |

Other Documents

| | |
|---|---|
| WG-SAM-15/P01 | Standardisation of commercial CPUE<br>A. Salthaug and O.R. Godø<br>*Fish. Res*., 49 (2001): 271–281 |

Appendix D

## Diagnostics for integrated stock assessment models

### MPD

*Table of process error weighting*

Looking for: How different datasets are interpreted by model.

*MPD components*

Comparison of different model runs (e.g. previous and current assessments) and evaluation of the contribution of penalties.

Looking for: Understand the changes in contributions from each dataset between model runs and influence of penalty values and priors on model fits.

Table 1: MPD objective function values for model runs R1–R5.

| Objective function component | R1 | R2 | R3 | R4 | R5 |
|---|---|---|---|---|---|
| 2004 tags recaptured | 65.1 | 3.4 | 4.1 | 3.2 | 3.6 |
| 2005 tags recaptured | 35.9 | 3.2 | 4.7 | 3.9 | 4.3 |
| 2006 tags recaptured | 110.5 | 11.1 | 12.6 | 9.1 | 10.8 |
| 2007 tags recaptured | 42.0 | 4.9 | 6.0 | 4.2 | 5.0 |
| 2008 tags recaptured | 42.4 | 5.5 | 6.8 | 5.5 | 6.0 |
| 2009 tags recaptured | 73.2 | 9.4 | 10.4 | 7.4 | 8.9 |
| 2010 tags recaptured | 116.7 | 14.4 | 14.7 | 9.8 | 12.3 |
| 2011 tags recaptured | 68.7 | 7.6 | 7.9 | 5.5 | 6.7 |
| 2012 tags recaptured | 52.4 | 6.1 | 5.4 | 3.6 | 4.6 |
| Catch-at-age (882G) | 194.7 | 247.0 | 249.6 | 2.5 | - |
| Catch-at-age (North) | 1169.4 | 1349.9 | 1801.3 | 27.8 | 98.3 |
| Catch-at-age (Slope) | 1031.9 | 161.5 | 133.8 | 8.1 | 136.5 |
| Sub-total (observations) | 3003.0 | 1823.9 | 2257.4 | 90.7 | 297.1 |
| Penalties | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| $B_0$ prior | 9.3 | 9.5 | 8.9 | 8.8 | 8.9 |
| All other priors | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Total objective function | 3012.3 | 1833.4 | 2266.3 | 99.5 | 306.0 |
| Number of parameters | 25 | 25 | 23 | 23 | 15 |

*Age and length-frequency/abundance data*

Observed and expected values and residuals by fishery and year.

Looking for: Absence of systematic patterns in lack of fits across years and age classes.

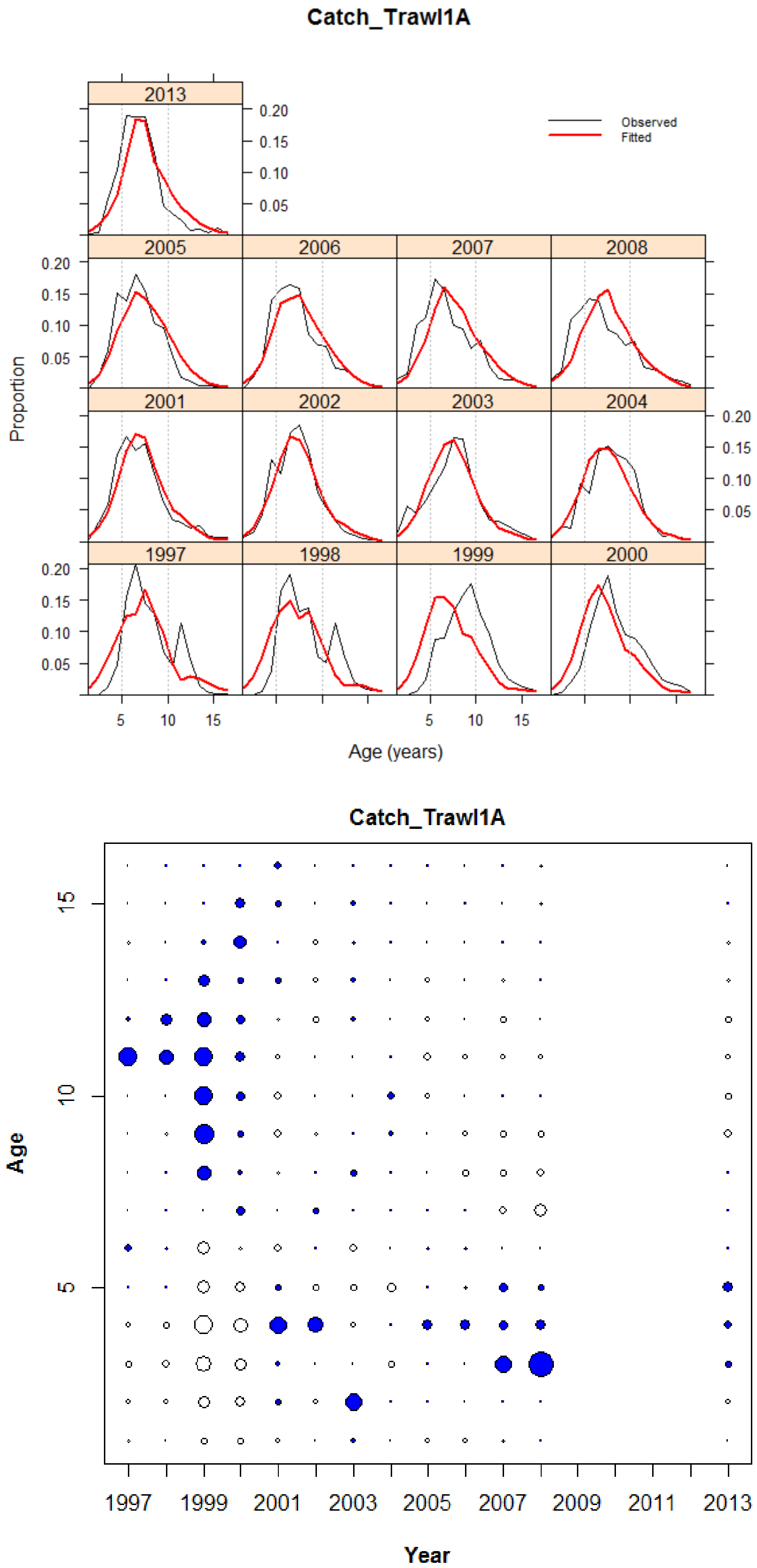


Figure 1: MPD fits to catch-at-age data (top) and Pearson's residuals of MPD fits by age and year for catch-at-age data (bottom). Filled circles are positive, empty circles are negative.

*Age and length-frequency/abundance data*

For each age by year, and for each year by age: Observed and expected values over time, observed versus expected values, standardised residuals from model fits, quantile-quantile normal plots for normally or lognormally distributed error structures and 1:1 line and ACF plots.

Looking for: Absence of systematic patterns in fits across years and age classes, distribution of residuals should meet assumed error distribution.

*Mean age*

Expected versus observed values.

Looking for: Absence of systematic patterns across years.

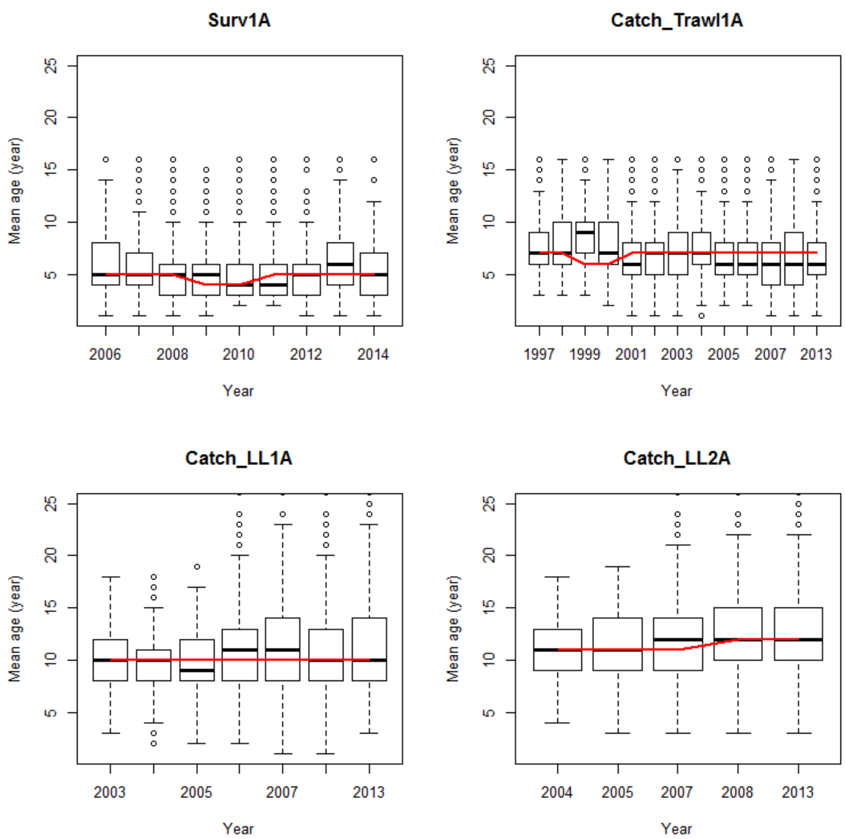


Figure 2: Boxplots of observed and predicted median age.

*Indices of abundance (e.g. from survey or catch rates)*

Observed and expected values and residuals by fishery and year.

Looking for: Absence of systematic patterns in fits across years and age classes.

*Indices of abundance (e.g. from survey or catch rates)*

Observed and expected values over time, observed versus expected values, standardised residuals from model fits, QQ norm plots for normally or lognormally distributed error structures and 1:1 line and ACF plots.

Looking for: Absence of systematic patterns in fits across years and age classes, the distribution of residuals should meet assumed error distribution.

*Tagging data*

Observed and expected values and residuals by fishery, year and length of recaptured fish.

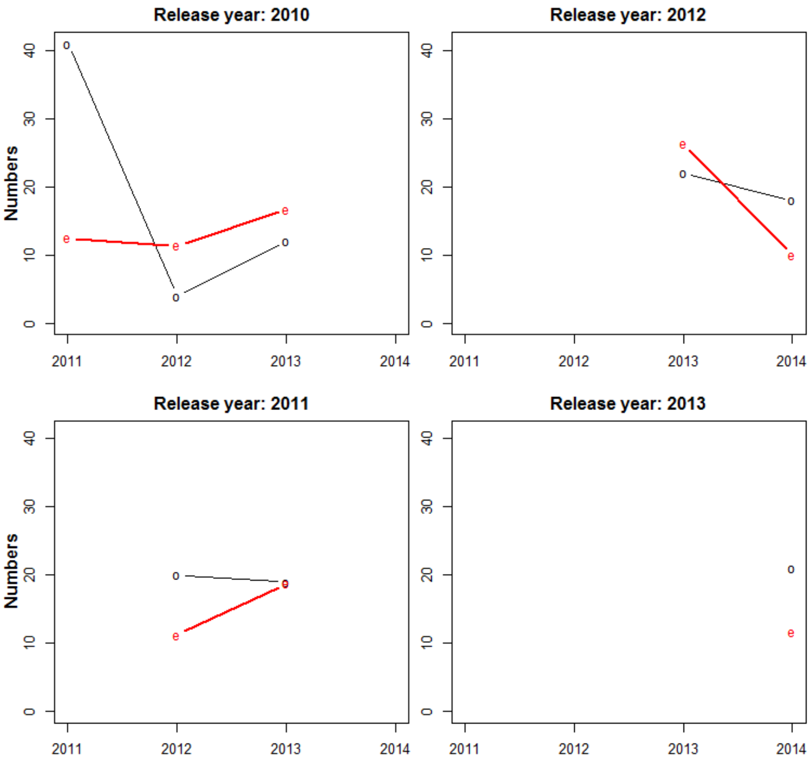


Figure 3: Observed (black 'o') and expected (red 'e') numbers of recaptures by release year.

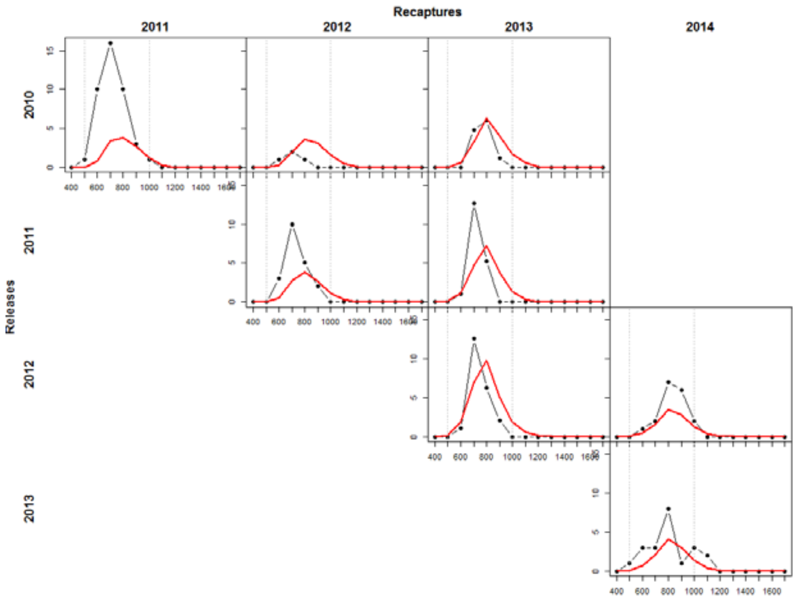


Figure 4: Observed (black) and expected (red) numbers of recaptures by release year and recapture length.

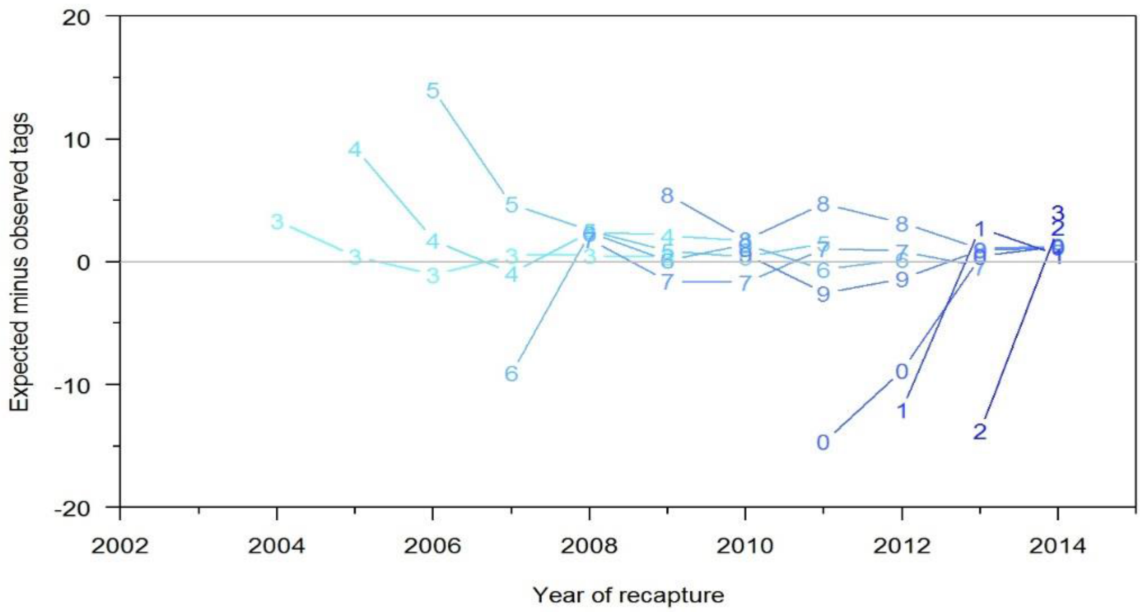


Figure 5: Residual fits to tag data.

## LL profiles

*Likelihood profiles*

Profiles for $B_0$, catchability $q$, declining right-hand limb of selectivity functions where appropriate and other important parameters (i.e. estimated productivity parameters when estimated).

Looking for: Each dataset should decline to an obvious minimum value from at least one side for this dataset to make a substantial contribution to the scale estimation of the parameter. The likelihood contributions by the important data sources should show consistent trends.

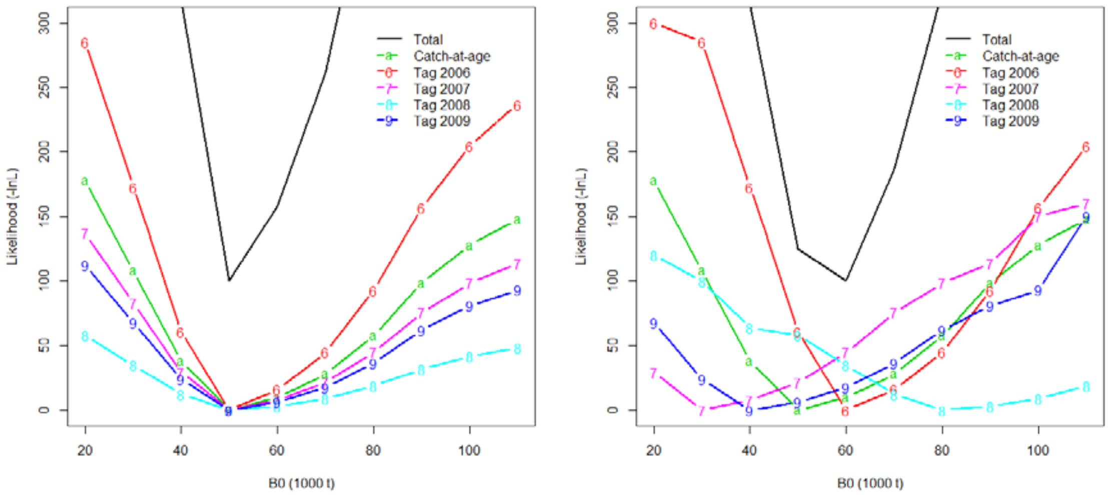


Figure 6: Illustrative example of likelihood profile for $B_0$ with a high yet unlikely (left) and low (right) level of agreement between different data sources about the most likely $B_0$ level.

## MCMC

*Model convergence*

- Visual evidence of convergence at a stationary distribution:
  - Stationary loess estimate of MCMC samples
  - Absence of trends in running means
  - Geweke diagnostics to compare the means of different parts of a chain
  - Heidelberg and Welch diagnostic to evaluate whether the chain is sampled from a stationary distribution
  - Gelman and Rubin diagnostic for multiple chains.

Looking for: Plots should look like a 'hairy caterpillar' indicating good mixing behaviour and stationary chains. No correlation between parameters or correlations without substantial consequences for model fits.

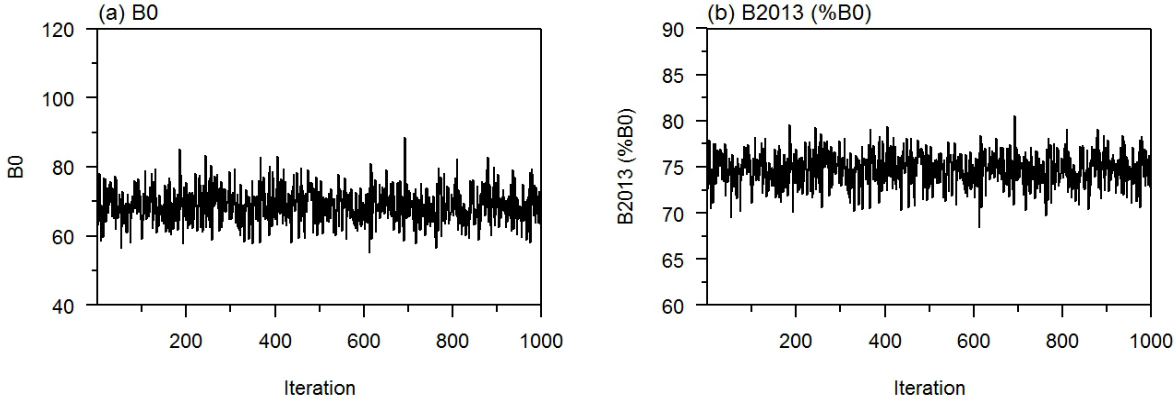


Figure 7: MCMC posterior trace plots for $B_0$ and stock status in 2013.

*Parameter estimates*

MCMC values of the parameters estimated by the model, and how they compare to their priors and estimation bounds.

Looking for: Does distribution of estimate follow that of the prior, distribution of estimates is narrower than that of the prior (but not unrealistically precise), estimates do not hit bounds.

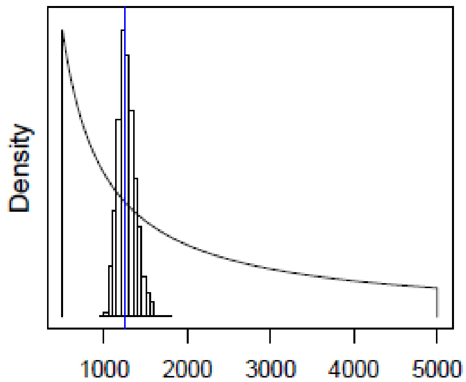


Figure 8: Estimated fishing selectivity functions with 95% credible intervals obtained from the MCMC samples.

*Model-derived estimates with MCMC intervals*

Selectivity functions

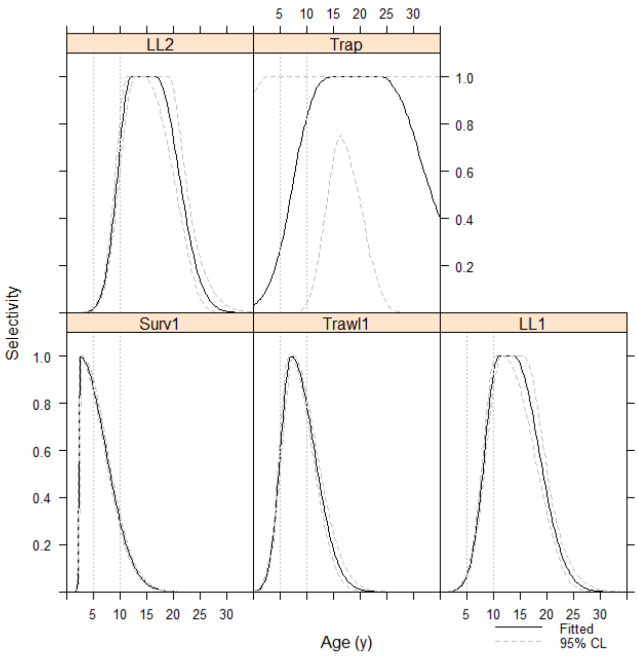


Figure 9: Estimated selectivity functions with 95% credible intervals obtained from the MCMC samples.

*Annual spawning, total biomass and stock status*

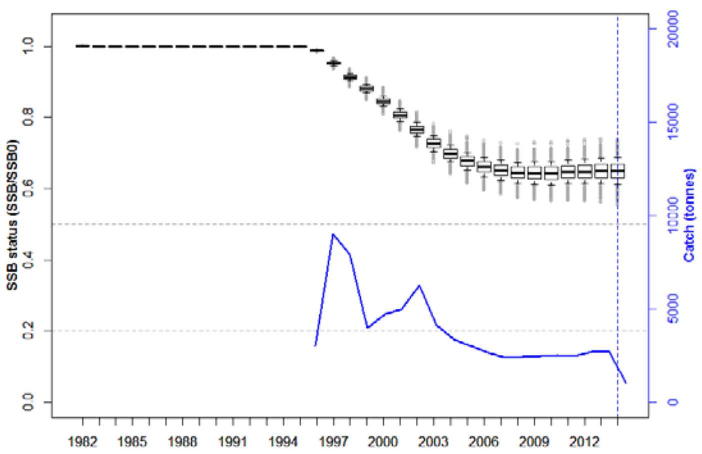


Figure 10: Estimated *SSB* status (black) and historical catch time series (blue).

*Year-class strength*

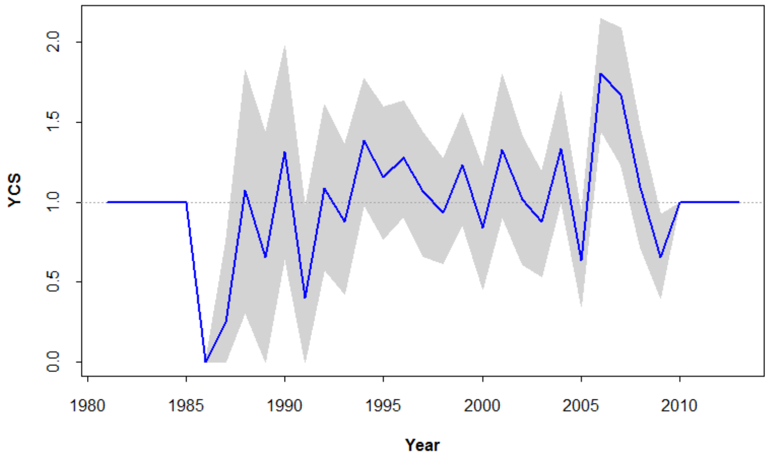


Figure 11: Estimated year-class strength (YCS) with 95% credible intervals obtained from the MCMC samples.

*Annual harvest rates or proxy*

Total catch relative to vulnerable biomass (or spawning biomass as a proxy).

*Stock projections*

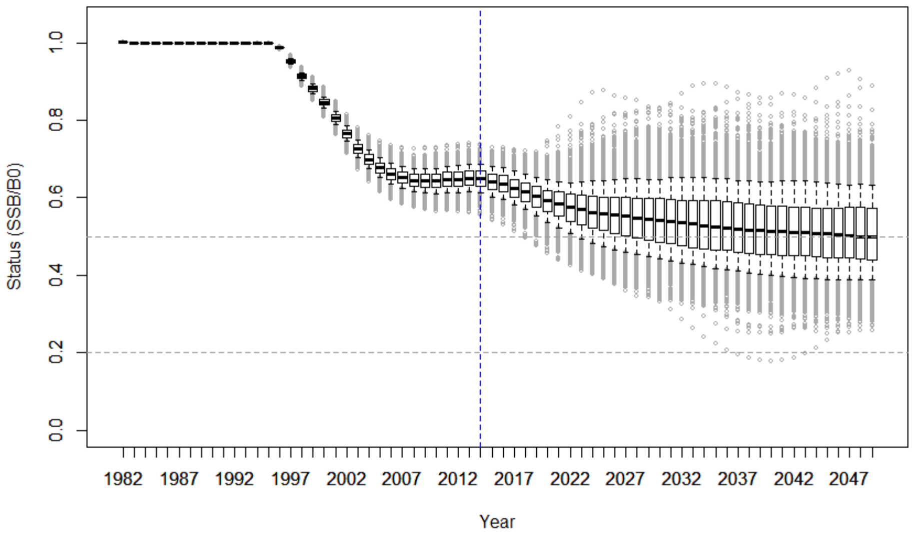


Figure 12: Projected *SSB* status relative to $SSB_0$ using MCMC samples and future random lognormal recruitment from 2011 to 2049 with annual constant catches.

*Risk profile*

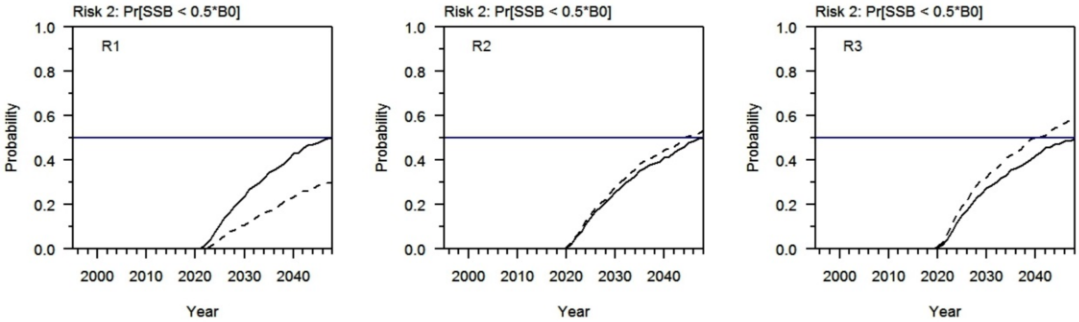


Figure 13: Estimated risks for three models under the CCAMLR decision rules for probability that SSB < 0.5 $B_0$ with the current catch limit (dashed lines) and maximum catch that meets the decision rule criteria for each model (solid lines).

**Report of the Working Group on**
**Ecosystem Monitoring and Management**
(Warsaw, Poland, 6 to 17 July 2015)

# Content

Page

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## Opening of the meeting

1.1 The 2015 meeting of WG-EMM was held at the Ministry of Agriculture and Rural Development, Warsaw, Poland, from 6 to 17 July 2015. The meeting was convened by Dr S. Kawaguchi (Australia). The meeting was opened by Dr M. Kaniewska-Krolak (Ministry of Agriculture and Rural Development) and Prof. P. Jonczyk (Institute of Biochemistry and Biophysics, PAS) who welcomed the Working Group to Warsaw.

1.2 Dr Kawaguchi welcomed participants (Appendix A) and reviewed the current work of WG-EMM. He also outlined the meeting's agenda that focused on the krill-centric ecosystem and issues related to the development of the feedback management (FBM) of the krill fishery.

### Adoption of the agenda and organisation of the meeting

1.3 The Working Group discussed the provisional agenda. While there was no specific agenda item dealing with climate change, WG-EMM reiterated the importance of climate change in its work. The Working Group agreed to note the discussion points that were relevant to climate change for further consideration by the Scientific Committee. The agenda was adopted (Appendix B). Subgroups were formed to address detailed aspects of the agenda.

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 4.

1.6 The report was prepared by T. Brey (Germany), A. Constable (Australia), R. Currey (New Zealand), C. Darby (UK), O.R. Godø (Norway), S. Grant and S. Hill (UK), B. Krafft (Norway), J. Melbourne-Thomas (Australia), D. Ramm, K. Reid and L. Robinson (Secretariat), C. Reiss (USA), M. Santos (Argentina), C. Southwell (Australia), P. Trathan and J. Watkins (UK) and G. Watters (USA).

## The krill-centric ecosystem and issues related to management of the krill fishery

### Issues for the present

#### Fishing activities

##### Krill Fishery Report

2.1 The Working Group reviewed the draft krill fishery report (WG-EMM-15/30) noting that:

(i) in 2013/14:

(a) 12 vessels fished in Subareas 48.1, 48.2 and 48.3

(b) Subarea 48.1 was closed on 17 May 2014 when the catch of krill in that subarea reached the apportioned limit of 155 000 tonnes

(c) the total catch of krill was 293 814 tonnes (WG-EMM-15/30, Appendix 3, Table 3, see also *CCAMLR Statistical Bulletin*)

(d) the total catch and the catch in Subarea 48.3 (75 169 tonnes) were the highest catches reported in the fishery and in that subarea since 1990/91 (WG-EMM-15/30, Appendix 3, Table 3).

(ii) in 2014/15 (to 10 June 2015):

(a) 13 vessels fished in Subareas 48.1 and 48.2

(b) Subarea 48.1 was closed on 28 May 2015 (total catch of krill: 153 946 tonnes)

(c) vessels were currently fishing in Subarea 48.3

(d) the total catch of krill reported in catch and effort reports was 175 240 tonnes.

2.2 The Working Group noted that in 2013/14 and 2014/15 fishing occurred in Subarea 48.1 in December and January, particularly in the southern part of Bransfield Strait (Gerlache Strait). The pattern for February and March was also similar in both seasons with a focus towards Bransfield Strait in April and May prior to the closure of Subarea 48.1.

2.3 The Working Group noted that only 17 100 tonnes of krill had been taken to date from Subarea 48.2 in 2014/15 compared with 72 455 tonnes in 2013/14. Sea-ice charts for 1 May 2014 and 2015 (see gis.ccamlr.org) indicated that the northern extent of sea-ice in Subarea 48.2 was greater in 2015 than in 2014, with sea-ice extending to the South Orkney Islands in May 2015. Sea-ice extent along the Antarctic Peninsula (Subarea 48.1) was also greater in 2015 than in 2014.

2.4 The Working Group agreed that trends in sea-ice extent on the krill fishing grounds should be included in the Krill Fishery Report, noting that a routine had been developed for time series analysis of sea-ice extent in exploratory fisheries for toothfish (SC-CAMLR-XXXIII, Annex 7, paragraphs 3.18 to 3.23).

2.5 The Working Group noted that the data available to date for 2014/15 revealed discrepancies between the amounts of by-catch reported in observer and fishery (C1) data. Two vessels did not appear to be reporting by-catch in their C1 data (WG-EMM-15/30, Table 4); the observers on those two vessels had reported by-catch in 65–75% of the hauls observed.

2.6 The Working Group reiterated that the reporting of fish by-catch, other than the by-catch in the 25 kg samples collected by observers, was a vessel responsibility and should be reported in the C1 data (SC-CAMLR-XXXIII, Annex 6, paragraph 2.37).

2.7 The Working Group also noted the advice from WG-SAM-15 related to discrepancies in the reporting of by-catch in the fishery (C2) data from the Ross Sea toothfish fishery (Annex 5, paragraph 2.27). WG-SAM had requested that the Secretariat correspond with those Members that had participated in that fishery to obtain information in order to develop a better understanding of how by-catch data are collected and reported on the C2 forms.

2.8 WG-EMM agreed that the information sought by WG-SAM would also be useful in understanding discrepancies in the reporting of by-catch in krill fisheries. The Working Group requested that the Secretariat extend its correspondence on this matter (Annex 5, paragraphs 2.27i and ii) to Members involved in krill fisheries.

2.9 The Working Group thanked the Secretariat for further developing the structure and content of the draft Krill Fishery Report. The Working Group noted that:

(i) catch maps were included in an appendix, pending a decision by the Commission on the publication of such maps in fishery reports

(ii) spatial shifts in fishing areas could be illustrated in a figure that does not require maps pending the decision of the Commission in (i).

2.10 The Working Group agreed that the length frequencies for krill in Subarea 48.1 would be better represented if grouped into northern small-scale management units (SSMUs) (Antarctic Peninsula West (APW), Drake Passage West (APDPW), Drake Passage East (APDPE), Elephant Island (APEI)) and southern SSMUs (Bransfield Strait West (APBSW), Bransfield Strait East (APBSE), Antarctic Peninsula East (APE)).

2.11 The Working Group provided further editorial suggestions during the course of the meeting, and requested that the Secretariat submit a revised version of the Krill Fishery Report to SC-CAMLR-XXXIV.

### Redevelopment of the CCAMLR database

2.12 The Working Group noted the Secretariat's work in redeveloping the CCAMLR database and supporting infrastructure (WG-SAM-15/33). The new structure follows an

Enterprise Data Model and will simplify the database architecture, improve data-quality assurance and modernise the workflow. As a result, data quality and database documentation should substantially improve for users from late 2015 onwards. The Working Group welcomed these developments and the resulting improved integration, inter alia, of fishery and observer data. The Working Group also noted the advice from WG-SAM on this matter (Annex 5, paragraph 2.51).

### Green weight estimation

2.13 The Working Group reviewed the methods and data reported by fishing vessels in 2014/15 for the direct estimation of the green weight of krill caught (WG-EMM-15/19; see also Conservation Measure (CM) 21-03, Annex 21-03/B). Fishing vessels used five methods for directly estimating green weight: codend volume, holding tank volume, flow meter (method 2), flow scale and meal conversion. Two vessels had each used two methods concurrently.

2.14 WG-EMM-15/58 reported on a comparative analysis of data from the *Betanzos* which had used the codend volume method and flow meter method 2. The Working Group recalled that the flow meter method 2 was documented in 2014 (SC-CAMLR-XXXIII, Annex 6, paragraph 2.18), and that this was a valid method for estimating green weight. This method provided a more accurate estimate of product-to-green weight ratio than the codend method.

2.15 The Working Group considered methods used in other fisheries where small-sized fish were caught, and noted that the krill fishery differed from these fisheries in the range of methods of on-board processing. The development of methods for the direct estimation of the green weight of krill caught aimed to get precise estimates of the total amount of krill brought on board.

2.16 The Working Group considered the use of strain gauges to measure the weight of the codend as it is winched on board and tasked a small group coordinated by Dr Krafft to further investigate the feasibility of using strain gauges to measure the weight of the codends and, if feasible, to develop a protocol for trial use in 2015/16.

### Fishery notifications

2.17 The Working Group reviewed notifications for krill fisheries in 2015/16 which were submitted in accordance with CM 21-03 (WG-EMM-15/30, see also www.ccamlr.org/en/fishery-notifications/notified/krill). Prior to the meeting, the Secretariat had been advised that Russia had withdrawn its notifications for the vessel *Viktoriya*, and Poland had withdrawn the *Saga*'s notifications for Subareas 48.3 and 48.4 and Divisions 58.4.1 and 58.4.2. The remaining notifications for krill fisheries in 2015/16 were considered during the meeting: Chile (2 vessels), China (8 vessels), Republic of Korea (3 vessels); Norway (3 vessels), Poland (1 vessel) and Ukraine (1 vessel) (Table 1). A total of 18 vessels had notified, with a total expected catch level of 574 000 tonnes. All vessels had notified for fishing in Subarea 48.1, and most vessels had also notified for fishing in Subareas 48.2 and 48.3. In addition, two vessels had notified for fishing in Subarea 48.4.

2.18 The Working Group noted that 16 vessels notified the use of conventional trawling and two vessels notified the use of the continuous fishing method (Table 1). WG-EMM-15/01 to 15/03, 15/08, 15/49 and 15/60 provided diagrams of trawl nets and marine mammal exclusion devices for each of the notified vessels. Codend mesh size ranged from 11 to 20 mm. Some trawl nets were made up of the same mesh in all net panels, while other trawl nets used coarse mesh in the mouth of the net with decreasing mesh sizes towards the codend. Two general types of marine mammal exclusion devices were notified for use: a panel across the mouth and a panel in the net (in front of the codend) with an escape window. Panel mesh size in these exclusion devices ranged from 125 to 300 mm (Table 1).

2.19 The Working Group also noted that (Table 1):

(i) six methods had been notified for the direct estimation of green weight of krill caught (see also paragraphs 2.13 to 2.16)

(ii) vessels used either Simrad or Furuno echosounders and 38 kHz was the most common frequency in use; some vessels used multiple frequencies ranging up to 200 kHz

(iii) vessels used either Simrad or Furuno sonars.

2.20 The Working Group recalled that the instruction manual developed by SG-ASAM for the collection of fishing-vessel-based acoustic data (Annex 4, Appendix D) was currently limited to Simrad (ES60, ES70 and EK60) echosounders. The Working Group noted that 13 of the 18 vessels notified in 2015/16 used these types of echosounder, and one vessel (*Insung Ho*) was considering installing a Simrad echosounder during the next refit.

2.21 The Working Group encouraged Members with vessels using other types of echosounders to develop data collection procedures for inclusion in the instruction manual. The Working Group also noted that further work is required before acoustic data from sonars could be used in an FBM strategy.

2.22 The Working Group noted that the expected level of catch provided in the notifications was of limited use to its work, and recommended that, instead, Members notify each vessel's daily processing capacity (in tonnes of green weight).

2.23 The Working Group also reviewed its requirements for information on fishing gear configuration, and agreed that the following net information was essential in developing estimates of stock assessment parameters:

(i) net-mouth opening height (m)
(ii) net-mouth opening width (m)
(iii) total net length (m) (including codend, measured along the centreline of the net)
(iv) codend-mouth opening height (m)
(v) codend-mouth opening width (m)
(vi) codend length (m)
(vii) codend mesh size (mm) (stretched mesh).

2.24 The Working Group recommended that the notification pro forma in CM 21-03, Annex 21-03/A, be revised and that the parameter listed in the net configuration table be replaced with the parameters above (paragraph 2.23).

### Fishing gear library

2.25 The Working Group noted the ongoing development of the CCAMLR fishing gear library (WG-EMM-15/35; see also www.ccamlr.org/node/74407). The fishing gear library is a candidate for future work to continue the Secretariat's efforts to improve the utility and functionality of the website, and the Secretariat was seeking advice in relation to:

(i) the utility, structure, function and information content of the current gear library in relation to its application in CCAMLR

(ii) possible future requirements of a gear-related resource on the CCAMLR website. For example, if future work on fishing gear selectivity is anticipated, are additional parameters that characterise specific gear-types required?

2.26 The Working Group agreed that information on fishing gears and exclusion devices was important in developing estimates of total removals from krill fisheries and estimating stock assessment parameters. Gear parameters essential to this work were identified in paragraph 2.23.

2.27 The Working Group encouraged the Secretariat to further develop the website and online forms for fishery notification, and archive gear parameters identified in paragraph 2.23 and associated diagrams of trawl nets and marine mammal exclusion devices using the gear library and vessel registry where appropriate.

### Scientific observation

2.28 WG-EMM-15/06 presented a photographic reference guide to fish species of the by-catch species of the Southern Ocean. Photographs were taken by the author on board a trawler targeting Antarctic krill (*Euphausia superba*) and a longliner targeting *Dissostichus* spp. in Areas 48, 58 and 88. Dr S.-G. Choi (Republic of Korea) noted that the author would like to continue his work during the next year in other areas and would like to collaborate with other Members to progress the work. The Working Group commented on the high quality of the photographs and the format of the guide; there were a few minor identification problems noted which will be communicated to the author. It was also noted that the translations used in the guide were very useful.

2.29 The Working Group noted that a series of guides for each CCAMLR area had been developed by other Members and that there was a need to coordinate their reviews and development such that CCAMLR could make use of them as a standardised reference series. The Working Group referred WG-EMM-15/06 to WG-FSA for review and requested that WG-FSA and the Scientific Committee consider how this series of guides that are becoming available for different regions are reviewed and made available as a library to observers to facilitate their work.

2.30 WG-EMM-15/16 evaluated the spatial and temporal patterns of the length of Antarctic krill in Subarea 48.1 recorded by scientific observers. Generalised additive models (GAM) and generalised additive mixed models (GAMM) indicated that median krill length showed a complex pattern and varied significantly with fishing location, fishing depth, season, month and vessel. The paper recommended that the current sampling strategy to observe krill length in SSMUs in Subarea 48.1 needs to be modified in order to gain a comprehensive understanding of the temporal and spatial variability in krill length distribution and to determine the scale of observer coverage in the longer term. The paper also recommended that krill length measurements should be conducted on all vessels in every fishing season to reduce the likelihood of potential biases in the overall krill length estimates. In order to develop and evaluate alternative observer sampling strategies for measurements of particular properties of a krill population, the paper also proposed a simulation approach.

2.31 The Working Group agreed that evaluating the current sampling strategy for the krill observer program and modifying the design to meet the data requirements for management would be valuable and that simulation approaches would provide a useful method by which to develop and evaluate schemes. However, it noted that the analysis in WG-EMM-15/16 had been calculated on a haul-by-haul basis, whereas sampling was actually specified on a daily basis due to the use of the continuous fishing system and considered that the analysis and simulations should be conducted using this sampling approach. It also noted that the analysis in WG-EMM-15/16 had pooled the data collected by the conventional and continuous fishing systems to simulate the variability of length distribution, which would mix the effect of monitoring the different fishing patterns on the krill catch. The effect of mesh size that potentially impact on the length distribution was also excluded in the analysis. However, WG-EMM-15/16 indicated that trawl type and mesh size were highly correlated with vessel.

2.32 The Working Group noted that using fishing vessels to collect information on the krill stock, for instance for FBM, would require consideration of the fishing strategy and mesh size required by the vessel and the sampling scheme associated with it. This was noted in the review of data fitted within the integrated model (WG-EMM-15/51 Rev. 1), in which it was difficult to determine year-class strength from the observer data, potentially due to the variation in fishing behaviour. Furthermore, changes in behaviour which alter the selectivity of the fishery will also influence the dynamics of the recorded catch-per-unit-effort (CPUE) in terms of variability and trends and this was also considered within WG-EMM-15/26.

2.33 WG-EMM-15/57 Rev. 1 reviewed the observer coverage within the krill fishery which remains the only fishery within the CAMLR Convention Area that does not require 100% scientific observer coverage (i.e. having an observer on a vessel for all of the time that it was engaged in fishing for krill). The coverage in the observer scheme for the krill fishery in Area 48 during 2013 and 2014 was evaluated in terms of the spatial and temporal pattern of the fleet, by subarea and season and the composition and abundance of by-catch species.

2.34 The Working Group noted that in fisheries where 100% observer coverage was not mandatory, there was no standard metric to describe the actual level of observer coverage and, therefore, requested that the Scientific Committee develop such a metric.

2.35 A total of 15 vessels fished for krill during the 2013 and 2014 seasons, with a total fishing effort of 2 978 days and 511 500 tonnes of krill caught. Considering all vessels combined, the fleet had 65% or more observer coverage across both years, with a minimum of 58% in summer and 63% in winter. The observer coverage of the fleet across both years was 80%, equivalent to 2 382 days at sea.

2.36 The deployment of scientific observers on board krill vessel has increased significantly from 2010 onwards since the first adoption of CM 51-06 in 2009. This increase is lower in the conventional trawl fleet, while the continuous trawl fleet had very high observer coverage rates (in terms of the number of days of fishing during which an observer was on board).

2.37 The Working Group noted that, while the fishery overall fulfilled the requirement for greater than 50% coverage across the fleet, there are three vessels that had an observer coverage level below the minimum 50% requirement (CM 51-06) for 2013 and 2014. The Working Group, therefore, recommended that the Secretariat provide a review of the information to the Scientific Committee.

2.38 The authors of WG-EMM-15/57 Rev. 1 recommended that the requirements for systematic observer coverage within CM 51-06 should be applied to all subareas and that achieving the required coverage should be a requirement for a one-year rather than a two-year period. In addition, they recommended the number of by-catch samples taken during a season should be increased by increasing the minimum requirement for observer coverage and/or the number of samples taken by observers.

2.39 The Working Group agreed that there was a need to increase the observer sampling frequency for fish by-catch and that improving the sampling capability should be accompanied by increased training in the collection of the data and in the identification of fish to family level.

2.40 The Working Group noted that management advice could be provided as to the likely impact of the level of by-catch at the family level as in WG-EMM-12/28 and 12/29. These papers had estimated the likely scale of the impact of the krill fishery on fish stocks in Area 48 using data from a single vessel fishing with the continuous fishing method and the Working Group encouraged further considerations and observations to address this issue for all vessels.

2.41 The Working Group recalled the discussions at the Scientific Committee in 2014 regarding CM 51-06; there was general acknowledgement that 100% coverage (i.e. having an observer on a vessel for all of the time that it was engaged in fishing for krill) was scientifically desirable (SC-CAMLR-XXXIII, paragraph 7.16). In 2014, some Scientific Committee Representatives stressed that increasing the quality of data collected by observers was a higher priority than an increase in observer coverage. The Working Group considered this view and noted that analyses presented to this Working Group (WG-EMM-15/16, 15/51 Rev. 1, 15/57 Rev. 1) indicated that the quality is adequate, but that sampling frequency and design of the observer coverage need further development; however, it was noted that there was also a need to improve the quantity and quality of the fish by-catch sampling as well as observer training in fish identification (paragraph 2.39; WG-EMM-15/57 Rev. 1; SC-CAMLR-XXXIII, Annex 6, paragraph 2.43).

2.42 The Secretariat indicated that when each set of observer data was received, a routine data-quality report was sent to the data providers. The Working Group recommended that the number of issues identified by this process could be used as a metric to measure improvements in data quality.

2.43 Given the increase in the amount of observer data coming from the krill fishery, and the ongoing discussion on the level of coverage required, the Working Group recommended that the Scientific Committee should consider establishing a working group focussed on the CCAMLR Scheme of International Scientific Observation (SISO) to:

(i) review the krill observer coverage for the fishery and finfish by-catch
(ii) recommend sampling schemes and levels of coverage
(iii) identify where there may be a need to improve data quality
(iv) clarify the objectives of the observer data collection in different subareas and seasons.

Should such a group be established, the Working Group recommended that it coordinate with WG-FSA to determine the best temporal and spatial coverage of the finfish by-catch sampling and with WG-EMM to ensure that the data required for FBM is collected.

### Krill biology, ecology and management

2.44 WG-EMM-15/05 reported on the results of a series of cruises to investigate the abundance and distribution of Antarctic krill around the Antarctic Peninsula by the US AMLR Program in winters with contrasting ice conditions.

2.45 Krill biomass and density was extremely low in offshore waters during winter compared to summer. Krill biomass was an order of magnitude higher (~5 500 000 tonnes in 2014) in Bransfield Strait compared to the summer average biomass (520 000 tonnes), and this winter concentration represents 79% of the mean summer biomass (6.9 million tonnes) in the larger (124 000 $km^2$) study area averaged over 19 years of surveys.

2.46 The authors argued that krill overwinter in coastal basin environments independent of ice and primary production. This overwintering occurs in areas that are becoming more frequently ice free, increasing their availability to autumn and winter krill fisheries.

2.47 The Working Group noted that the same seasonal pattern of changes in krill abundance between inshore waters in winter and offshore waters during summer had been observed in other areas along the Peninsula. The Working Group noted that estimates of krill biomass could potentially be determined more efficiently if surveys were conducted during winter when krill were concentrated in a smaller area.

2.48 The Working Group also noted that the at-sea distribution of two species of seal, crabeater (*Lobodon carcinophagus*) and Antarctic fur (*Arctocephalus gazella*) seal, was examined in this study and indicated that analysis of the at-sea distribution of other species, including birds and whales, could be useful in examining predator overlap with the krill fishery.

2.49 The Working Group also noted that the reported low ice concentrations, which could make areas accessible to the fishery in some years, highlight the importance of considering climate change in providing advice to the Scientific Committee on the future spatial distribution of the fishery.

2.50 WG-EMM-15/13 reported on the quality and quantity of acoustic data collected by Norwegian fishing vessels involved in krill fisheries and the kinds of research questions that might be addressed using acoustics on krill fishing vessels. Using data from the 2011 fishing season, the authors described standardised surveys to estimate krill biomass trends, compare the biomass patterns between the standardised survey and the fishery, and examine information on changes in vertical and horizontal distribution patterns of krill over a range of time and space scales from diel changes to longer-term (seasonal) trends.

2.51 The paper highlighted several important patterns observed in the acoustic data. Diel migration of krill to the surface was more pronounced in the fishing area than outside the fishing areas and the mean krill depth increased over the season. The paper showed that krill biomass in the fishing area is variable over the season and there is no apparent trend. The paper indicated that fishing vessel data can be used to study a variety of phenomena important for science and management, and can provide data for use in FBM approaches that might be developed.

2.52 The Working Group agreed that this paper provided a good introduction to the vast amount of data that can be collected and the types of analyses that can be conducted using data collected by fishing vessels. The Working Group encouraged the authors to continue to analyse these data and present the results at future working group meetings.

2.53 WG-EMM-15/17 Rev. 1 reported on the results of an acoustic survey for krill biomass conducted around the Balleny Islands during the 2015 austral summer. The acoustic data were analysed using two parameterisations of the stochastic distorted-wave Born approximation (SDWBA) target strength (TS) model (i.e. orientation distributions $\theta = N(11,4)$ and $\theta = N(-20,28)$) which resulted in two different estimates of krill biomass. The biomass estimated with $\theta = N(-20,28)$ was 13 750 tonnes (CV = 0.14).

2.54 The Working Group noted that the two krill orientation parameterisations resulted in similar spatial distributions of krill biomass and that the differences in total abundance arose primarily as a result of the inclusion of a small number of additional high-density swarms. Noting its previous discussions about the sensitivity of interannual variation in mean krill density estimates to the number and density of the densest krill swarms detected (SC-CAMLR-XXXII, Annex 5, paragraphs 2.39 and 2.40), and the large impact of the parameterisations of krill orientation (which is generally inferred rather than observed) on survey results, the Working Group encouraged further work to better understand krill orientation.

2.55 The Working Group emphasised that SC-CAMLR-XXIX, Annex 5, paragraphs 2.13 to 2.19, described a series of issues in the model code used to generate the original $\theta = N(11,4)$ orientation distribution. In addition, it was noted that the standard deviation of the orientation distribution should be corrected for the sample-averaging effect of orientation variance as described in SC-CAMLR-XXIX, Annex 5, paragraphs 2.27 to 2.29. Given these issues, the Working Group reiterated the SG-ASAM advice that the parameters presented in WG-EMM-11/20, Table 1, were currently the best estimates for each variable used in the SDWBA.

2.56 The Working Group further noted that, while the $\theta = N(-20,28)$ orientation distribution was the CCAMLR recommended distribution, the krill identification dB-difference window for 200–120 kHz used in WG-EMM-15/17 Rev. 1 was much smaller than the CCAMLR recommended windows provided in WG-EMM-11/20, Table 2.

2.57 Dr Constable corresponded with the authors of WG-EMM-15/17 Rev. 1 to determine whether a revision to the calculations could be progressed and completed for review by the Working Group meeting. The authors gratefully acknowledged the feedback on the paper and the issues raised with respect to the calculation.

2.58 The authors clarified that the dB-difference windows used in WG-EMM-15/17 Rev. 1 were based on the minimum and maximum dB difference range that occurred between the 2.5% and 97.5% length quantiles, but were based on the simplified SDWBA model rather than the full SDWBA model. The WG-EMM-11/20 procedure does not calculate the minimum and maximum dB difference between the 2.5% and 97.5% length quantiles, but rounded down the lower 2.5% quantile and rounded up 97.5% quantile to the nearest 10 mm (as described in SC-CAMLR-XXIX, Annex 5, paragraph 2.30).

2.59 The Working Group agreed that it was not easy to understand and implement the current protocol because different elements are distributed in different reports and publications over a series of years. In addition, there were published papers that are no longer consistent with the present protocol that are still frequently cited. The Working Group, therefore, agreed that to facilitate the implementation and citation of the current acoustic protocol, SG-ASAM should be requested to document the full protocol together with associated code in one single publication.

2.60 WG-EMM-15/21 reported on the 60th Russian Antarctic Expedition during the 2014/15 austral summer on board the research vessel *Akademik Fedorov*. The study was conducted off East Antarctica (the Cosmonauts Sea, the Commonwealth Sea and the Davis Sea). The cruise conducted studies on the plankton community structure in this region and data were collected along a cruise track that sampled from near shore to the open ocean. Samples were also collected for genetic and laboratory study.

2.61 The Working Group welcomed this contribution and noted its importance in light of the lack of data in this region compared to other areas of the Southern Ocean (e.g. Area 48). The authors were encouraged to work with other Members, including Australia and Japan, that are initiating or continuing studies in this region, and with other international programs like the Southern Ocean Observing System (SOOS).

2.62 WG-EMM-15/22 presented preliminary information regarding an opportunistic marine science survey conducted by the Australian Antarctic Division off East Antarctica during the 2015 austral summer. The study investigated the spatial variability of the prey field for penguins, flying seabirds and marine mammals in East Antarctica using three frequencies of acoustics and net tows in a series of survey boxes at the shelf slope. Additional data on small-scale variability of prey in key foraging locations near to land-based colonies of penguins and flying seabirds were also collected. The paper indicated the utility of opportunistic cruises to undertake ecosystem monitoring and research.

2.63 The Working Group noted the importance of using ships of opportunity, or of using all opportunities to collect data in the Southern Ocean in support of basic science, assessments and for data collection in support of monitoring efforts for marine protected areas (MPAs). In particular, participants noted that the ability to design and manage a survey with little advance notice was important given current funding constraints.

2.64 WG-EMM-15/14 reported on a current study into fishing net selectivity and escape mortality. This study will use field experiments, modelling and analysis to develop a prediction method for trawl selectivity and escape mortality, intended to enable the industry to optimise trawl design. The Working Group looked forward to field results, noting that an understanding of size selectivity will help with the interpretation of length-frequency data from commercial trawls. The Working Group noted the importance of this and recent studies (e.g. WG-EMM-14/14) and looked forward to seeing a completed analysis in future years.

2.65 WG-EMM-15/23 presented a histological study of krill collected in the Scotia Sea. The resulting histological atlas of healthy krill is a baseline for future research into krill pathogens. The most common pathogen identified in the study was the protozoan gut parasite gregarine, *Cephaloidophora pacifica*. There was also evidence of possible viral infection in the hepatopancreas.

2.66 The Working Group agreed with the authors that future warming may affect the susceptibility of krill to infection by disease agents which require specific temperatures for survival. Krill experience a wide range of habitats over their life span and, therefore, have complex exposure to the effects of climate change, including those mediated through pathogens. The Working Group further noted that such baseline work could be usefully developed into a long-term monitoring tool to understand how climate change could alter the distribution and occurrence of these and other diseases in krill populations. The Working Group recommended that the Scientific Committee consider how this could be progressed.

2.67 WG-EMM-15/26 reported an analysis of a standardised CPUE index and a CPUE index for each national fleet that operated in Area 48 between 2008 and 2014. The authors identified a period of high CPUEs from 2008 to 2010 followed by low CPUEs in 2011/12. CPUE then increased in 2013/14. Despite the increase, CPUE over the last two years was lower than in the period from 2006 to 2010. This pattern is apparent in the CPUE dynamics in each subarea (Subareas 48.1, 48.2 and 48.3) and SSMU analysed, regardless of the fishing method used.

2.68 The pattern was most clear in the CPUE index in Subarea 48.1, where most of the catch was from three SSMUs in Bransfield Strait. This was also the location of the highest CPUEs. CPUE varies between vessels, fishing methods, months and years. The mean SSMU-scale CPUE index for conventional trawls was higher than the corresponding index obtained using the continuous fishing method. The variability between vessels operating at the same fishing grounds is often greater than the temporal variability in CPUE. There was no effect of fishing method on vessel location. The authors proposed to analyse the effect of on-board krill processing technology on CPUE to improve understanding of the krill fishery.

2.69 The Working Group encouraged submission of further information on standardisation and model diagnostics. CPUE is a potentially useful index of fishable biomass, which could be used in conjunction with acoustic data and predator data to study krill abundance, distribution and demography. Fishers make active choices about which krill densities they fish and information about these preferences is important in the interpretation of CPUE data.

2.70 WG-EMM-15/28 presented an index of krill biomass in Area 48 based on krill abundance and size data from scientific nets (the Krillbase database, Atkinson et al., 2009). This index, together with three indices from local acoustic surveys, shows no evidence of a systematic change in krill biomass since 2000 (the year of the CCAMLR synoptic survey). The study also suggested that the trigger level is less than 2% of krill biomass estimated in any year 2000 to 2011.

2.71 Subarea surveys cover less than 25% of each subarea (48.1 to 48.3) but generally detect substantially more krill biomass than would be taken if the relevant subarea catch limits specified in CM 51-07 were to be achieved. The paper suggested that at the area scale the trigger level is appropriate for achieving the Commission's Article II objectives for the krill stock, but recalled that neither the trigger level nor the subarea catch limits are intended to manage localised fishery impacts on krill predators.

2.72 The Working Group agreed that if catches at the subarea trigger level were to be taken in a few SSMUs, as is gradually occurring with concentrated fishing, then the Commission's objectives may not be achieved. Catch-to-survey-biomass ratios exhibit high values when krill biomass is low in extreme years and in such cases spatial management of the krill fishery at the SSMU scale is likely to be required to ensure precautionary management at such scales.

2.73 WG-EMM-15/28 also assessed catches and catch limits relative to the lowest biomass observed in a time series. The Working Group supported this approach, noting that the single available $B_0$ estimate, from the CCAMLR-2000 Survey, gives limited information on the pre-exploitation state of the krill stock.

2.74 The Working Group agreed that current levels of catches are not observed to cause a trend in krill biomass and noted that the paper's comparison of catch and catch limits to krill biomass indices is useful for providing advice. It is important to maintain the current suite of time series to indicate krill abundance and the local processes that influence its variability. Early detection of systematic changes to krill abundance may be difficult with these relatively short and highly variable time series, but the probability of reliable detection will increase with the length of the time series, especially if the spatial replication is maintained.

2.75 WG-EMM-15/45 demonstrated that it may be possible to use annular growth bands in krill eye stalks to age krill. Studies demonstrate that the number of growth bands is consistent with the known age of laboratory-reared krill. The nominal age-at-length based on krill growth models is also consistent with the age indicated by annular rings in wild-caught krill.

2.76 The Working Group agreed that the ageing of krill is important and encouraged the authors to continue their work.

2.77 WG-EMM-15/P08 reported an analysis of the salp species *Salpa thompsoni* in the Drake Passage. This species competes with krill for food, has a very patchy distribution and can use two contrasting reproductive strategies. The dominant sexual reproductive strategy was found in both the north and south of the Drake Passage, while the more efficient asexual strategy was found only in the warmer conditions in the north of the Drake Passage. Development was also more advanced in the north. The paper concluded that climate change is likely to lead to increasing populations of *S. thompsoni*.

2.78 The Working Group noted that WG-EMM-15/P08 and 15/23 highlight the importance of considering the potential effects of climate change on all components of marine ecosystems, including in the planktonic community, as some of these are likely to drive changes in krill and dependant and related species.

2.79 WG-EMM-15/24 reported on research to understand the relative importance of the advection of krill by the prevailing geostrophic currents around South Georgia as an example of the importance of water replacement to the catch rates of krill. The authors calculated that the full volume of the water, and thus krill, in each SSMU is replaced between six and eight times during the fishing season. Some evidence of the significant krill flux in Subarea 48.3 was illustrated from the fluctuations of krill density over the fishing grounds in different months from 1988 to 1990 from multiple acoustic surveys in the local area. The authors concluded that the harvest-rate indicators should be estimated against krill biomass available in subarea/SSMUs during a year or fishing season and krill catch limits based on single surveys can underestimate the total biomass of krill available to krill-dependent predators and the fishery. The authors further argued that the FBM must properly account for this water replacement when developing conservation measures.

2.80 The Working Group noted that the calculation of flux and the relationship with the replacement rate of krill biomass in fishing areas is a source of uncertainty in the management of the krill fishery and determining fishery impacts on krill-dependent predators.

2.81 The Working Group noted that the geostrophic method for determining replacement is potentially useful, however, newer oceanographic models that can examine onshore and offshore flows and eddies and can include biological processes like vertical migration (see for example WG-EMM-14/08) could ultimately provide more precise and accurate calculations for most areas where fishing occurs. The Working Group also noted that acoustic data collected by the fishery may also provide a method for estimating the flux of krill in fishing areas.

2.82 WG-EMM-15/40 examined catch among subareas over the last four fishing seasons and argued that, while CM 51-07 has been effective in redistributing krill catch in a manner envisaged by the Commission, the closure of the krill fishery in some subareas early in the season is inflexible and has the potential to impact the economics of the fishery. The authors proposed that catch percentages be modified for all subareas, including an increase in Subarea 48.1 to 50%. Additionally, the authors argued that catch limit percentages should be re-examined biennially.

2.83 The Working Group noted that there was no scientific basis provided by the authors to support the changes to the conservation measure. The ultimate determination of catch limits or allocations is an item for the Commission to decide, and the Working Group, therefore, referred the paper to the Commission.

### Role of fish in the ecosystem

2.84 WG-EMM-15/52 documented long-distance movements and site fidelity of Type C killer whales moving between the southern Ross Sea (74–77°S) and subtropical New Zealand waters (31–35°S), with tagged whales moving from Terra Nova Bay to the Kermadec Trench and photo identification matches between southern McMurdo Sound and the northeastern coast of New Zealand's North Island. Scars consistent with cookiecutter shark (*Isistius brasiliensis*) bites that are considered to have occurred north of 50°S were observed on more than one-third of individuals photographed in the southern Ross Sea, indicating such movements may be relatively common. The whales show evidence of site fidelity between years in both regions, with photographic matches of individuals up to a decade apart. The authors noted that the annual retreat and break-up of coastal sea-ice in the southern Ross Sea permits Type C killer whales to forage in areas of relatively shallow bathymetry where they can target prey such as silverfish in Terra Nova Bay or the large sub-adult and adult toothfish found in McMurdo Sound (e.g. WG-EMM-14/52).

2.85 The Working Group noted the value of odontocete distribution studies, given most cetacean tagging studies conducted in the Southern Ocean have focused on mysticetes. It encouraged stable isotope analysis to help elucidate trophic relationships as well as genetic comparisons between areas and with sympatric killer whale ecotypes. Dr Watters noted similar tagging studies had been conducted by US scientists and these studies yielded similar results. A combined analysis of the data from the New Zealand, Italian and US efforts would be powerful.

2.86 The Working Group noted the importance of monitoring the availability of Type C killer whale prey in McMurdo Sound and Terra Nova Bay. It recalled that toothfish monitoring in these areas was an objective of the proposed Ross Sea shelf survey (WG-SAM-15/45) considered at WG-SAM (Annex 5, paragraphs 4.23 to 4.26), while acoustic monitoring of silverfish in Terra Nova Bay was an objective of the New Zealand–Australia Antarctic Ecosystems Voyage (WG-EMM-15/56) discussed below (paragraph 2.93).

2.87 The Working Group recalled the discussion of papers on killer whale depredation (WG-SAM-15/27 and 15/28) at WG-SAM (Annex 5, paragraphs 2.56 to 2.61). The Working Group agreed that there was a risk that depredation by killer whales could occur in the southern Ross Sea in the future, given observed killer whale depredation behaviour in other CCAMLR fisheries. The movements of Type C killer whales from the Ross Sea may also mean that they encounter longline fisheries outside the Convention Area. The Working Group recommended that depredation mitigation and management options for the Ross Sea be considered by the intersessional group formed by WG-SAM, led by Drs M. Belchier and M. Söffker (UK), and be presented for consideration by WG-FSA and the Scientific Committee.

2.88 The Working Group recalled the suggestion of WG-SAM that WG-EMM and WG-FSA consider the process by which the three parts of the depredation issue (mitigation, impacts on stock assessments and ecosystem effects) might be addressed in the coming years so that recommendations can be made to the Scientific Committee (Annex 5, paragraph 2.60). The Working Group requested that the Scientific Committee consider the best mechanism to address all aspects of the depredation issue. It noted that one mechanism might be a group to consider top–down structuring mechanisms for ecosystems, which would be a broad topic of interest to SC-CAMLR, not just in relation to killer whales.

2.89 WG-EMM-15/53 examined the hypothesis that predation release of Antarctic silverfish (*Pleuragramma antarctica*) due to fishing of Antarctic toothfish (*Dissostichus mawsoni*) could have contributed to the large increase in the number of breeding pairs of Adélie penguins (*Pygoscelis adeliae*) at breeding colonies in the southern Ross Sea. However, as the mass of silverfish estimated as being released from predation by fishing was equivalent to only about 2% of the amount of silverfish consumed annually by Adélie penguins in this region, the authors concluded that the increase in penguins is inconsistent with the predation-release hypothesis. The authors encouraged the development of further specific testable hypotheses on fishing effect mechanisms that could affect Adélie penguins in the Ross Sea.

2.90 The Working Group noted there had been a previous diet study in 1978, 1979 and 1981 that indicated toothfish in midwater in the southern McMurdo Sound may have a greater proportion of silverfish in their diet compared to those at the bottom (Eastman, 1985). It noted that sensitivity analyses may be insightful to assess the proportion of silverfish in the diet of toothfish that would be required to generate the observed increases in the number of Adélie penguin breeding pairs. At the request of the Working Group, the authors of WG-EMM-15/53 have completed additional sensitivity analyses for presentation to WG-FSA.

2.91 The Working Group noted that the diet samples used in the analysis in WG-EMM-15/53 were obtained from 422 *D. mawsoni* stomachs collected over the Ross Sea shelf using bottom longlines as part of dedicated systematic surveys between 2011/12 and 2013/14 (WG-FSA-12/41, WG-SAM-13/32, WG-FSA-14/51). It noted the importance of diet samples being obtained over the relevant spatial and temporal scales. The Working Group recommended that research be conducted using vertical longlines to sample large neutrally buoyant *D. mawsoni* over the Ross Sea shelf to obtain information on their vertical distribution and associated diet in midwater.

2.92 The Working Group noted the value of studies that test hypotheses of importance for management. It recommended the consideration of alternative hypotheses to explain the observed increases in the number of Adélie penguins breeding in the southern Ross Sea. It noted the importance of identifying mechanisms driving population trends, irrespective of their direction, and recommended that future analyses consider intrinsic factors such as breeding success and recruitment, extrinsic factors such as ice conditions, and alternative model structures such as metapopulation models.

2.93 WG-EMM-15/56 provided an overview of the New Zealand–Australia Antarctic Ecosystems Voyage to the Ross Sea on the New Zealand research vessel *Tangaroa* that undertook ecological studies of marine food webs of importance to top predators to help quantify key structural and functional components of the Ross Sea ecosystem to further develop ecosystem models. The objectives of the voyage were to: (i) determine factors influencing the abundance and distribution of humpback whales around the Balleny Islands; (ii) assess habitat characterisation of blue whale foraging 'hotspots' in the northern Ross Sea; (iii) conduct a demersal trawl survey of the Ross Sea slope; (iv) deploy a moored echosounder to study Antarctic silverfish spawning in Terra Nova Bay during winter; and (v) undertake oceanographic and atmospheric observations of the Southern Ocean. Data collection for all five science objectives was successfully completed. Analyses are ongoing and results will be presented to CCAMLR in the coming years.

2.94 The Working Group recognised the value of this collaborative research cruise and noted that the first results from the voyage were presented in WG-EMM-15/17 Rev. 1 (paragraph 2.53). The Working Group also welcomed the clarification that the data obtained from the survey would be made available to Members either on request or via the International Whaling Commission's Southern Ocean Research Partnership.

### Feedback management (FBM)

2.95 Dr Kawaguchi introduced the topic of FBM for the krill fishery, noting:

(i) the adoption of the staged approach (SC-CAMLR-XXXII, paragraph 3.15) and the need to move towards stage 2 of that approach

(ii) that stage 2 involves increasing catches from the trigger level (CM 51-01) 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 CCAMLR Ecosystem Monitoring Program (CEMP) and other observation series

(iii) possible tools for developing stage 2 include increasing the frequency of krill surveys and expanding the number of CEMP sites or sites where predator monitoring compatible with CEMP is conducted, and use of land-based and at-sea monitoring combined in space and time

(iv) at-sea monitoring and CEMP need to be undertaken in a practical and feasible way, with documented standards and protocols, and in areas relevant to managing krill harvesting

(v) the implementation of stage 2 will require managing the risks with an appropriate level of confidence, while using any opportunity to learn about the regional ecosystem to improve CCAMLR's ecosystem approach to harvesting (SC-CAMLR-XXX, Annex 4, Figures 3 and 4)

(vi) that the conservation measure for exploratory krill fisheries (CM 51-04), includes the concept of the data collection plan, together with agreed catch limits, which could also be used to enable further development of FBM approaches, particularly if there are research requirements to test different views on what is needed.

2.96 Dr Kawaguchi encouraged the Working Group to examine the strengths, gaps and limitations of the different approaches tabled for discussion (WG-EMM-15/04, 15/10, 15/11, 15/33, 15/36, 15/55 Rev. 1) and to consider the possible synergies between candidate approaches, particularly with regard to their principles and properties and proposed decision rules, assessment methods and data requirements. He also encouraged the Working Group to consider how CCAMLR might begin implementing any of the approaches.

2.97 The Working Group agreed that a written history documenting the development of CCAMLR's approaches to managing the krill fishery would be useful in order to keep both scientists and managers abreast of methods, issues and resolutions considered in the past. It recalled the discussion on this topic last year (SC-CAMLR-XXXIII, Annex 6, paragraph 2.7) and agreed to discuss this under future work (paragraphs 5.16 and 5.17).

2.98 To help provide some general background for discussions at the Working Group, Dr C. Jones (USA) presented the talk he delivered to the Commission in 2014 (CCAMLR-XXXIII, paragraphs 5.11 and 5.12), which covered the following points:

(i) the concept and general processes of FBM

(ii) the Commission's conclusion of FBM as the best approach to achieve Article II of the CAMLR Convention, and the interim precautionary approach as FBM is developed

(iii) the spatial footprint of the krill fishery becoming increasingly constricted from the entire Convention Area to very limited regions within Area 48

(iv) a historical summary of the Scientific Committee's progress toward approaches to FBM

(v) recent developments and adoption of the current staged approach.

2.99 The Working Group noted that fisheries may affect krill predators through a number of mechanisms, including, inter alia:

(i) removal of krill
(ii) disturbing feeding behaviour of predators
(iii) disrupting distributions of krill
(iv) enhancing foraging success of predators.

2.100 The Working Group agreed to structure the reporting of its discussions in the following manner:

(i) Submitted approaches, considering the submitted approaches and how to progress them:

(a) FBM in Subarea 48.1 (paragraphs 2.102 to 2.110)

(b) development of FBM in Subarea 48.2 (paragraphs 2.111 to 2.120)

(c) a general approach to FBM at the SSMU scale (paragraphs 2.121 to 2.126)

(d) general points for developing these approaches (paragraphs 2.127 to 2.132).

(ii) General considerations for management of the krill fishery, considering current issues, developing stage 2 and FBM generally:

(a) state of the krill-based food web at present (paragraphs 2.133 to 2.141)

(b) precautionary requirements for predators at SSMU-scales (paragraphs 2.142 to 2.145)

(c) using existing data and monitoring (paragraphs 2.146 to 2.148)

(d) further development of at-sea monitoring and CEMP sites (paragraphs 2.149 to 2.153)

(e) structured fishing to further FBM (paragraphs 2.154 and 2.155)

(f) implementation of FBM (paragraphs 2.156 to 2.158).

(iii) Future work to progress stage 2, considering the next steps in developing FBM (paragraph 2.159):

(a) current state of the krill-based ecosystem and the fishery (paragraphs 2.160 and 2.161)

(b) stage 2 subdivision of catch and/or update of trigger level (paragraphs 2.162 and 2.163)

(c) precautionary requirements for predators at SSMU scales (paragraph 2.164)

(d) krill surveys and CEMP in stage 2 (paragraphs 2.165 to 2.173)

(e) general (paragraphs 2.174 to 2.178).

2.101 The Working Group noted that terms used to describe the different spatial scales of the krill-based ecosystem can be confusing. In this respect, the Working Group adopted the following terms as part of its discussion:

(i) area scale – the scale approximated by the size of the CCAMLR-2000 Survey (Trathan et al., 2001)

(ii) subarea scale – the scale approximated by the size of subareas in Area 48; pelagic SSMUs are close in scale to the subarea scale

(iii) SSMU scale – the scale approximated by the size of coastal small-scale management units but noting that actual locations of interest may be within one or among more than one SSMU depending on the location.

### Submitted approaches

#### FBM in Subarea 48.1

2.102 Dr Watters presented details on two FBM approaches that were proposed for implementation in Subarea 48.1. The first of these approaches is outlined in WG-EMM-15/04, the second in WG-EMM-15/33. Neither approach was designed to include structured fishing (in this context, where the spatial distribution of catches would be pre-specified with the objective of learning how fishing might impact krill-dependent predators) or reference areas (areas that might be closed to fishing to facilitate comparisons with areas that are open to fishing). The proposed implementation of both approaches would follow a common time line:

(i) A ‘base’ catch limit would be established for Subarea 48.1 on 1 December. The base catch limit would be determined using an integrated assessment model and decision rules that are analogous to the current decision rules for krill.

(ii) Monitoring data (CEMP data and data collected from the fishery) would be collected from approximately October to March and submitted to the Secretariat by 15 March. The Secretariat would process these monitoring data and determine whether to adjust the catch limit using new decision rules. The adjustment would occur on 15 April and apply for the remainder of the fishing season.

(iii) The catch limit would reset to its base on 1 December, and the process would repeat for four fishing seasons. After the fifth fishing season, the base catch limit would itself be reset.

2.103 WG-EMM-15/04 outlined an approach to increase catches from the base catch limit. The upward adjustment would occur if a suite of CEMP observations indicated that krill-dependent predators were successful during the breeding season and standardised monthly surveys conducted by krill fishing vessels indicated stable or increasing biomass of krill. The upward adjustment would apply at the subarea scale and the approach is intended to allow the fishery to capitalise on favourable conditions.

2.104 WG-EMM-15/33 outlined an approach to decrease catches from the base catch limit. The base catch limit would be distributed among groups of SSMUs (e.g. to the Bransfield Strait SSMUs and Drake Passage SSMUs) based on agreed 'allocation fractions' that would be specified in advance. Downward adjustments from these default allocations would be based on CEMP observations of penguin fledging mass and age at crèche. Data collected at Cape Shirreff and Copacabana indicate that both fledging mass and age at crèche are related to survival during the birds' first one or two years of independence, and previous work (e.g. Hinke et al., 2007) has demonstrated that overwinter survival of newly independent birds is a primary driver of trends in penguin abundance. Catch limits would be adjusted according to the lower catch limit of those determined from application of decision rules based on observed fledging masses and ages at crèche respectively. This is intended to reduce catches when penguin survival is expected to be below a critical threshold during the forthcoming austral autumn and winter. The downward adjustments would apply to groups of SSMUs and be determined by species-specific decision rules. For example, if the fledging mass of Adélie penguins was below its threshold, the catch limit might only be reduced in the two Bransfield Strait and the Antarctic Peninsula East SSMUs. The authors of WG-EMM-15/33 used data from winter tracking studies to suggest groups of SSMUs relevant to each of the three Pygoscelid penguins and noted that a new network of remote cameras being installed within Subarea 48.1 would provide increased monitoring of age at crèche.

2.105 The Working Group noted that the FBM approaches proposed in WG-EMM-15/04 and 15/33 could be combined. A hybrid approach that allows for increased catches when conditions are favourable and decreased catches when poor conditions are predicted from leading indicators of predator success would capitalise on useful elements of both approaches. Similarly, the approaches proposed for Subarea 48.1 could be harmonised with that proposed in WG-EMM-15/55 Rev. 1 by using krill density, rather than krill biomass or predator success, as an indicator. Harmonisation with the approach proposed in WG-EMM-15/10 could be accomplished by including a reference area in the design for Subarea 48.1.

2.106 The Working Group also noted that in-season adjustments to catch limits like those proposed for Subarea 48.1 might be difficult to implement and be problematic in an Olympic fishery (e.g. the base catch limit might be taken before the desired data could be collected or the adjustment could be made). An alternative that could work in both cases would be to delay starting the fishing season in Subarea 48.1 until March or April, after some monitoring data were already collected.

2.107 Some participants questioned whether CEMP data could be used in decision rules to adjust catch limits for the krill fishery, at least during stage 2 while uncertainties about functional relationships between krill and krill predators are large. It was, therefore, suggested that available data from Subarea 48.1 be used to explore functional relationships. It was further suggested that future work to evaluate candidate feedback approaches (paragraphs 2.109 and 2.110) include analyses that compare the effects of using and omitting CEMP data from decision rules that adjust catch limits.

2.108 Several topics need to be addressed to advance the approaches presented in WG-EMM-15/04 and 15/33 (or a hybrid of them) during the coming intersessional period so that an FBM strategy could be considered for implementation in Subarea 48.1. Specific issues are identified in Table 2, and general issues are outlined below.

2.109 To advance implementation of the approaches proposed for Subarea 48.1, it will be necessary to parameterise candidate decision rules for each approach, or for a hybrid approach, and evaluate the expected consequences for krill, predators and the fishery of applying these candidates. Parameterisation of decision rules includes 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 candidate decision rules should be quantified in terms of risks, mean effects and variability in the effects.

2.110 Candidate decision rules would be evaluated with simulation models, empirical analyses of time-series observations, and/or other methods, depending on the complexity in understanding the relative effects of the rule on krill, predators and the fishery. Using simulation models might take several years and delay implementation of stage 2. Retrospective analyses using, or based on, data already available from Subarea 48.1 could be undertaken relatively easily in the coming year and allow implementation of stage 2 to progress in the near term. These latter efforts should aim to fill the blanks in statements like 'if decision rule __ had been implemented in year __, catches might have been __ and predator success might have changed by __'. Potential impacts on predator success could be evaluated over the short (e.g. foraging-trip durations), medium (e.g. survival from fledging to first breeding) and long term (e.g. trends in breeder abundance), each of which may have different implications for parameterisation and implementation of the candidate decision rules.

## Development of FBM in Subarea 48.2

2.111 WG-EMM-15/10 presented an outline proposal for a structured experimental framework for managing krill in Subarea 48.2. Dr Trathan referred to WG-EMM-14/04 which concluded that movement towards stage 2 in Subarea 48.2 would be highly improbable based on the current level of ecological knowledge; he indicated that the experimental framework described in WG-EMM-15/10 was therefore intended to improve levels of relevant management information. He emphasised that the framework would develop over time, based on advice from WG-EMM and the Scientific Committee. He indicated that WG-EMM-15/10 does not attempt to answer all questions, as he foresaw that part of the process of implementing a structured experimental approach would depend on scientific, logistical and analytical contributions from many different Members. The object of WG-EMM-15/10 was therefore to initiate a discussion about how CCAMLR might proceed in Subarea 48.2.

2.112 Dr Trathan suggested that a complete experimental framework would need to encapsulate a number of clearly articulated hypotheses, an ordered and well-designed research strategy, a list of expected outcomes and an appropriate risk analysis. All of these should form the focus of community effort and could be led by an appropriately qualified task-team. He suggested that without an appropriate level of community involvement, the necessary level of scientific information might not be available, and therefore the catch limit in CM 51-07 would be unlikely to change in Subarea 48.2 such that the krill fishery would remain under-developed.

2.113 WG-EMM-15/10 proposed that, given the highly localised nature of the krill fishery in Subarea 48.2, it is plausible the fishery could be managed using acoustic information collected by the fishery in order to assess whether the stock is likely to fall below some previously agreed threshold.

2.114 WG-EMM-15/10 suggested that the experimental framework should focus on the relationships between oceanography, krill abundance and predator populations, and determine how krill fishing might modify these relationships. The proposed framework includes the use of CEMP sites, remote cameras at important land-based predator breeding colonies, oceanographic moorings with acoustic sensors, acoustic data capture during fishing operations and repeated acoustic surveys. The paper proposed that the experiment should be evaluated after five years in order to explore initial results and to determine if the experimental framework should be continued.

2.115 WG-EMM-15/10 proposed that there should be two temporal phases to the experiment: an initial phase of two years, with a fixed catch limit, and a second phase of five years with a variable catch limit. The purpose of the first phase would be to collect information on inter- and intra-annual variability in krill biomass and baseline information on predator (penguins and cetaceans) populations. The purpose of the second phase would be to test and refine a management strategy for maintaining krill biomass above an agreed reference level. Phase two of the experiment is potentially a complete FBM approach which modifies catch limits in response to information about the krill stock and uses information about krill predators to assess and control impacts. However, Dr Trathan indicated that at the moment, it is premature to predict the outcomes of the experiment and the form of the eventual long-term management strategy.

2.116 WG-EMM-15/10 identified that the spatial framework for the experiment includes two areas with contrasting levels of fishing. Currently most harvesting already occurs within the South Orkney West (SOW) SSMU, so most fishing vessels could participate in the proposed experiment. If the South Orkney North East SSMU and/or the South Orkney South East SSMU were to be closed to harvesting, this would represent a risk to the fishery. However, 95% of the historical harvest in Subarea 48.2 has taken place in the SOW SSMU, so the risk to the fishery would be small while the potential increases in management information could be significant. The trade-off between risk to the fishery and increase in management information will need to be evaluated.

2.117 The two areas with contrasting levels of fishing should each have land-based predator monitoring, at-sea predator monitoring and acoustic surveys to assess ecological status. The design of the monitoring system will need to be evaluated to ensure that observed differences between the contrasting areas help provide evidence to enable scientific advice as to whether the fishery is having an impact upon krill-dependent predators.

2.118 WG-EMM-15/10 included a proposed set of restrictions and rules that elucidate how the candidate FBM approach could work. These identify catch limits for the two areas of contrasting harvest, details of how the phased approach might develop into the future, proposed harvesting limits and how these might change and a default catch limit should the proposed experiment fail to deliver useful information (see paragraph 2.131). Each of the restrictions and rules will need to be evaluated as the proposed approach develops.

2.119 WG-EMM-15/11 highlighted how the spatial harvesting footprint within Area 48 varies from year to year. It noted that potential impacts arising from increased spatial overlap between the fishery and krill-eating penguin colonies are plausible but not yet investigated at scales smaller than the SSMU-scale, e.g. at the scale of krill swarms or aggregations of swarms (paragraph 2.143). As such, WG-EMM-15/11 suggested that it is appropriate to explore functional overlap further as part of an experimental approach, in order to gather data to test the hypothesis that functional overlap occurs. Determining krill critical density thresholds for predators will be vital for FBM approaches.

2.120 The Working Group thanked Dr Trathan and his group for their work in developing their proposal. In subsequent discussion, the Working Group identified key issues that need to be addressed (Table 3).

### A general approach to FBM at the SSMU scale

2.121 In introducing WG-EMM-15/36 and 15/55 Rev. 1, Dr Constable indicated that the FBM system for krill needed to include methods to:

(i) determine a catch limit for the krill population

(ii) divide that catch limit into smaller areas at a scale relevant to predators in order to avoid inadvertent disproportionate impacts on some predators over others

(iii) minimise effects on predators when available food is at critical levels

(iv) account for changing productivity and relationships in the system

(v) validate/check the management system.

2.122 WG-EMM-15/36 proposed methods that could achieve the first two parts of the management system – catch level and division of that catch into smaller areas. It draws together past experience in CCAMLR and provides (i) an empirical ecosystem assessment model, (ii) a decision rule for determining SSMU-scale catch limits based on a designated spatial harvest strategy and a single-species assessment of yield, and (iii) a method for implementing the procedure. The decision rule for setting catch limits for a given harvest strategy has a straightforward expression of the target conditions to be achieved for krill, krill predators and the fishery and the uncertainties that need to be managed. It is a natural extension of the current precautionary approach of CCAMLR for krill and can utilise existing datasets, including $B_0$ surveys, local-scale monitoring of krill densities, local-scale monitoring of predator performance, monitoring of predator foraging locations and time series of catches from the fishery. The procedure developed in the paper:

(i) enables the spatial harvest strategy to be determined by fishers and then set SSMU-scale catch limits according to the uncertainties in food-web status and dynamics

(ii) provides a common framework for inserting data, assessment methods and candidate modelling approaches for assessing catch limits

(iii) has a formalism that provides for the development of a fishery, enabling advice to be updated as improvements are made in any component of the procedure, including the provision of data, implementation of new assessment or projection models or a revision of the decision rule

(iv) formalises the decisions that need to be made in dealing with uncertainty across an ensemble of plausible food-web models and dynamics

(v) provides the primary expectation for managing uncertainty, either by obtaining better estimates of parameters for the projection models and/or by altering the harvest strategy

(vi) is able to respond to trends in the status of the ecosystem, including trends arising from climate change.

2.123 WG-EMM-15/55 Rev. 1 extended the management system to minimise effects on predators when available food is at critical levels. The paper indicated how this management system can be made operational in the early phases of a fishery in SSMU-scale areas. A decision rule for adjusting catch limits at SSMU scales when krill density is near critical levels for predators is proposed. This rule uses an estimate of krill biomass density (e.g. g $m^{-2}$) and recruitment strength in a given year to determine an adjustment of the long-term annual catch for the area in the following year. This decision rule is designed to keep the probabilities of low reproductive performance by predators at acceptable levels in the long term. The process for undertaking the assessment using a population projection model and its application is demonstrated in the paper. Lastly, the paper outlines a process for testing the management system in the early phases of the fishery by concentrating the fishery in some SSMUs and testing whether the reproductive performance of predators is maintained at acceptable levels.

2.124 Dr Constable concluded his presentation by indicating that progress could be made in the coming year by assembling available krill and predator data to estimate critical biomass densities of krill in SSMUs and for progressing the implementation of a population projection model, which could be based on the generalised yield model (GYM). It would also include further modelling of the properties of the decision rule and the management system as a whole.

2.125 The Working Group thanked Dr Constable and his group for their work in developing these proposals. The Working Group noted that:

(i) the decision rule for short-term adjustments of the long-term catch limit in an SSMU is based on estimates of krill biomass and recruitment strength, which could be obtained from surveys or fishing data

(ii) shifts in the ecosystem, or changes in the food web, can be included in this approach if needed

(iii) the empirical ecosystem assessment may need to factor in time lags in predator responses

(iv) the short-term adjustment approach derives from predator–prey theory and requires empirical data on the links between the reproductive performance of predators, their foraging activities and krill availability to identify critical prey densities (data will need to be assembled to identify critical krill densities)

(v) the one-year projection model may need to include parameters for krill flux; the sensitivity of the approach to different levels of flux could be explored

(vi) the effect of the decision rule for adjusting catch limits on variability of catches will need to be explored in order to minimise volatility in catches, noting that this approach is only for adjusting catches in SSMUs rather than the whole of the area

(vii) the method for adjusting catch limits at the SSMU scale is consistent with the approach being developed for Subarea 48.2 and encouraged the proponents of the two approaches to consider how they may be combined.

2.126 The key issues identified by the Working Group to be addressed in developing these approaches are given in Table 4.

### General

2.127 The Working Group thanked Members for submitting candidate proposals for progressing FBM towards stage 2. It agreed that the approaches and supporting papers submitted (WG-EMM-15/04, 15/10, 15/11, 15/33 15/36, 15/55 Rev. 1), had a number of common elements and similar data requirements. It also agreed that different parts of the CAMLR Convention Area may need different approaches because of the nature of the ecosystem in different regions, as well as the different levels of data and monitoring capability currently available. The Working Group recognised that a common framework would be desirable across all of the krill fishery, with a means of learning about the ecosystem and testing the management system during the development of the fishery. However, the Working Group noted that achieving a common framework may take some time. The Working Group encouraged the proponents to continue to progress their proposals in the coming year, taking account of the points in Tables 2, 3 and 4. The Working Group recommended that the progress on FBM be highlighted to the Scientific Committee and the Commission.

2.128 The Working Group agreed that work to address the approaches and evaluate candidate decision rules could be advanced by holding a workshop in 2016. Compiling relevant datasets in advance of this workshop would facilitate the workshop and, since all approaches to FBM are likely to utilise the same types of data, it was noted that additional feedback approaches could be submitted to the workshop or WG-EMM-16 and potentially be evaluated at these meetings. It was agreed that submission and evaluation of additional approaches would not delay implementation of stage 2; new ideas could be implemented in a revision to stage 2 or during advancement to stage 3, noting that consideration might need to be given as to how such proposals may impact on existing implementations.

2.129 Ultimately, decision rules applied in FBM approaches need to be understood by policy-makers and stakeholders and minimise risks to achieving the objectives in Article II. The Working Group agreed that a submission of an approach needed to be accompanied by suitable documentation to understand the basis and implementation of the approach as well as how it would result in conservation measures. The Working Group recommended that the pro forma adopted by SC-CAMLR in 2014 be amended to include the following:

(i) public summary: a simple and concise explanation that is accessible to a range of potential stakeholders that describes how this specific FBM approach would be implemented

(ii) rationale and implementation summary: a summary for appending to the WG-EMM report that describes the rationale and implementation of the approach suitable for the Scientific Committee.

2.130 The Working Group also agreed that implementation of all stage 2 approaches need to be reviewed after a trial period with clear courses of actions to be taken, if needed, given positive and/or negative outcomes of the review. Review of stage 2 approaches is needed to balance CCAMLR's precautionary approach with a need to improve FBM through an active learning process (see also SC-CAMLR-XXXII, Annex 5, paragraph 2.89).

2.131 The Working Group agreed that until stage 2 can be implemented, or if stage 2 is implemented and the reviews identified in paragraph 2.130 indicate that the implemented approaches are not successful, the risks to achieving the objectives in Article II could be minimised by maintaining the subarea catch limits currently established in CM 51-07.

2.132 The Working Group noted that, given the current approach to the management of the krill fishery, implementing an FBM approach in one subarea might have broader implications for management of the krill fishery in other subareas. Furthermore, any changes to the implementation of the decision rules may have implications for other fisheries more generally.

## General considerations for management of the krill fishery

### State of the krill-based food web at present

2.133 The Working Group considered the potential effects that krill fishing might currently be having on krill and its predators. It noted that the last area-scale survey within Area 48 took place in 2000, but that there was currently no evidence for a recent trend in krill biomass (WG-EMM-15/28), density (g $m^{-2}$; e.g. Fielding et al., 2014), or abundance (individuals caught by research nets; e.g. Atkinson et al., 2014; Steinberg et al., 2015) in Subareas 48.1 to 48.3.

2.134 The Working Group agreed that the subarea-scale catch limits established in CM 51-07 may risk failure to achieve the Commission's objectives at the SSMU scale. In this regard, it was noted that:

(i) results from surveys conducted by the US AMLR Program demonstrate that, at the SSMU scale, interannual differences in krill biomass within Subareas 48.1 can span two orders of magnitude, and annual biomass estimates in the Bransfield Strait and north of the South Shetland Islands have periodically been less than the subarea-scale catch limit established for Subarea 48.1 in CM 51-07 (WG-EMM-11/26)

(ii) fishing activity has become more concentrated into some SSMUs, with particular focus on Bransfield Strait in Subarea 48.1 (WG-EMM-14/11)

(iii) given points (i) and (ii) above and catch limits that are only resolved to the subarea-scale, it is not possible to rule out SSMU-scale harvesting impacts that would result in failure to achieve management objectives. In some years, SSMU-scale harvest rates may inadvertently be higher than would be expected from application of the krill decision rules at the SSMU scale.

2.135 The Working Group agreed that:

(i) Catch is currently at about 48% of the trigger level and 5% of the precautionary catch limit; catches are currently less than 0.5% of the biomass estimate from the CCAMLR-2000 Survey.

(ii) Interannual trends in SSMU-scale biomass are not evident (with only limited information on seasonal or monthly cycles of SSMU-scale biomass). However, given the observed variation described above (paragraph 2.134i), it is not possible to rule out small-scale harvesting impacts because fishing activity has become more concentrated into some SSMU-scale areas and local harvest rates in some years may be higher than expected by gamma.

(iii) A consideration in interpreting CEMP data is that the different CEMP parameters integrate across different time and space scales. For example, foraging trip duration may be affected by conditions in the foraging area at the time of foraging, while breeding success and fledging weight integrate conditions in the foraging areas over several months during the breeding season. Breeding population size integrates conditions at the scale of years. Thus, CEMP and subsequent analyses need to be organised in such a way that they detect the spatial and temporal effects intended to be observed. Within-season effects of fishing will need to be detected using parameters that indicate conditions at locations and times where there is coincidence between foraging and fishing area and the months of fishing.

(iv) At present, the effects of current fishing activities on krill-dependent predators monitored at breeding colonies are uncertain. Noting that different sets of indices are recorded at each CEMP site, it is also unclear whether variation in the set of indices that have been recorded at each site can be attributed to fishing activity. This is an important research topic, and investigating this issue will, inter alia, require attention to the amounts of bias and observation error in each CEMP index, the time and space scales over which each index integrates, covariation among indices and the amount of fishing activity that occurred within the time–space frame to which the monitored indices are relevant.

2.136 The Working Group agreed that the spatial distribution of the trigger level in CM 51-07 should be continued in order that harvesting is further not concentrated and does not impact adversely upon predators. A realistic work program for establishing stage 2 is being progressed and CM 51-07 should ultimately be revised to reflect stage 2.

2.137 The Working Group agreed the following points:

(i) Krill biomass is not homogeneously distributed within the subareas. Consequently, an increase in catch may be possible if the catch for a subarea is subdivided into smaller spatial units that take account of predator needs, or other safeguards to predators are put in place.

(ii) The fishery has become concentrated in some SSMU-scale areas in recent years (WG-EMM-15/30, Appendix 3, Table 3).

(iii) There is a need to avoid harvesting impacts upon the ecosystem at the SSMU scale.

(iv) During certain time periods, particularly during the breeding season, krill beyond a critical distance from land are not accessible to land-based predators. Similarly, the fishery also preferentially targets krill in some locations. The krill readily available to breeding land-based predators is likely to be the main focus of the fishery, although the degree of overlap will depend on, inter alia:

(a) the time of year

(b) the individual constraints on foraging of the breeding and non-breeding parts of the predator populations at that time

(c) the aggregation/distribution of krill.

(v) Fishing in areas distant from land may not affect land-based predators but could affect pelagic predators such as whales, pack-ice seals, fish and other predators foraging in those areas.

(vi) Full implementation (i.e. stage 4) of FBM requires that CCAMLR is able to estimate the ecosystem effects of fishing; CEMP currently only includes land-based predators, making these the best opportunity for detecting such effects at present. Detecting effects in pelagic areas may need monitoring of krill predators utilising those areas, such as cetaceans, ice seals and fish.

(vii) The trigger level (CM 51-01) was based on the highest aggregate catch in the historical time series. No information is available on whether that catch had an effect on the ecosystem or whether sustained catches at that level would or would not have an effect. Kinzey et al. (2013) concluded that better information is required about krill recruitment variability and natural mortality before increasing catches much beyond the trigger level. Watters et al. (2013) also indicated in simulations that sustained catches at the trigger level would increase the risks of CCAMLR not meeting the objectives of Article II, including by failing to facilitate the restoration of depleted predator populations.

(viii) Krill consumption by predators within different SSMUs could be used as a basis for distributing catch limits. An approach for undertaking these calculations is available in Everson and de la Mare (1996). Estimates are also available in Hill et al. (2007).

(ix) If the existing spatial distribution of the trigger level (CM 51-07) was removed, precautionary management would still be required. This is because more concentrated fishing might then occur in subareas or SSMU-scale areas, and CCAMLR would only be able to detect the effects of fishing, if the fishing occurred in areas where monitoring exists.

2.138 The Working Group agreed that a future revision of CM 51-07 should consider how the fishery is arranged within subareas in order to avoid impacts on predators within some SSMU-scale areas.

2.139 The Working Group agreed that consideration should be given as to whether it is more precautionary for the subareas in Area 48 to be managed separately. A task for the intersessional period considered in future work is to review and evaluate whether it is more precautionary to manage subareas independently or within a regional context (paragraph 2.161vii).

2.140 The Working Group noted the following points were raised in relation to the task in paragraph 2.139:

(i) There is a need to consider connectivity between subareas as well as whether subareas are sources or sinks for krill. A key issue is whether the flux of krill is sufficiently high that the subareas are closely connected or relatively independent.

(ii) Oceanographic modelling indicates that a high volume of water moves between subareas and that some subareas have multiple sources (e.g. Subareas 48.1, 48.2 and 48.3). This needs to be taken into account in relation to the behaviour of krill. The management implications of different scenarios for ocean connectivity will need to be considered.

(iii) Krill can move actively, not simply drifting as particles in the water – they can swim at speeds equivalent to current flows and can migrate vertically and horizontally taking them into different water masses; they can also associate and move with sea-ice. Their capacity to move actively may allow them to migrate small distances, but this can then have important consequences for distribution. The implications of krill behaviour are therefore important for krill transport (paragraphs 2.79 and 2.80).

(iv) The mobility of predators, where they forage and the degree to which they might be affected across subareas, will need to be considered.

(v) Results presented by Watters et al. (2013) indicate that in modelling scenarios with no oceanographic connectivity, risks to the ecosystem are higher than in scenarios where oceanographic movement occurs. If movement of krill between subareas is limited, then management at subarea scale may be more precautionary.

2.141 The Working Group agreed that facilitating fisheries research that contributes towards development of FBM was important; e.g. requirements for fishing vessels to conduct acoustic surveys (paragraph 2.169), might necessitate careful consideration of temporal/seasonal catch limits. The Working Group noted that the Secretariat could notify fishing vessels at key times during the fishing season (e.g. at different levels of catch relative to the catch limit) so that acoustic observations can be collected at suitable times before the season closes.

### Precautionary requirements for predators at SSMU-scales

2.142 The Working Group noted that extreme events occur naturally in the marine environment. These events are known to have important impacts upon components of the natural ecosystem and safeguarding against the consequences of harvesting exacerbating the impacts, or increasing the frequency, of these extreme events will be necessary in any approach to FBM.

2.143 The Working Group recognised that at the SSMU scale, approaches for taking precaution for predators will be important, particularly during the interim period while new monitoring CEMP sites and new methods are established. The Working Group noted the following:

(i) The aim of any SSMU-scale decision rule might be to help avoid exacerbating problems in critical years. Such rules could be used in conjunction with a shift or increase in catch in subareas. Such rules might contribute towards the future development of CM 51-07.

(ii) The need to consider the critical krill density for predators in order to apply any such SSMU-scale decision rule and the need for other data for providing the annual adjustment.

(iii) Information to help elucidate critical krill densities for penguins include:

   (a) comparisons between fished and non-fished areas

   (b) information from habitat models (WG-EMM-15/09) that help improve understanding about necessary levels of krill density

   (c) estimates of critical krill densities across different sites.

(iv) Data available for determining the critical krill density might include CEMP data combined with SSMU-scale krill surveys. To further such analyses:

   (a) the Secretariat should compile available data and make them accessible to Members for analyses

   (b) WG-EMM should establish an e-group to facilitate the development of these analyses from all the subareas and for the communication between data holders and analysts

   (c) there will be a need to include factors that might impact upon the use of CEMP data, such as sea-ice and oceanography

(d) there will be a need to look at variables at the right spatial scale; foraging scales for predators are often season-specific

(e) a CEMP workshop would help progress this program of work, although there is a need to define questions that are relevant to FBM.

2.144 The Working Group noted that some areas may already be affected at current fishing levels, e.g. Bransfield Strait (SC-CAMLR-XXXIII, Annex 6, paragraph 2.121). The creation of precautionary no-take buffer zones around predator colonies or foraging areas would help provide safeguards for predator needs. The Working Group recognised that new tracking data collected since 2002 could help progress these safeguards, noting previous discussions on critical distances from predator colonies (Agnew and Phegan, 1995; see also WG-EMM-15/09 and 15/11).

2.145 The Working Group also noted that protecting krill nursery areas would be a precautionary approach to help protect krill that will eventually recruit to predator foraging areas and fishing grounds.

### Using existing data and monitoring

2.146 The Working Group noted that estimates of variability and trends in recruitment could be obtained from existing datasets. Integrated stock assessments (e.g. WG-EMM-15/51 Rev. 1) might provide such estimates as well as assisting with drawing inferences about the dynamics of krill generally.

2.147 The Working Group also noted that CPUE analyses may be able to help identify whether fishing effects krill at SSMU scales. However, CPUE can be hyperstable and also may be determined by vessel factory requirements rather than characteristics of the stock. Such analyses will need to take these considerations into account when estimating the relationship of CPUE with krill density.

2.148 The Working Group noted several points related to the use of CEMP indices in FBM:

(i) CEMP indices can describe conditions at a range of scales. Combining indices across CEMP sites, SSMUs and subareas can respectively describe conditions at the SSMU, subarea and area scales

(ii) the scale at which CEMP indices should be combined (or not) should be determined by the specific question of interest

(iii) additional work is needed to understand whether and how variations in some CEMP indices (e.g. arrival mass and chronology) affect abundance over the long term. Predator population models could be used to examine such effects (paragraph 2.160)

(iv) habitat modelling can provide information on the spatial locations and scales for which CEMP indices are applicable indicators of foraging conditions and krill availability. Work to progress such modelling has already begun for penguins (paragraph 2.195).

Further development of at-sea monitoring and CEMP sites

2.149 The Working Group noted a number of issues related to FBM and possible future area-scale krill surveys (WG-EMM-15/28); these included:

(i) how an area-scale survey relates to SSMU-scale surveys and how krill becomes concentrated in predictable ways

(ii) a series of area-scale surveys would help address area-scale questions, potentially including with respect to possible impacts of climate change; those Members interested in pursuing this may wish to establish a design process to:

(a) determine how area-scale surveys will help understand the effects of climate change

(b) determine how these surveys may provide context for variability between and within subareas and SSMUs and how such surveys could be linked to subarea- and SSMU-scale surveys.

2.150 The Working Group noted that the effects of fishing on SSMU-scale densities of krill will be critical to understand. It recognised that use of fishery acoustics may help in monitoring of seasonal and monthly cycles in SSMU-scale biomass, or trends over longer time scales. The Working Group noted that:

(i) use of fishery acoustics will need consideration of vessel acoustic calibrations (Annex 4, paragraphs 3.13 and 3.14). However, use of the same vessel may provide indices of data without the need to calibrate acoustic equipment. The use of different vessels would need intercalibration/standardisation across vessels

(ii) surveys of areas before, during and after fishing should help determine if there are SSMU-scale effects on krill density or swarm structure

(iii) repeat sampling within season in areas without fishing will help improve understanding about seasonal variation

(iv) it will be necessary to critically review survey results because multiple mechanisms may explain changes in surveys over time

(v) the spatial and temporal design of surveys will be important as a change in biomass between acoustic surveys may not just be because of harvesting but could be because of flux or predator consumption

(vi) seasonal patterns in krill biomass have been documented, including during the Elephant Island experiment (Kim et al., 1998); seasonal patterns in biomass should be taken into account within FBM

(vii) it would be desirable to trial some transects for a year to look at data and then determine how it might be scaled up (see paragraphs 2.229 to 2.232)

(viii) China, the Republic of Korea and Norway have indicated a willingness to collect acoustic data from fishing vessels. To develop FBM, the proposed program of work in paragraphs 2.229 to 2.232 will be important. Observers could usefully be involved in the collection of acoustic and ancillary data, such as length-frequency data, for generating indices of abundance or enabling estimation of abundance from acoustic data.

2.151 The Working Group noted the following in using CEMP indices and encouraged further development of CEMP for FBM:

(i) parameters and species should be chosen to signal change in different parts of the ecosystem affected by fishing or reflect dynamics and change in the ecosystem overall (e.g. calving of whales – Leaper et al., 2006)

(ii) sub-lethal parameters (e.g. foraging, diet, reproductive success) may help determine interactions in advance of seeing population changes

(iii) cameras will help automate the collection of some CEMP data but the methods require further development and standard procedures (paragraph 2.185)

(iv) given the resources available for CEMP, there may be trade-offs between the number of CEMP parameters measured at a site and the number of sites. This will be less likely as more Members become involved and CEMP parameters are identified on which efforts should be concentrated. Linked at-sea work needs to be spatially and temporally coordinated with monitoring at CEMP sites:

    (a) Bransfield Strait may be an area of high priority for additional monitoring given the concentration of the fishery there

    (b) design of CEMP should aim to have contrasting sites to understand the effects of fishing, e.g. control sites to fishing would be useful, or perhaps vary fishing intensity between areas

    (c) the performance of CEMP should be regularly reviewed in order to maintain the contrasting design

    (d) use of habit models to examine the utility of existing CEMP sites will help with some of the questions being posed

    (e) the monitoring design could utilise the deployment of cameras and other sampling in a way that has the parameters sampled for species at appropriate sites but not requiring all species be monitored for all parameters at all sites, e.g. akin to a latin-square statistical design

(v) the location of new sites could be evaluated for their utility to CEMP using locations of land-based predators (e.g. WG-EMM-15/32) coupled with habitat models.

2.152 The Working Group noted that indicators of the performance of the fishery will be useful to develop. It noted the following suggestions and asked the authors to develop papers for future meetings of WG-EMM:

(i) Dr K. Demianenko (Ukraine) proposed one such indicator that could relate to accessibility of the fishery to the stock. Such an indicator could be derived from satellite data of ice cover in a region along with survey data. He proposed that the accessibility index would be calculated as the sum across areas within a region of the index for an individual area. The index for an area would be the proportion of the year that an area is accessible multiplied by the proportion of the krill stock in the area. He also indicated that the accessibility index for the region can be readily adapted to include the management arrangements for an area, such as whether it is open or closed to fishing.

(ii) Dr S. Kasatkina (Russia) proposed to estimate krill flux between subareas and across individual SSMUs in Area 48 using the reanalysed CCAMLR-2000 Survey data. It was also proposed to analyse interannual and monthly dynamics of CPUE by SSMUs using time series of standardised CPUE as well as CPUE index by national fleets derives from the CCAMLR database. She proposed to undertake the above said analysis in the coming intersessional period for WG-EMM-16. The Working Group noted that these analyses may provide additional information to determine how krill biomass may have varied in Area 48 since 2000.

(iii) Dr Kasatkina noted it is necessary to clarify the understanding of the threshold to trigger the application of the precautionary approach to krill fishery management. There is not scientific-based argument that trigger level should be established at the level of 620 000 tonnes and used as the precautionary catch limit for Area 48. She recalled that trigger level does not reflect the status of krill stock and predators in the times past as well as the current status of krill stock and predators. The trigger level has remained the same magnitude despite significant increased estimates for krill biomass $B_0$ and allowable catch in Area 48 during recent years, particularly the allowable catch increased from 4 million tonnes (2007) to 5.61 million tonnes (since 2011). The trigger level needs scientific justification. Moreover, there is a need for additional substantiated reference points for krill fishery management.

2.153 The Working Group noted that the SISO could be used to collect data for FBM. For example, other than krill data considered elsewhere (paragraph 2.41), wildlife observations could be collected. For example, sightings of cetacean and other krill predators reported with the amount of time spent making wildlife observations could be obtained by observers on krill vessels. When possible, photos of cetaceans could help with identification and mark-recapture programs based on photos. In addition, if scientists can participate in voyages, they could collect biopsy samples or deploy tracking tags or other devices. This is similar to what occurs in other CCAMLR fisheries. Cetacean data could be managed by the International Whaling Commission Southern Ocean Research Partnership (IWC SORP) as one of the few multinational cetacean data repositories. Other wildlife could also be observed, such as penguins and seals.

### Structured fishing to further FBM

2.154 The Working Group noted that structured fishing refers to designing where and when fishing should be undertaken. It has been discussed over many years and as a general term it has been used in various ways, including the following examples:

(i) where fishing is undertaken in specific locations or concentrated there, possibly at different catch densities in different areas, to answer specific questions about, say, the effects of fishing on predators and/or krill in those areas

(ii) having fishing avoid areas in order to estimate species or food web parameters or their status in the absence of fishing

(iii) concentrate fishing in some areas early in the fishery in order to achieve catch densities at the scale expected of a fully developed fishery to test the management system

(iv) have fishing vessels undertake survey or other work to collect data needed in assessments.

2.155 These examples of structured fishing may all contribute to assessments and/or the acquisition of data for use in decision rules on catch limits.

### Implementation of FBM

2.156 The Working Group noted that the timeline for implementation of FBM will depend on the development and implementation of various technologies. These include the continuing development of fishing vessel acoustic methods (Annex 4) and remote cameras. For remote cameras, important issues include the length of time series required to establish a baseline (SC-CAMLR-XXII, Annex 4, Appendix D). Proxy data, or appropriate links to data from other sites, may facilitate the incorporation of data from a new monitoring site into long-term series already in existence. Without such data, a new monitoring site may take five to 10 years to achieve a sufficient base line.

2.157 The Working Group agreed that the development of written materials to document the value of CEMP to FBM, including the establishment of CEMP sites and long-term field activities to support them, would be useful.

2.158 The Working Group also agreed that interactions with the fishing industry and Members to promote monitoring would be essential. This could be through a workshop or some other mechanism such as a subgroup that involved industry.

### Future work plan to progress stage 2

2.159 The Working Group agreed that significant progress has been made in developing options for stage 2. It noted that a number of topics will need to be addressed in the coming years in developing FBM and encouraged Members to participate in this work. For the coming year, the Working Group recommended that the following topics are a high priority on which progress needs to be made:

(i) the current state of the krill-based ecosystem and managing the effects of fishing (paragraphs 2.160 and 2.161)

(ii) stage 2 subdivision of catch and/or update of trigger level (paragraphs 2.162 and 2.163)

(iii) precautionary requirements for predators at SSMU scales (paragraph 2.164)

(iv) krill surveys and CEMP at SSMU scales in stage 2 (paragraphs 2.165 to 2.173).

General points are also made in paragraphs 2.174 to 2.178.

### Current state of the krill-based ecosystem and the fishery

2.160 In order to have available the best scientific evidence for deliberations on stage 2, the Working Group encouraged Members to continue work on the current state of the krill-based ecosystem and possible effects of fishing, and, if possible, provide updates in the coming year on the following:

(i) the krill biomass relationships between SSMUs and subareas within areas to determine the connectivity of krill between these areas for management, including:

   (a) whether SSMU-scale surveys could be used to determine the proportion of krill biomass in SSMUs at any one time and the proportion vulnerable to the fishery at that time (e.g. WG-EMM-11/20 provided this for approximately the subarea scale using the reanalysed CCAMLR-2000 Survey data)

   (b) the percentage of the stock (and the catch limit) that is vulnerable to the fishery in the areas where it operates, both historically and with the current fishing spatial distribution

(ii) whether the area-scale survey from the CCAMLR-2000 Survey can be related to subarea-scale surveys to determine how krill may have varied in Area 48 since 2000, including consideration of temporal trends

(iii) the availability of krill to the fishery and to predators and what spatial and temporal overlap there may be

(iv) the response of predators to krill density, including identifying and comparing CEMP sites that have been potentially exposed to the effects of fishing with those that have not been exposed, noting that not all krill predators are monitored, including fish, whales and pack-ice seals

(v) using predator population models to understand the properties of CEMP parameters, taking account of various scenarios for krill and the environment

(vi) whether competition between different predators is able to be determined from these data.

2.161 The Working Group requested Members to undertake the following work on this issue in the coming year:

(i) review the variability and trends of krill at SSMU scales for use in developing stage 2 management approaches

(ii) assess the current harvest rates of krill at SSMU scales

(iii) assess whether CPUE data from the krill fishery is useful for quantifying variability and trends in SSMU-scale krill biomass, while recognising that acoustic data collected during krill fishing operations might provide higher temporal resolution information (paragraphs 2.67 to 2.69)

(iv) review whether acoustic data collected continuously during fishing may serve as the basis for a spatial–temporal index of abundance/biomass/density at SSMU scale (WG-EMM-15/13)

(v) evaluate SSMU-scale relationships between krill density, predators and the fishery, giving appropriate consideration to, inter alia:

  (a) the overlap of predator foraging areas with fishery harvesting areas

  (b) whether penguins may be attracted to fishing vessels for feeding (WG-EMM-15/25)

  (c) the relative importance of different locations to predators and the fishery and the lengths of krill revealed by diet studies and SISO data

  (d) determining the level of foraging success in relation to the density of krill and intensity of functional overlap with the fishery (paragraphs 2.190 and 2.191)

  (e) considering wildlife observations at sea for estimating predator–fishery overlap

  (f) taking note of the role that flux may have on SSMU-scale dynamics e.g. Bransfield Strait

  (g) taking account of prey switching

(vi) evaluate whether the effects of fishing can be detected at present, including whether CEMP indices suggest such effects

(vii) review and evaluate whether it is more precautionary to manage subareas independently or within a regional context.

### Stage 2 subdivision of catch and/or update of trigger level

2.162 The Working Group noted the different approaches for stage 2 aimed at updating CM 51-07 and/or revising the trigger level (paragraphs 2.102 to 2.132). It requested proponents of these approaches to continue work in the year as indicated in Tables 2, 3 and 4 and take account of relevant issues in paragraphs 2.160 and 2.161. The Working Group also requested Members work on evaluating the likely performance of proposed approaches with respect to krill, krill predators and the fishery.

2.163 The Working Group noted the consideration of multinational surveys of Area 48 (paragraph 2.149). It encouraged interested Members to continue to plan for this work.

### Precautionary requirements for predators at SSMU scales

2.164 The Working Group requested Members to consider precautionary requirements for predators at SSMU scales in stage 2, including work on SSMU-scale decision rules. In that respect, the Working Group requested this work to consider:

(i) the likely performance, with respect to krill, krill predators and the fishery, of the decision rules, including the consequences for catches over time, e.g. the mean and variability of the catch levels, and how the catch may be optimised in the context of Article II and taking account of uncertainties

(ii) the requirements for implementation, such as through work identified in Tables 2, 3 and 4 and paragraphs 2.160 and 2.161

(iii) the roles that fishing vessels and observers may play in collecting data, including undertaking krill surveys.

### Krill surveys and CEMP in stage 2

2.165 The Working Group congratulated CCAMLR Members on bringing together this long-standing time series and noted that the data can, once standardisation is achieved, be used as the basis for the development of FBM, harvest control rules and associated advice for the Scientific Committee and the Commission.

2.166 The Working Group agreed that the approaches considered for managing the krill fishery at subarea and SSMU scales are dependent on the continuation of subarea krill surveys and the maintenance of time series of data from CEMP. The Working Group recommended that the Scientific Committee highlight the importance of these surveys and CEMP data collection to the Commission so that Members may consider ways to ensure their continuation and expansion.

2.167 The Working Group requested the Scientific Committee consider the mechanisms that may be needed to sustain these monitoring activities into the future. It noted that decision rules and assessments will need to take account of the spatial and temporal frequency of monitoring able to be achieved, and that advice will need to account for the uncertainties arising from that monitoring.

2.168 The Working Group requested Members to continue to develop and design a capability for undertaking surveys by fishing vessels to assess within-season dynamics of krill, including depletion by fishing and/or predators and the flux of krill in an area, including:

(i) considering the design and instructions provided by SG-ASAM

(ii) commitment to do the research by fishing vessels

(iii) consideration of when during the season those surveys need to be undertaken and the role that the Secretariat may play in coordinating those times

(iv) calibration of vessel equipment as considered by SG-ASAM.

2.169 With respect to the design of within-season surveys, the Working Group agreed that it would be desirable for fishing nations to collect acoustic data on the SG-ASAM transects as much as possible during the coming season and then for SG-ASAM to analyse data in the coming year. This work would form the pilot for designing regular within-season surveys for the future by allowing a test of the potential utility of such data in estimating depletion and flux and for use in FBM. The Working Group agreed that these data should be reviewed next year in order to evaluate the requirements for inter- and intra-annual surveys by fishing vessels to obtain the data necessary for FBM.

2.170 The Working Group requested Members to evaluate for next year what the spatial and temporal requirements might be for CEMP to facilitate the implementation of the management approaches, including the species and parameters to be monitored in space and time and the costs and timeliness of implementation.

2.171 The Working Group recommended to the Scientific Committee that priority be given to the following tasks for the Secretariat:

(i) assist with assembling data for work by Members on FBM in the coming year, including helping prepare time series of data on krill, CEMP parameters and the fishery and validating those data and providing details on the quality of records as appropriate

(ii) assist with developing and making available metadata records for (i) and for providing a conduit between data owners and data users

(iii) document the spatial and temporal scales of CEMP parameters in different SSMUs in Area 48

(iv) in consultation with the e-group (paragraphs 2.143(iv) and 2.172), analyse the relationships between those parameters at subarea and area scales.

2.172 The Working Group agreed that this work should be facilitated through an e-group, including coordination and access to datafiles and data extractions. It noted that notifications to data owners under the Rules for Access and Use of CCAMLR Data should be made when such data are posted to the e-group site. It encouraged Members to submit other data useful for this work and to engage in facilitating contributions from the broader scientific community.

2.173 The Working Group agreed that the development of different candidate approaches for FBM would require a number of different data sources. It noted that access to CEMP data and catch data were already governed under the Rules for Access and Use of CCAMLR Data (www.ccamlr.org/node/74296). It agreed that these rules would also provide the necessary security for owners of other data not currently held by the CCAMLR Data Centre, but which may be needed in the development of FBM. The Working Group recognised that it was essential to develop positive collaborations with the wider scientific community, and so agreed that the Rules for Access and Use of CCAMLR Data should be highlighted when seeking external data.

General

2.174 The Working Group agreed that the following topics will need to be progressed in the coming year:

(i) advise on CM 51-07, the trigger level and/or precautionary measures for krill predators at SSMU scales

(ii) consider critical densities for krill predators, according to the work plan in paragraph 2.143(iv)

(iii) mechanisms for monitoring krill and CEMP parameters

(iv) status and uncertainties in the krill-based ecosystem and interactions with, and effects of, the fishery.

2.175 The Working Group advised the Scientific Committee that in order to progress to stage 2, the Scientific Committee will require advice from the following groups on the following topics:

(i) SG-ASAM on acoustic surveys using fishing vessels

(ii) WG-SAM on assessment methods and decision rules and their evaluation

(iii) WG-EMM on the status and uncertainties in the krill-based ecosystem and precautionary approaches for krill predators at SSMU scales.

2.176 The Working Group also agreed it would be desirable to have workshops in some form to:

(i) engage with stakeholders on what is being undertaken with respect to stage 2 and to communicate and discuss the need for surveys from fishing vessels, amongst other research activities

(ii) facilitate work and discussions on the three topics in paragraph 2.174.

2.177 The Working Group agreed to establish an e-group to develop the proposed work plan for FBM and timeline for consideration by the Scientific Committee, noting:

(i) the need to engage with stakeholders and the wider scientific community

(ii) the need to be realistic on what can be achieved in the coming year, given existing commitments

(iii) the cost of bringing experts to multiple meetings within one year, including working group meetings.

2.178 The Working Group requested that the Scientific Committee be flexible in its management of the agenda and priorities for working groups next year in order that sufficient consideration of FBM can be achieved.

## CEMP and WG-EMM-STAPP

### CEMP data submission

2.179 In 2014/15, CEMP data were submitted by nine Members for 12 CEMP parameters from 15 sites (WG-EMM-15/07 Rev. 1). In addition to ongoing annual submissions, the Secretariat reported on submissions from New Zealand on historical breeding population size (A3) data for penguins at Ross Island, and Norway on historical data for penguins and seals at Bouvet Island. Italy has resumed collection and submission of CEMP data collected at Edmonson Point. The Working Group welcomed these additional data submissions.

### New methods and tools for CEMP

2.180 The Working Group has previously recognised the utility of remotely operating cameras for increasing the spatial and temporal extent of monitoring in a cost-effective and non-invasive manner. The cost-effectiveness of camera monitoring is demonstrated in WG-EMM-15/P03, where camera monitoring is shown to be cheaper than direct observation by a factor of 10 under a scenario of monitoring at 20 sites in three regions over 10 years in the east Antarctic.

2.181 WG-EMM-15/31 and 15/P03 outlined the extent of current camera deployments at penguin colonies in Subareas 48.1, 48.2 and 48.3 and Divisions 58.4.1 and 58.4.2 (21 cameras, one species) and focused attention on the task of processing the growing number of images. The papers described three processing methods currently being developed or investigated:

(i) manual processing using custom-made software (WG-EMM-15/P03)

(ii) ‘citizen science’ processing through the PenguinWatch site on the Zooniverse platform (WG-EMM-15/31)

(iii) machine learning and computer vision techniques to develop automated image recognition algorithms (WG-EMM-15/31).

2.182 The Working Group noted that development of automated image analysis methods is being finalised intersessionally through the CEMP Methods e-group and recognised that such methods could enhance the utility of camera monitoring for FBM if shown to be successful.

2.183 The Working Group noted that the data from cameras can be used to count the number of birds in the colony through the season as well as to collect detailed observations of nests for measurement of breeding success and phenology. An alternate use of cameras is for them to be located at an elevated vantage point further from the colony, to count breeding population size over some or all of a colony.

2.184 An emerging issue is the management of large volumes of images and data produced from the growing camera networks in CCAMLR areas. This issue is common to camera network initiatives across other disciplines and regions and data management procedures developed for these initiatives may be suitable or adapted for CCAMLR's needs.

2.185 The Working Group agreed that prior to the incorporation of data from camera studies into management processes, validation of the time series of data and derived estimates will be required. This would include a full description of the methods applied to collect the data and a full description of the data analysis to derive time series of estimates and their associated uncertainty. As the data collected from camera networks would be eventually considered in conjunction with data collected for CEMP, the Working Group noted that it was important to ensure a similar standardisation approach across sites to that applied to the CEMP data collection.

2.186 Three papers reported on applications or evaluations of unmanned aerial vehicle (UAV) technology for predator populations. WG-EMM-15/48 described the use of two different UAVs (PW-ZOOM, CryoWing) in 2014/15 at two protected areas with penguin colonies (ASPA No. 128 – Western Shore of Admiralty Bay and ASPA No. 151 – Western Shore of King George Bay (Lions Rump) on King George Island, as well as Chabrier Rock and Shag Islands, South Shetland Islands). In total, eight colonies were surveyed. The use of the UAVs reduced the time to survey the colonies from 14 days by manual methods to five hours and the authors plan to extend the research area to include colonies not accessible by foot.

2.187 WG-EMM-15/50 investigated the potential effects of wildlife disturbance by UAVs with electric or combustion engines. During 2014/15, UAV overflights at the altitude of 300−350 m AGL were conducted in the Adélie penguin colony at Pt. Thomas (Western Shore of Admiralty Bay, King George Island, Subarea 48.1). Electric UAVs had no impact on penguin behaviour. During the overflight by a UAV powered by combustion engine, symptoms of vigilance were noticed, similar to those observed when skuas flew over a penguin colony without trying to attack nesting birds. These observations fed into formulation of preliminary guidelines for UAV use.

2.188 WG-EMM-15/P06 presented results from the first use of vertical take-off and landing (VTOL) aircraft for estimating abundance, colony area and density of krill-dependent predators in Cape Shirreff, Livingston Island, South Shetland Islands, during January and February of 2011 and 2013. Several characteristics of small battery-powered VTOLs make them particularly useful in wildlife survey applications (portability, stability in flight, limited launch area requirements, safety and limited sound when compared to fixed-wing and internal combustion engine aircraft). The paper also reported on the utility of VTOLs for missions other than abundance and distribution, namely to estimate size of individual leopard seals (*Hydrurga leptonyx*).

2.189 The Working Group agreed that UAVs offer great potential for efficient monitoring of land-breeding predator populations, especially at inaccessible sites and over larger spatial scales. The Working Group also noted the concerns about the potential for UAVs to disturb wildlife, an issue that had also been considered by the Committee for Environmental Protection (CEP) at its meeting in 2015. During the discussion it was also pointed out that special attention should be paid to the issue of safety, particularly in the coordination of manned and UAV flight operations in the region. The Working Group noted that this is an area of mutual interest between CCAMLR and the CEP and requested the Scientific Committee to consider who would be the appropriate body to lead the development of guidelines.

2.190 WG-EMM-15/25 reported on preliminary results of using vessel acoustics to detect diving patterns of krill foraging predators. Echogram data and direct-observation data on seabirds and marine mammals during active commercial fishing and during pre-set cruise lines of scientific surveys were collected and an automated detection procedure was compared against manual processing by experienced analysts. The study showed that some form of automatic acoustic detection of diving predators is possible. However, the automatic method missed many dives that were detected manually, so there is significant room for improving the simple algorithm. The results highlighted possibilities of using fishery-derived data to study predator–prey interactions and to provide information on the extent of conflict between fisheries operations and predator foraging behaviour.

2.191 The Working Group noted that the detection of predators in the acoustic data used to estimate krill biomass may potentially provide a means to study the relationship between at-sea density of krill predators and the abundance and distribution of krill. The Working Group welcomed these advances in the use of acoustic data and noted the potential to study swarm dynamics and how these might change in response to the presence of predators and fisheries.

2.192 WG-EMM-15/P01 described the principles underlying a marine ecosystem acoustics (MEA) concept, which combines acoustic sensor technologies, advanced operational capabilities and tailored modelling to answer scientific questions in marine ecology and management. Noting that operational matters could constraint the use of acoustics, the paper described some novel operational solutions for expanding acoustics and discussed the role of modelling to secure the integrity and consistency of ‘big data’ collected from acoustic technology. It concluded with a common frame of reference for multidisciplinary work taking place under the MEA concept.

2.193 WG-EMM-15/P05 assessed the accuracy of very high frequency (VHF) radio telemetry data for monitoring the foraging trip duration of Antarctic fur seals (CEMP Standard Method C1) by comparing VHF and time-depth recorder (TDR) data collected concurrently at Bouvet Island. The study found that VHF data overestimated attendance duration by around nine hours compared with TDR data and that errors were not systematic. The authors concluded that VHF is not an appropriate way of collecting attendance data.

2.194 The Working Group agreed that reviewing the suitability of CEMP methods is an important element of its work and suggested that the reported inaccuracies in VHF data may be location dependent. The Working Group agreed that collecting foraging trip duration using TDR technology may become a viable alternative to VHF technology as it becomes cheaper, however, a potential alternative and practical solution may be to combine VHF technology with a wet/dry sensor to detect when seals come ashore.

### CEMP monitoring in Area 48

2.195 WG-EMM-15/09 reported on a workshop, which was held in Cambridge, UK, from 11 to 15 May 2015 and convened by the British Antarctic Survey (BAS), BirdLife International and US AMLR. The aim was to bring together researchers working with penguin tracking data to discuss methodologies and approaches for using tracking data in habitat use modelling.

2.196 Penguin tracking data for five species (gentoo (*Pygoscelis papua*), Adélie, chinstrap (*P. antarctica*), king (*Aptenodytes patagonicus*) and macaroni (*Eudyptes chrysolophus*) penguins) collected at 22 different colonies in Area 48 were compiled before the workshop in the BirdLife International Seabird Tracking Database (www.seabirdtracking.org). The datasets covered different breeding stages.

2.197 The Convener of the workshop (Dr Trathan) thanked data contributors and the Working Group congratulated Dr Trathan for successfully organising the workshop.

2.198 WG-EMM noted the recommendations from the workshop, in particular that:

(i) using tracking data to develop at-sea preferred habitat use models for krill-dependent predators has the potential to provide valuable management information for CCAMLR, particularly as part of the future development of FBM approaches for the krill fishery as well as for marine spatial planning and the possible future designation of marine protected areas

(ii) there are a number of different modelling approaches that might be used to develop penguin habitat preference models. It noted that any such models were only part of the information needed to make management decisions, but that they could form an important component

(iii) identifying preferred penguin habitats and determining how interference from fisheries takes place within these habitats is complex; in general there are insufficient data available to determine the degree of competition

(iv) competitive effects are more likely to occur at certain times of year, particularly when animals are highly constrained and fisheries operate close to their foraging locations (e.g. during brood and crèche)

(v) habitat preference models would be valuable for the development of candidate FBM proposals, particularly for where the spatial overlap of penguins and fisheries occur and where available monitoring data are not available.

WG-EMM recognised that competitive effects are likely to occur, but are difficult to document; nevertheless, habitat models could be useful for identifying the times and locations where competition potentially occurs and this will be important for the implementation of FBM.

2.199 WG-EMM-15/12 summarised penguin research efforts conducted by the Korean Antarctic Program in Barton Peninsula (ASPA No. 171), King George Island, where colonies of chinstrap and gentoo penguins occur. The size of breeding populations has been monitored occasionally from 1989/90 to 2006/07 and annually from 2006/07 in accordance with CCAMLR standard methods. Other research involves camera-based monitoring and behaviour studies using different types of loggers and recorders. In the future, the authors intend to continue research at this site, develop international collaborations with other research groups working in the area and contribute to CCAMLR science in a more committed and systematic fashion.

2.200 The Working Group welcomed this work by the Korean research program and encouraged the continued engagement of Korean scientists in the work of WG-EMM. The Working Group also noted that the Secretariat was in discussion with scientists from the Korea Polar Research Institute (KOPRI) about the submission of the monitoring data to CEMP.

2.201 WG-EMM-15/37 reported on season variation in the diet of Antarctic fur seal at 25 de Mayo/King George Island from scats collected in the 2004 winter and 2004/05 summer on the coasts of Stranger Point. For the total study period, krill was the main prey taxon, followed by fish, cephalopods and penguins. For fish, myctophids (*Gymnoscopelus nicholsi* and *Electrona antarctica*) and the nototheniid *P. antarctica* constituted the dominant fish prey species during summer, while *P. antarctica* was dominant in winter and myctophids were absent. The only squid species present in the diet was *Slozarsykowia circumantarctica*. The paper concluded that fur seals centred their foraging activity on a krill community and fish associated with krill aggregations.

2.202 The Working Group recognised the value of data that provided information on non-krill (alternate) food webs and noted that the data from fur seal scats provide information on the occurrence and size frequency of myctophids and other fish species and that diet data of this type could be useful in a broader ecosystem monitoring program.

2.203 WG-EMM-15/47 provided an update on the project ‘Admiralty Bay as a model for the long-term marine monitoring program’. The first comprehensive concurrent analyses of biotic and abiotic elements of the environment of Admiralty Bay and adjacent waters occurred in the 1980s and 1990s, when the effects of climate change were less evident than now. Collection of biotic and abiotic data under this new project, which commenced in 2014/15, will allow an assessment of changes over the past 30 years, and create the possibility for future predictions. The biological, chemical and geological samples collected in 2014/15 are currently being analysed.

### Spatial correlation of CEMP parameters

2.204 WG-EMM previously agreed that an analysis of spatial correlations between CEMP parameters was important for determining those parameters that might reflect local- and regional-scale changes in krill abundance (SC-CAMLR-XXXI, Annex 6, paragraph 2.122). WG-EMM-15/07 Rev. 1 presented an analysis of the spatial correlation in A3 data from the CEMP database and concluded that the level of correlation between colonies of the same species in the same subarea and division was quite variable. The Working Group agreed that the level of correlation in the A3 data between colonies was important in determining how such data should be aggregated, but also noted that it is important to consider the overall population trajectories of those colonies, even if the year-to-year variability was poorly correlated.

2.205 The Working Group thanked the Secretariat for the correlation analyses in WG-EMM-15/07 Rev. 1. It noted that such correlations are difficult because other factors may impact on the ability to achieve correlations and that further work in that regard would be beneficial (paragraph 2.171).

2.206 The Working Group noted that the A3 data used in the correlation analysis varied in the level of aggregation over sub-colonies or colonies within individual CEMP sites and reiterated its advice from 2012 (SC-CAMLR-XXXI, Annex 6, paragraph 2.123) that in submitting A3 data from sites where the 'colonies' within a site were in fact convenient counting units, rather than discrete colonies, that it may be more appropriate to submit a single value for the population surveys from that site. The Secretariat was requested to help assemble data to enable Members to assess the most appropriate aggregation of sub-colonies or colonies within individual CEMP sites to allow the correct interpretation of time series of penguin populations.

2.207 WG-EMM-15/P04 reported on spatial variability in A3 data for Adélie penguin populations in the east Antarctic where populations have shown consistent regional increases over the past 30 years, suggesting a common large-scale driver notwithstanding variability within regions related to local processes. The Working Group had no comments on this paper.

### Standardisation

2.208 WG-EMM-15/44 provided an overview of the importance of standardising new methods against existing methods to maintain the robustness of time series from work presented in the following papers.

2.209 WG-EMM-15/P02 used data from remotely operating cameras to reassess historical abundance estimates for Adélie penguins in the east Antarctic and found there was a general trend for reconstructed estimates to be higher (20–30%) and more uncertain than published estimates. WG-EMM-15/P04 compared recent Adélie penguin population estimates at 99 sites across the east Antarctic with count data from the same sites 30 years ago. The historical and recent data were standardised to a common metric using the same correction data and process. The paper concluded that increases in Adélie penguin populations across the east Antarctic were regionally consistent, a conclusion that differs from a recent comparison of contemporary satellite estimates and historical published data, which concluded that populations in the east Antarctic had increased in some areas, decreased in others and remained stable in others. The differing conclusions may be due to aspects of non-standardisation in the satellite study, which used ground-based estimates from the Antarctic Peninsula and Ross Sea to calibrate satellite estimates for the east Antarctic. These regions could differ in a number of factors that could affect calibration, including differing colony structures, diets and their effects on guano reflectance, background substrate affecting detection, or density-dependent changes in nesting density as populations increase.

2.210 Finally, WG-EMM-15/P03 presented an evaluation of how well camera-derived observations compare with direct observations consistent with current CEMP standard methods. The work showed that cameras can provide unbiased estimates of breeding success (A6) and that, while breeding phenology (A9) events can be more difficult to observe from cameras than from direct observation, it may be possible to develop proxy observations from cameras that can effectively monitor some A9 events.

2.211 The Working Group noted that CEMP is defined by its objectives rather than by the current set of standard methods. There is scope to increase the number of CEMP parameters, based on standard methods, particularly relevant to FBM of krill.

2.212 The Working Group agreed that technological advances are increasingly leading to new and improved methods for ecosystem monitoring and it is important to ensure that existing time series remain robust as new methods are developed. Therefore, it is important to determine a minimum set of standards to be considered in accepting and using new methods for ecosystem monitoring. In particular, there was a need to understand the methods by which data had been collected in order to allow an evaluation of how that data could be used in providing advice.

2.213 The Working Group recognised that in the future of CEMP development there will be a need to make better use of existing CEMP data, data from other sources and initiatives outside of CCAMLR such as the Scientific Committee on Antarctic Research (SCAR) Horizon Scan, Integrating Climate and Ecosystem Dynamics in the Southern Ocean (ICED) and SOOS in order to develop a better system-level understanding through improved population and ecosystem models. The Working Group considered that this could be achieved by holding a workshop in the near future to consider these issues and noted that there have been many methodological developments and additional data sources since a previous CEMP review workshop in 2003. It may be possible to fund such a workshop through a proposal to the CEMP Special Fund in 2016.

2.214 Dr T. Ichii (Japan) recalled that a variety of CEMP indices has been collected for more than 25 years, but so far none of them have been assessed whether they are useful for krill fishery management. He indicated that existing CEMP indices should be thoroughly assessed at the CEMP review workshop and that, if their usefulness is uncertain, WG-EMM should be careful with the use of the CEMP indices in stage 2 of FBM.

2.215 WG-EMM-15/32 highlighted the value of a new inventory of important bird areas (IBAs) in Antarctica as a scientific resource for WG-EMM and SC-CAMLR. The effort to compile an IBA inventory for Antarctica was first initiated by BirdLife International and SCAR in 1998 and its recent completion was aided with further support from Australia, New Zealand, Norway, UK, USA, the Pew Charitable Trust and the British Birdwatching Fair. Australia, New Zealand, Norway, UK and the USA jointly submitted a working paper and information paper on the IBA report to the CEP meeting in Bulgaria in June 2015. The Working Group agreed that this was a valuable resource for CCAMLR and thanked the authors and contributors for this significant work. The full report is available for free download from the websites of BirdLife International (www.birdlife.org) or Environmental Research and Assessment (www.era.gs/resources/iba/Important_Bird_Areas_in_Antarctica_2015_v5.pdf). Future work is planned to link terrestrial IBAs with important marine areas identified from tracking data.

#### WG-EMM-STAPP

2.216 The Working Group discussed the progress of WG-EMM-STAPP towards its goal of developing spatially explicit prey consumption estimates for air-breathing predators within CCAMLR subareas around Antarctica. An update of progress in 2011 (WG-EMM-11/30) outlined a five-year program of work from 2011 to 2016 and indicated it would take at least five years to achieve a number of critical milestones (SC-CAMLR-XXX, Annex 4, paragraph 2.199). The Working Group encouraged WG-EMM-STAPP to document and report on its progress over this period, identify any further work required after this period and indicate how any further work might proceed, at WG-EMM-16.

### Integrated assessment model

2.217 WG-EMM-15/51 Rev. 1 summarised recent work to develop an integrated modelling framework to estimate krill population dynamics in Subarea 48.1. The model uses statistical fits to catch and length-composition data from the krill fishery, together with biomass indices and length compositions from research surveys, to estimate parameters and then project future stock dynamics at pre-specified catch levels. The model is used to compare predicted krill spawning biomass under projected future catches to the CCAMLR decision rules. Alternative decision rules, which are based on comparing krill spawning biomass expected under projected future catch levels to spawning biomass expected without any fishing during the same future period, are also evaluated. In particular, the model suggests that if observers collect twice as much length-frequency data as they have collected to date, and those data have the same characteristics as existing data, estimates of stock status from the model would not change appreciably. By contrast, changing the precision of total estimated removals does seem likely to impact assessments of stock status. Results from this paper have implications for scientific observation of the krill fishery.

2.218 WG-EMM-15/P07 provided more details on the model and data assimilation framework and evaluated the effects of fitting to different combinations of survey data and also using two forms of selectivity.

2.219 The Working Group acknowledged the importance of developing a suite of diagnostics for evaluating the performance of assessment models, and that this had also been a topic of discussion at WG-SAM-15 (Annex 5, paragraphs 2.34 to 2.37). It suggested that the authors of WG-EMM-15/51 Rev. 1 and 15/P07 should routinely provide equivalent diagnostics such that model fits can be evaluated, especially as this model is a modification to that previously reviewed at WG-SAM-14. The Working Group suggested that model and diagnostics should be reviewed by WG-SAM-16 and that its development could also be progressed via an e-group. An overlapping meeting of WG-EMM and WG-SAM might also be an appropriate venue for a review of the model (paragraph 5.4).

2.220 Dr Watters noted that the Center of Independent Experts in the USA is scheduled to review the model in March 2016. If possible, the report from this review will be tabled to the appropriate SC-CAMLR working group (WG-SAM-16).

2.221 The Working Group also discussed the following points in relation to variability and uncertainty in the context of integrated assessment models:

(i) the spatial scale at which an assessment model is applied has implications for the degree of variability in model outputs, particularly given that observational data at subarea and local scales are highly variable

(ii) as the number of parameters in an assessment model increases, it may become difficult to interpret structural versus observational uncertainty. This is especially the case in this model where selectivity, catchability, natural mortality, $B_0$ and steepness are being estimated simultaneously – parameters which are confounded in integrated models and, therefore, diagnostic output is critical to understanding the model fit before stock projections can be evaluated.

2.222 The Working Group noted that estimated high levels of variation in krill recruitment have implications for the CCAMLR decision rules; a projection framework, as is used for mackerel icefish (*Champsocephalus gunnari*), might be suitable to account for this, or one similar to that proposed in de la Mare et al. (1998). It also noted that application of the current decision rules to krill would result in relatively stable catches over time as intended, but that an F-based rule based on short-term projections, like those used for mackerel icefish, could potentially result in highly variable catch limits that are not easy to manage. Importantly, any changes to the decision rule as part of the staged approach to FBM should take account of environmental change. An evaluation of the properties of different decision rules could be part of the work plan for FBM (paragraph 2.132).

2.223 The Working Group concluded that integrated assessment models could potentially be used within FBM strategies for krill. It also acknowledged the value of ensemble approaches for ecosystem integrated assessments and noted the contribution of the assessment model presented in WG-EMM-15/36 in this regard.

### Collection of fishing vessel acoustic data

2.224 A summary of the 2015 meeting of SG-ASAM was provided by Dr Watkins. SG-ASAM-15 noted the submission of a paper entitled 'The use of fishing vessels to provide acoustic data on the distribution and abundance of Antarctic krill and other pelagic species' written by scientists involved in SG-ASAM and describing the proof of concept study undertaken by SG-ASAM. Dr Watkins reported during the present meeting that this paper had just been accepted for publication in a special issue of *Fisheries Research* on 'Fishing vessels as scientific platforms'.

2.225 The Working Group recognised that the present focus of SG-ASAM on the use of acoustic data from fishing vessels to provide qualitative and quantitative information on the distribution and abundance of krill is an important component for the ongoing discussions of FBM.

2.226 An instruction manual detailing acoustic data collection protocols, instrument set up and metadata requirements for use by krill fishing vessels had been provided as Appendix D of the SG-ASAM-15 report (Annex 4). The Working Group recognised that this was a very clear and concise document that could now be used by fishing vessels to collect acoustic data in the coming season.

2.227 SG-ASAM-15 noted the key role of a SISO observer in the collection of acoustic data. The Working Group agreed that observers on board fishing vessels had an important role in the collection of acoustic data and the associated metadata as detailed in Annex 4, Appendix D.

2.228 The Working Group agreed that information on the length-frequency distribution of krill was necessary to generate estimates of krill density from acoustic data collected on fishing vessels. While sampling of the krill catch for length measurements is regularly undertaken by the observers, it would be important to ensure that any selectivity in the size of krill in the catch was taken account of in the generation of krill TS.

2.229 The Working Group noted the recommendation of SG-ASAM-14 and agreed that collecting acoustic data on CCAMLR transects was a priority activity (SC-CAMLR-XXXIII, Annex 4, Table 2). SG-ASAM-15 selected a subset of transects from each subarea on the basis of their biological and oceanographic interest. The Working Group agreed with these recommendations and also that, in order to use the data collected along these nominated transects to investigate temporal variation in krill abundance, the transects should be sampled as frequently as possible during the fishing season.

2.230 The Working Group noted that for the development of FBM procedures, a focus on repeated within-season occupations of these nominated transects (possibly by different appropriately equipped vessels) would be more valuable than single occupations of other transects.

2.231 The Working Group recommended that acoustic data collected by fishing vessels along these nominated transects should be submitted to the CCAMLR Secretariat and then analysed jointly by participants at the next SG-ASAM meeting. The results of this joint analysis should be presented to the next meeting of WG-EMM (paragraph 2.150). The Working Group noted that this process would also help with broadening the use, development and dissemination of the recommended analysis protocols.

2.232 The Working Group noted that providing information to the CCAMLR Secretariat on when transects were undertaken in near-real time could facilitate scheduling of repeated transects. This could also provide positive publicity for fishing companies engaged in providing acoustic data for use in the FBM process.

### Scientific surveys undertaken from fishing vessels

2.233 WG-EMM-15/54 described the analysis of five annual krill surveys undertaken between 2011 and 2015 in Subarea 48.2 using two fishing vessels. The five surveys were undertaken at the same time each year over the same nominal transect lines, however, the differing quantities of sea-ice present in the survey area led to very different areas of survey coverage each year. The fishing vessels were equipped with similar echosounder systems but the available 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. A substantial proportion of the survey area is south of the South Orkney Islands, which was frequently covered in sea-ice at the time of the survey. In order to avoid variability due to different areas of coverage between years, a stratum covering the transect sections on the northern side of the South Orkney Islands covered in all years except 2013, was defined.

2.234 The Working Group noted that future work planned as part of the joint UK–Norway studies to be undertaken in January/February 2016 would provide additional sampling in this region and in particular the distribution, abundance and potential flux of krill through the main fishing region on the northwest side of the South Orkney Islands.

2.235 The Working Group noted that 70 kHz had not been used previously within CCAMLR either as part of the target identification process or as the frequency at which krill density was estimated. WG-EMM-15/54 raised a series of issues around the use of this frequency as well as other issues (paragraph 2.233) that were very relevant to the work of SG-ASAM and the Working Group recommended submission to that Subgroup.

2.236 WG-EMM-15/54 presented krill length-frequency distributions collected during the acoustic surveys that showed a strong year class in 2012 (detectable as 25 mm cohort). The Working Group noted that this cohort was detected in winter surveys undertaken in Subarea 48.1 by the US AMLR Program and also in the length-frequency distributions provided by scientific observers on board fishing vessels and in the Krill Fishery Report (WG-EMM-15/30). Furthermore, a compilation of all summer and winter survey data collected by Germany, Peru and the USA from 2012 to present was being undertaken and it was possible to see the progress of this year class through this cohort over a three-year period. Importantly, it was also noted that there was no sign of any other significant recruitment in this time period.

2.237 The Working Group noted that the data in the Krill Fishery Report (WG-EMM-15/30) showed that over a longer time scale strong recruitment peaks occurred episodically (for instance in 2008 and 2012). The Working Group reiterated that such extreme variability in annual recruitment had implications for management strategies as these would be very different from those required if there was a consistently low level of recruitment every year.

2.238 The Working Group noted that understanding the fishing strategies used by fishing vessels was important, for instance in determining critical krill densities required for fishing, or what signals might be used to choose fishing regions. Recalling the workshop organised by the Association of Responsible Krill harvesting companies (ARK) in Punta Arenas, Chile (June 2014), it was agreed that this had been a very valuable forum for direct communication with fishing masters and others directly involved in deciding fishing strategy. However, the Working Group noted that not all fishing companies were presently represented in ARK and that mechanisms by which formal dialogue with all fishers might be established should be considered by SC-CAMLR.

#### Proposals for future krill surveys

2.239 WG-EMM-15/43 presented Japan's outline plan for surveys in East Antarctica.

2.240 Two kinds of survey are proposed:

(i) An annual survey undertaken from a dedicated cetacean sighting vessel equipped with a scientific echosounder system, a vertical net and conductivity temperature depth probe (CTD) system. These surveys would be carried out for 12 years using a zigzag stratified survey design optimised for sighting whales. The aims of these surveys include obtaining an index of relative krill abundance.

(ii) A dedicated krill survey carried out from a trawler-type research vessel equipped with a multifrequency scientific echosounder system, research net such as RMT8 or IKMT and a full CTD/multi-bottle water sampler. These surveys would be carried out once in each of two six-year periods using a survey design compatible with CCAMLR survey protocols and an area of coverage similar to those used in previous surveys carried out in the region (BROKE in 1996 and BROKE West in 2006). The main aim of these surveys is to obtain an index of absolute krill abundance.

2.241 The Working Group noted that survey design was important for determining whether outcomes of such work would be relevant to WG-EMM and CCAMLR.

(i) The survey undertaken from the whale sighting vessel was primarily designed for work outside of CCAMLR. The collection of data on the krill ecosystem, other than whale sightings, was also proposed. However, the proposed whale sighting survey design is not consistent with survey designs established by CCAMLR for monitoring krill.

(ii) In this regard it was noted that this whale sighting survey would consist of a zigzag design of alternating phases of independent observer and closing modes. This raised two potential issues that would need to be considered in the context of a krill ecosystem survey: (i) the survey will involve approaching the sighted whales to confirm identification, determine school size and, in some cases, to take samples (biopsy and photo-id), (ii) zigzag surveys result in an uneven sampling effort that needs to be taken into account.

(iii) The Working Group noted that the whale sighting surveys would cover areas where there had been little oceanography data collected previously. Therefore, deploying expendable CTDs regularly during these surveys would be valuable. In this regard the Working Group was informed that oceanographic data from the previous 24 years of whale sighting surveys was now available for use by the scientific community (http://icrwhale.org/pdf/oceanographicdata.pdf). The Working Group also noted that in this area there was a sparse coverage from surface drifting meteorological buoys and the possibility of deploying such drifters on behalf of the relevant international programs could be considered.

(iv) WG-EMM-15/43 proposed that the two dedicated krill surveys would be carried out in two separate regions of the east Antarctic, over the survey areas covered by BROKE and BROKE West surveys in the past. The Working Group recommended that, given that there would be two such surveys within a 12-year period, it would be more valuable to undertake the two surveys in the same region using the same survey design. This would provide a better temporal coverage for one area.

(v) The Working Group noted that different net sampling gear and protocols were proposed for the two types of survey: a small vertically hauled net with an attached light/strobe in the whale sighting surveys in contrast to an obliquely hauled krill research trawl in the CCAMLR-endorsed design surveys. Given these differences, the Working Group encouraged conducting comparisons between the nets and also on the effect of using a light to fish for krill.

(vi) The Working Group encouraged submission of details of the broader objectives of the research program in order to aid the interpretation of the survey design. Recognising that WG-EMM-15/43 was a preliminary proposal, and taking into account the different time frames for the two types of survey, the Working Group recommended that a more detailed paper on the proposal for the dedicated krill survey should be submitted to the next meeting of WG-EMM. With regard to the whale sighting-type survey, it was noted that the first survey would take place next season. However, the Working Group is not currently able to assess the utility of data from surveys of this design. It was agreed that detailed information on survey design would be submitted with data from the first of these surveys to the next meetings of SG-ASAM (to consider the utility of the acoustic data for estimating relative and absolute krill abundance), WG-SAM (to assess the survey design, in particular the trade-offs between the primary goal of gathering information on cetaceans versus the secondary goal of gathering information on krill) and WG-EMM (to review the results).

### Multinational coordination

2.242 The Working Group realised that this agenda item is much broader than suggested by the submission of a single paper (WG-EMM-15/27). It noted that SG-ASAM-15 (Annex 4) demonstrated the potential of coordinated effort from the fishing fleet. Other papers suggested utilising coordinated fishing vessel effort from several nations to achieve the observation requirements for FBM (WG-EMM-15/04, 15/10, 15/33). The Working Group agreed that multinational coordination should be considered as a regular agenda item for WG-EMM to ensure progress in the data collection for FBM.

2.243 WG-EMM-15/27 discussed requirements for carrying out a new area-scale survey covering Subareas 48.1 to 48.4. The paper refers to Article II of the Convention requiring that harvest does not negatively impact the goal of ensuring a spawning population that supports stable recruitment. The authors recommended that WG-EMM consider the need for such surveys and, if such surveys are likely to be important, establish a planning process which will allow an efficient response to future requests for area-scale surveys.

2.244 The paper underlined that the existing subarea-scale surveys show high variability without trend and that there are major uncertainties associated with the impact of flux within and between regions that are not resolved through the current monitoring. An area-scale survey should support better understanding of these uncertainties in present assessments. The FBM requires subarea-scale stock assessments but another paper (WG-EMM-15/10) also suggested that these have to be combined with area-scale surveys carried out at intermittent or regular intervals.

2.245 WG-EMM-15/27 introduced practical considerations for planning an area-scale krill survey by reference to the CCAMLR-2000 Survey and provided the basis for discussions within WG-EMM to establish a planning process. The paper suggested that many of the procedures behind the CCAMLR-2000 Survey be followed, although advances in e.g. data management and processing of acoustic data need to be included. The paper emphasised that it is not only realistic, but probably the only viable option, to include fishing vessel effort as a major contribution if such a survey should be carried out. Thus, as the planning will be time-consuming and demanding, it will have to start now if a survey is to be carried out in the near future.

2.246 The Working Group welcomed the initiative. The CCAMLR-2000 Survey was a complicated task and the Working Group realised that a new survey involving more vessels will cost time and effort in coordination and planning. The Working Group agreed that such a process could learn from experience gained in complex coordination tasks in other parts of the Convention Area. It also agreed that cross-reference to other activities in the Antarctic should be taken into account to secure temporal and spatial coordination with these activities without complicating the planning and execution of the survey. For example, some coordination with activities with SOOS could be useful in this regard (WG-EMM-15/61).

2.247 China, the Republic of Korea and Norway confirmed the interest of their industries to participate in multinational coordinated subarea-scale surveys which underline the potential of using multinational fishing vessel effort for area-scale surveys in the future. A particular challenge will be to manage combining the completion of the subarea-scale surveys in the same year as CCAMLR carries out the area-scale survey. Success of similar coordinated effort within the International Council for the Exploration of the Sea (ICES) demonstrates the potential of such coordinated effort. The Working Group emphasised that definition of the basic scientific questions is required as a basis for the planning and execution of an area-scale survey.

2.248 The Working Group requested that Members that undertake krill fishing activities liaise with their industry representatives to determine whether their krill fishing vessels are willing to participate in these research activities.

2.249 The Working Group recalled its advice from last year (SC-CAMLR-XXXIII, paragraph 3.39) that absolute estimates of krill biomass in the whole of Area 48 are unlikely to be available on a regular basis and there will be a need to have management approaches that are not dependent upon data that are unlikely to be available at the spatial and temporal scales required for a particular management approach. However, the Working Group agreed that large-scale surveys provide essential data related to variability and trends in the subarea-scale surveys and krill distribution, abundance and the impacts of climate change.

## Spatial management

### Marine protected areas (MPAs)

#### MPA Planning Domain 1 (Western Antarctic Peninsula and southern Scotia Sea)

3.1 WG-EMM-15/34 reported on a domestic workshop to identify US stakeholders' objectives and protection priorities for one or more MPAs in Planning Domain 1. The workshop was held in La Jolla, USA, in March 2015, and hosted by scientists from the US AMLR Program. The USA has substantive interests within the boundaries of Planning Domain 1, and the aim of the workshop was to develop background information and to provide a basis for future collaborations and discussions on MPA planning in this region.

3.2 Key outputs from the workshop included:

(i) list of specific objectives for MPAs in Domain 1

(ii) map of priorities for spatial protection, based on the list of objectives. This was done using an expert opinion approach, where groups of participants were asked to assign varying levels of priority to areas across the planning domain, in an effort to achieve all of the defined objectives

(iii) estimates of conservation targets inferred from these priorities, for application in decision-support tools such as Marxan

(iv) stakeholders' views on MPA size and duration, the management tools (e.g. no-take areas, gear restrictions and seasonal closures) that may be required to achieve various MPA objectives, and the future research and monitoring efforts needed to underpin one or more MPAs.

3.3 The workshop also reviewed a range of newly compiled data layers on the spatial distributions of zooplankton, fish and upper-level predators, the physical environment and the distributions of fishing, tourism and research activities in Domain 1. Much of this data was subsequently made available as GIS shapefiles for use at the Second International Workshop on identifying MPAs in Domain 1 (see paragraphs 3.8 to 3.11).

3.4 Participants at the workshop prioritised protection of the continental shelf and inshore waters along the western coast of the Antarctic Peninsula, from around Alexander Island and Marguerite Bay northeast to the tip of the peninsula and Joinville Island, including various islands and archipelagos such as the South Shetland Islands. These areas largely coincide with the Palmer LTER and US AMLR study areas, and their prioritisation is consistent with the stakeholders' aspiration to 'preserve the integrity of existing studies'. The highest conservation targets were inferred for two small canyons cutting across the continental shelf north of Livingston Island, and for the Gerlache Strait, which is an inshore nursery for larval krill.

3.5 Participants at the workshop also agreed that the size of an MPA should be determined by the spatial requirements needed to achieve its specific objectives; that several scientific issues are relevant to the duration of MPAs; and that existing international research and monitoring efforts in Domain 1 provide a useful baseline for assessing future changes.

3.6 The Working Group thanked Dr Watters for this informative report, which is useful in highlighting the areas that US stakeholders believe are important for protection. It noted that broad engagement with stakeholders in such discussions is very valuable and, in particular, that there had been a positive response from the International Association of Antarctic Tour Operators which was pleased to have been involved in this process.

3.7 Dr Watters noted that the current status of protection in some areas by ASPAs and Antarctic Specially Managed Areas (ASMAs) did not influence stakeholder priorities, and that such areas were too small to significantly influence the outcomes. There was a range of opinions in this stakeholder group on whether or not to prioritise the existing South Orkney Islands MPA, however, it was noted that it falls outside the main area of US interest.

3.8 WG-EMM-15/42 presented a report on the Second International Workshop for identifying MPAs in Planning Domain 1. This workshop was held in Buenos Aires, Argentina (25 to 29 May 2015), and was as co-convened by Drs E. Marschoff (Argentina) and J. Arata (Chile). It was attended by representatives from Argentina, Chile, European Union, Germany, Norway, UK, USA, NGOs and the fishing industry.

3.9 The Working Group thanked the workshop conveners and participants, and welcomed the progress made on MPA planning in Domain 1. It acknowledged the valuable opportunity provided by the international workshop in Buenos Aires for Members to review and contribute to the work being done by Argentina and Chile.

3.10 New and updated data available for this workshop was shared before the start of the meeting through a CCAMLR e-group. Preliminary activities included national workshops carried out by Argentina, Chile, UK and USA and aimed to (i) compile new data, (ii) discuss different conservation objectives, (iii) analyse penguin habitat modelling and (iv) identify high-priority areas for conservation within Domain 1.

3.11 Workshop discussions focused on reviewing and analysing new and updated data, and in further developing the conservation objectives. A large amount of new data had been provided for objectives that previously had incomplete information, including prey distributions (larval and adult krill, crystal krill (*Euphausia crystallorophias*), bigeye krill (*Thysanoessa macrura*) and salps), important areas for zooplankton life cycles (krill nurseries), non-breeding whale distributions, emperor (*Aptenodytes forsteri*) and macaroni penguin colonies, and new information on benthic communities. Updated data included new classifications for canyons, minimum and maximum sea-ice extent, predator colonies with relevant buffers and tracking data (breeding and non-breeding distributions) and important areas for fish life cycles.

3.12 In previous workshops, Marxan software was agreed to be the most appropriate tool to support decision-making in the design of a system of MPAs in Domain 1. The workshop recognised the value of exploring a range of different Marxan scenarios to better understand the influence of conservation objectives and cost layers. Parameters for three different protection scenarios (low, medium and high) were agreed during the workshop for use in Marxan analyses. Discussions also focused on definition of the cost layer, reviewing available data on human activities and investigating the parameters involved in its estimation.

3.13 The workshop noted the importance of considering the development of MPAs in Domain 1 in the context of the development of FBM of the krill fishery.

3.14 The workshop also noted the importance of considering the area at the boundary between Domain 1 and 3 (Weddell Sea planning domain), as the northern Antarctic Peninsula region is an area of particular ecological interest. It was suggested that WG-EMM-15 would provide a good opportunity for those involved in both the Domain 1 and Weddell Sea MPA planning processes to discuss common issues and approaches for this boundary region.

3.15 The Working Group thanked the workshop conveners and participants and welcomed the progress made on MPA planning in Domain 1.

3.16 Drs Arata and Santos indicated that a bilateral workshop between Chile and Argentina would be held in December 2015 and that the aim is to present a draft MPA proposal in 2016 or 2017.

3.17 Dr Santos noted that further updates would be made to penguin colony location and predator tracking data layers and that these will be made available to all Members through the Domain 1 Planning e-group. As agreed in the workshop, Dr Santos also noted that Marxan input files would be uploaded in this e-group to encourage other Members to conduct their own analysis.

3.18 The Working Group discussed how other spatial management processes (ASPAs, ASMAs, CEMP sites, vulnerable marine ecosystems (VMEs) and the existing South Orkney Islands MPA) integrate into the broader Domain 1 planning process. Dr Arata noted that Marxan analyses will be undertaken, both with and without VMEs and existing protected areas, to explore how such areas might influence the selection of additional areas for protection based on the conservation objectives. He noted that CEMP sites are not protected by CCAMLR and are not used as an input to the Marxan analysis, but that it may be useful to consider how spatial management of areas surrounding CEMP sites could contribute to FBM, in the context of Domain 1 conservation objectives relevant to scientific reference areas. He further noted that, while the existing South Orkney Islands MPA was not designed in the context of the wider Domain 1, it is useful to consider how it contributes to the Domain 1 conservation objectives.

3.19 Dr Jones suggested that the consideration of CEMP sites as part of the MPA planning process could also be included in future work towards refining stage 2 or moving to stage 2 of FBM, through potentially closing or limiting krill fishing near selected CEMP sites.

3.20 The Working Group also noted the importance of considering the broader circumpolar context of some of the data layers included in such regional analyses, for example the extent to which geomorphic features, such as seamounts occurring in Domain 1, are represented across the Convention Area.

3.21 WG-EMM-15/41 described a study of population structure changes in common benthic species of the proposed Stella Creek MPA in the vicinity of Akademik Vernadsky Station. It presented the results of scuba diving surveys during two seasons of observations (2012 and 2014). This was a non-destructive survey method using analysis of underwater photos. The study reported on changes in the population structure of three common species (limpet *Nacella concina*, sea urchin *Sterechinus neumayeri* and sea star *Odontaster validus*). The authors plan to continue this monitoring of the population dynamics of common species and their dependence on the hydrological characteristics in the Stella Creek MPA.

3.22 The Working Group welcomed the ongoing work in this area and noted that it would be useful to incorporate consideration of this proposal within the wider Domain 1 MPA planning process. It was also noted that there had been previous suggestions for this proposal to be considered as an ASPA rather than an MPA. Consideration of current threats and the urgency of protection will be important in determining the best way to achieve protection for this area.

3.23 The Working Group noted that future joint SC-CAMLR–CEP interactions may provide a useful opportunity to discuss how the respective protected area systems of these two bodies could be harmonised.

### MPA Planning Domains 3 and 4 (Weddell Sea)

3.24 Prof. Brey and Dr K. Teschke (Germany) presented three scientific background documents in support of a CCAMLR MPA in the Weddell Sea: WG-EMM-15/38 Rev. 1 (Part A: General context of the establishment of MPAs and background information on the MPA planning area); WG-EMM-15/39 (Part B: Description of available spatial data); and WG-EMM-15/46 (Part C: Data analysis and MPA scenario development).

3.25 The Working Group acknowledged the extensive work done by the Weddell Sea MPA project group to date. A large amount of relevant data are compiled for the Weddell Sea planning domain, which provides a good foundation for the MPA planning process. The Working Group also noted the valuable opportunity for discussion of data layers and conservation objectives that was provided by the International Expert Workshop held in Berlin, Germany, in April 2015.

3.26 WG-EMM-15/38 Rev. 1 includes four chapters: (i) synopsis of establishment of MPAs in general, (ii) boundaries of planning domain, (iii) comprehensive description of Weddell Sea ecosystem, and (iv) future work. WG-EMM-15/39 includes information on environmental data and biological parameters, with descriptions of new datasets that have been added and updates to existing datasets.

3.27 As an update to the information provided in chapter 1 of WG-EMM-15/38 Rev. 1, Dr Trathan reminded the Working Group of recent progress made by the UN 'Ad Hoc Open-ended Informal Working Group to study issues relating to the conservation and sustainable use of marine biological diversity beyond areas of national jurisdiction'.

3.28 Prof. Brey explained that information on pelagic fish will be included in the next version of the analysis and that the Russian toothfish data will be included when available. An additional scientific background chapter on demersal fish is currently being prepared.

3.29 The Working Group recalled that the toothfish data from the Weddell Sea were quarantined (CCAMLR-XXXIII, paragraph 3.12).

3.30 Prof. Brey noted that some data layers remain to be updated, including the sponge communities layer. He indicated that once data layers have been finalised, they would be published to a data repository such as Pangaea (www.pangaea.de), which would assign a unique digital object identifier (DOI) number to each dataset that can also be used when the data are uploaded to the relevant CCAMLR database. Version numbers will be included to allow tracking of the history of each dataset.

3.31 In discussing the scientific background information available for the Weddell Sea planning domain, the Working Group suggested that individual chapters from WG-EMM-15/38 Rev. 1 could be separated and attached to the respective data layers. Further discussions on general issues surrounding the archiving of data for MPA planning are summarised in paragraphs 3.67 to 3.69.

3.32 Dr Godø asked for clarification of the reasons for including such a large part of Planning Domain 4. Prof. Brey responded that limiting the planning area to Domain 3 would have cut through a major biogeographic region and that it was more meaningful to include the whole of the shelf and the Weddell Gyre (SC-CAMLR-XXXII, paragraphs 5.22 and 5.23).

3.33 WG-EMM-15/46 includes further analyses of the available data and a description of the development of MPA scenarios using Marxan analysis as part of a systematic conservation planning approach. The Working Group discussed a number of issues regarding these analyses and the data used therein.

3.34 Dr Trathan noted that there is little spatial overlap between the distribution patterns of krill and *Pleuragramma* with emperor penguins. Prof. Brey responded that the data have been accumulated from separate investigations, and may in addition be too patchy and sparse to show spatial correlation across such a large area. Dr V. Siegel (EU) indicated that spatial overlap between krill and emperor penguins would not be expected in the Weddell Sea. Dr Trathan agreed that the onshelf/offshelf distribution of krill could lead to such outcomes as could temporal mismatches in data collection. He therefore suggested that levels of uncertainty could be included in the analyses.

3.35 Dr L.A. Pastene Perez (Japan) indicated that the boundaries of any MPA within the Weddell Sea planning area will cover only part of the migratory range of humpback and Antarctic minke whales, and noted that there was little information on how these species might be monitored within the Weddell Sea.

3.36 Dr Trathan noted that data from cetacean observations in the eastern part of the Weddell Sea MPA planning region (Domain 4) have recently been submitted to the IWC (Findlay et al., 2014) and may be relevant for inclusion in future analyses.

3.37 Dr J. van Franeker (EU) proposed that information on flying seabird distribution be included in the MPA planning analysis, in particular for Antarctic petrels (*Thalassoica antarctica*) as the largest colony of this species in the Antarctic is located in the region. Although data on such species are currently poor, he suggested that distributions could be approximated using habitat models based on the available environmental data.

3.38 Prof. Brey noted that most flying seabirds target open water and the marginal ice zone, and that these habitats are presumably already covered by other data layers, but a seabird habitat model will be developed to investigate this.

3.39 Dr Kasatkina stated that data on the state of toothfish as an important component of the ecosystem were currently not available. Such data can be obtained through research fishing, which Russia considers should be undertaken in the Weddell Sea and results included in the MPA planning analysis.

3.40 The Working Group recognised the problems of toothfish data availability for this area, given that the Scientific Committee has determined that some data are quarantined and that these data cannot, therefore, be recommended for use until they have been deemed suitable. However, it suggested that generic toothfish data from elsewhere could be used as an alternative. Dr Trathan noted that a similar approach has been taken for emperor penguins, where data from elsewhere were used to generate a habitat model in the absence of tracking data for the Weddell Sea.

3.41 With regard to the conservation objectives for benthic habitats, the Working Group suggested that VME notifications for features such as sponge associations could be considered in parallel with the MPA planning process. Notification of VMEs under CM 22-06 may provide additional support for the designation of these areas as MPAs.

3.42 The Working Group discussed Table 2.3 in WG-EMM-15/46, which shows the results of the Marxan analyses and the extent to which the defined targets for each conservation objective had been achieved. It was noted that the results indicate that many of the objectives were easily achieved, with the spatial coverage for some objectives being greater than that specified by the nominal targets. This arose because of the spatial overlap of many objectives.

3.43 Prof. Brey explained that target values are set according to the importance of each feature; these may be low for features covering large areas such as krill distribution, or high for very important or unique features such as sponge communities. The targets defined in WG-EMM-15/46, Table 2.3, resulted from extensive discussions and reflect agreement at the workshop on what was considered to be reasonable.

3.44 The Working Group suggested that WG-EMM-15/46, Table 2.3, could be rearranged so that the conservation objectives which are the primary drivers of the Marxan results are listed separately to those that are achieved as a consequence. Demonstrating which objectives are driving the analysis will be important for understanding the effects of intercorrelation between objectives.

3.45 The Working Group also suggested that it would be useful to include a description of the properties of each data layer included in the analysis, together with the reasons for including it (or the reasons for excluding other data). Some data may not be relevant, and it would be helpful to set out a clear justification for which datasets are most important for each objective. The Working Group noted that much of this information is already available in WG-EMM-15/39.

3.46 The Working Group noted that information on data quality could also be added to data descriptions, including, for example, data accuracy, gaps and levels of uncertainty for different data layers. Marxan outputs could then be evaluated in relation to data quality. While the next steps will need to consider data uncertainties, the presentation of MPA scenarios is not dependent on the same level of detail being provided for all data relevant to the different conservation objectives.

3.47 Prof. Brey acknowledged the issue of data quality, but noted that it may be difficult to provide a common measure of quality for every dataset. In the current approach, expert knowledge was used to evaluate the Marxan results, and emphasis was placed on finding stable solutions to provide confidence in the outputs. In future analyses it may be useful to undertake further sensitivity testing by excluding one data layer at a time, which would also help to identify the data layers to which the result is most sensitive.

3.48 Dr Ichii drew the attention of the Working Group to the importance of including a cost layer in analyses. The Working Group discussed the types of information that this could incorporate.

3.49 The Working Group noted that analyses which do not include a cost layer can be used to identify priority areas, and that a separate process including a cost layer would then identify areas for protection. The cost layer modifies the outcomes and may reduce the spatial coverage for some objectives, but usually only for areas with low or medium targets.

3.50 The Working Group noted that the current analyses are focused on identifying priority areas and developing guidance on conservation objectives.

3.51 The Working Group discussed the possibility of using existing research fishing blocks as part of a cost layer, for example assigning a higher cost to more intensively fished areas, and a lower cost to areas in which there is no current fishing. Some suggestions were made on what could be included in a cost layer, including possibly: areas of toothfish habitat, inversely weighted with an index of sea-ice concentration (e.g. WG-FSA-14/54) and potentially with a minimum size for fishable areas; and potential krill fishing areas.

3.52 The Working Group further noted that although the research or exploratory fishing zones identified in Figure 2.4 of WG-EMM-15/46 have been considered by the Scientific Committee, they have not been formally established as spatial management zones. It would be useful to harmonise the terminology used to describe such areas.

3.53 Mr H. Moronuki (Japan) raised a general concern about the approach to designating objectives for a Weddell Sea MPA. He suggested that although MPAs are an important tool, there already exist other management tools such as fishery management measures or VMEs under the Convention, most of which are working well for the conservation and management of living resources in the Convention Area. He noted that, while the proposed MPA covers most of the area shallower than 550 m, there should be clear conservation objectives to justify such a large area. Mr Moronuki also noted that the MPA checklist proposed by Japan may be useful in this process.

3.54 The Working Group agreed that the three scientific background documents presented in support of a Weddell Sea MPA provide a good indication of priority areas of conservation importance, noting that it has not been presented as a complete MPA proposal at this stage. The Working Group recommended that further analyses be undertaken, taking into account recommendations on issues including missing data layers (e.g. paragraphs 3.39 and 3.40), data quality and uncertainty (paragraphs 3.46 and 3.47), the use of a cost layer (paragraphs 3.48 to 3.51) and the overlap with Domain 1 (paragraphs 3.55 to 3.59). The Working Group looked forward to future discussions on how best to achieve the conservation objectives for this MPA planning domain.

### Approaches to MPA planning in the boundary region between Domains 1 and 3

3.55 The Working Group noted that the area east of the northern tip of the Antarctic Peninsula has been identified to be of high conservation value both in Domain 1 and Domain 3. In both domains the conservation value of this area arises from a number of similar or identical objectives. This indicates that the border between Domains 1 and 3 artificially cuts through an area that may constitute a potentially important area for management.

3.56 The Working Group considered ways to account for this finding, i.e. how to adjust or modify the MPA evaluation process in both domains in order to demonstrate that it is a potentially important area for management. It was suggested that three alternative approaches might be considered:

(i) use expert knowledge to decide on the significance of the common border area in the MPA planning process at each domain

(ii) incorporate a buffer zone for both domains at their intersection (e.g. 2° latitude) to perform separate expanded spatial analyses (Marxan), including the relevant data layers identified in Table 5, to identify whether there are potential areas of overlap considered important for conservation in both domains

(iii) review, share and incorporate relevant data that describe those objects/features which extend across the boundary area (Table 5) into each separate analysis.

3.57 The Working Group recognised that either approach (ii) or (iii) could provide an objective and independent cross-validation of the identification of priority areas. The Working Group identified a preliminary list of data layers describing objects/features that cross the domain boundary and that may be relevant for this validation process, which are presented in Table 5. These data layers will be shared among both planning processes, using the CCAMLR rules of data access.

3.58 The Working Group recommended that those working on the MPA planning processes for Domain 1 and Domain 3 should include independent analyses for this boundary region and report their findings to the next meeting of WG-EMM.

3.59 The Working Group noted that similar issues may arise for other planning domains, particularly if the boundary region includes a high concentration of features likely to be identified as important for achieving conservation objectives. Future MPA planning analyses could consider including a buffer across the boundary area, if required.

### Archiving of background information and data layers used in MPA planning processes

3.60 The Working Group discussed the importance of making background information and data layers relevant to MPA planning available to all Members through the CCAMLR website. It was agreed that there are three broad types of information that might be useful in this regard, noting the distinction between MPA Reports, MPA planning reference documents and working materials. These could be made available in a hierarchical structure where access to some pages would be restricted to Members only:

(i) information on the status of MPAs and general background (public)

(ii) background information and MPA planning documents submitted to CCAMLR meetings (password-protected)

(iii) working information for MPA planning in progress (password-protected, e.g. e-groups).

3.61 In 2014, the Scientific Committee agreed that MPA planning reference documents could be placed on the CCAMLR website under a separate 'Conservation' tab, with an area for Member-only access. This area could also be used by Members to post documents related to, or commenting on, the MPA planning and proposals in a certain planning domain or region (SC-CAMLR-XXXIII, paragraph 5.48).

3.62 Dr Constable presented a potential structure for how information under such a Conservation tab might be organised, with separate pages for each MPA planning area, as well as general documents. He noted that there is currently no central place on the website for information on a range of conservation issues, such as incidental mortality, and that these could also be included under this tab.

3.63 The Working Group agreed that finding this information from the CCAMLR home page needed to be straightforward and intuitive. The need for headings to be easily discoverable by search engines was also emphasised. Some Members thought that a different term might be more appropriate as a heading for this website tab, as 'Conservation' includes all of the business of the Commission.

3.64 The Working Group agreed that it is up to individual Members to decide which document(s) they wish to have displayed as MPA planning reference documents in relation to a specific MPA planning region. This might be a single document expressing the current status of a proposal or analysis, or it may include a more extensive collation of papers that have previously been submitted to CCAMLR meetings and working groups.

3.65 The Working Group recognised the difference between MPA planning reference documents and MPA Reports, which would be provided once an MPA has been established. MPA planning reference documents would not need to be submitted in a standardised format, as there may be a wide variety of different approaches and information for different MPA planning regions. However, MPA Reports should have a standardised format, as previously agreed by the Scientific Committee (SC-CAMLR-XXXI, paragraph 5.33).

3.66 In addition to the MPA planning reference documents, the Working Group recognised the importance of areas on the CCAMLR website where Members can share information and discuss work in progress as part of MPA planning processes. The current system of e-groups is useful for this and could be maintained as part of the hierarchy suggested above.

3.67 While there is a facility for datasets to be shared via e-groups as part of work in progress, there is also a need to archive final versions of the datasets used in MPA planning processes. Some data relevant to MPA planning in Domains 7 and 8 are currently available through the data pages of the CCAMLR website, but it would be useful for links to such information to be accessible from the relevant MPA planning region web page.

3.68 The Working Group made the following general recommendations on issues to be considered for archiving data related to MPA planning:

(i) data layers used in MPA analyses should be made available for review and use by all Members as far as possible

(ii) multiple updates to different data layers during the MPA planning process will make it critical to have accurate and standardised metadata and control over use of the most recent version

(iii) metadata records for all data layers should provide information on where the data reside, how to access them and how to initiate discussions with data owners

(iv) such metadata records could also be included in papers describing analyses in which these data are used

(v) issues of data ownership and access may make it necessary to restrict access to some datasets

(vi) CCAMLR data access rules may need to be revisited to ensure that they provide sufficient protection for unpublished data

(vii) several data portal initiatives (e.g. SOOS, SCAR Biogeographic Atlas, Pangaea) are now assembling datasets. Some Members may choose to make their datasets available elsewhere (see e.g. paragraph 3.30), but it is important that all portals point to the same metadata.

3.69 The Working Group noted that similar types of datasets are being produced and analysed in different forms, and that facilitating shared access to such datasets for different aspects of CCAMLR's work could save significant time and effort. For example, data on penguin colonies relates not only to MPAs but also to management of the krill fishery.

3.70 The Working Group requested that the Scientific Committee consider how it wished to implement its recommendation from last year to help the Secretariat to implement this facility. Some MPA-related web pages are currently under development by the Secretariat, and these can be made available to Members to facilitate discussion.

## Vulnerable marine ecosystems

3.71 No papers were submitted under this agenda item. However, the Working Group noted the discussions under Agenda Item 3.1 on ecologically important sponge associations identified in the Weddell Sea MPA planning domain (paragraph 3.41) and the potential notification of these areas as VMEs under CM 22-06.

3.72 Dr Jones informed the Working Group that US scientists had recently identified two areas containing large sponges and gorgonians close to the Rosenthal Islands off the west coast of Anvers Island. No formal notification of a VME encounter has yet been made, but the appropriate documentation will be put together for next year.

## Advice to the Scientific Committee and its working groups

4.1 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.

4.2 The Working Group advised the Scientific Committee and other working groups on the following topics:

(i) Krill fishing activities –

(a) Finfish by-catch (paragraphs 2.6 and 2.8)
(b) Fishing gear library (paragraph 2.26)
(c) Notifications for 2015/16 (paragraphs 2.22 to 2.24)
(d) Reporting changes in the spatial distribution of catch (CM 23-06) (paragraph 2.9).

(ii) Scientific observations –

(a) Fish species reference guide (paragraph 2.29)

(b) General measure for scientific observation (CM 51-06) (paragraphs 2.34, 2.37, 2.39 and 2.42)

(c) Establishing a SISO working group (paragraph 2.43).

(iii) Krill biology and ecology –

(a) Acoustic protocols (paragraph 2.59)
(b) Disease in krill (paragraph 2.66)
(c) Krill catch impacts on biomass (paragraphs 2.72 and 2.74)
(d) Interim distribution of the trigger level in the fishery (CM 51-07) (paragraph 2.83).

(iv) Role of fish in the ecosystem –

(a) Depredation (paragraph 2.88).

(v) FBM –

(a) General (paragraphs 2.127, 2.175, 2,177 and 2.178)

(b) Implementation of FBM (paragraph 2.158) and specifically stage 2 (paragraphs 2.130, 2.131, 2.132 and 2.159)

(c) Krill surveys and CEMP in stage 2 (paragraphs 2.165 to 2.167)

(d) Fishing vessels contributing to FBM (paragraph 2.141)

(e) Interim distribution of the trigger limit (CM 51-07) (paragraphs 2.135 to 2.138).

(vi) CEMP and WG-EMM-STAPP (paragraphs 2.185 and 2.189).

(vii) Fishing vessel surveys (paragraph 2.231).

(viii) Multination coordination (paragraphs 2.248 and 2.249).

(ix) Spatial management –

(a) MPA planning data (paragraph 3.68).

(x) Future work –

(a) Climate change (paragraph 5.15)
(b) SC-CAMLR communication (paragraph 5.17).

(xi) Other business –

(a) Working group paper submissions (paragraphs 6.20 and 6.21).

## Future work

Streamlining the work of the Scientific Committee
and its working groups

5.1 WG-EMM-15/59 proposed some options for reorganising the work and structure of the Scientific Committee. These options include having three meeting periods timetabled through the year: a two-week period for workshops, a three-week period for the Scientific Committee and its working groups (and maybe workshops) in mid-year, and a short meeting of the Scientific Committee just prior to the annual Commission meeting. The paper also suggested a coordinating group be established in the Scientific Committee, comprising the Chair and Vice-Chairs of the Scientific Committee and the conveners of standing working groups (supported by the Secretariat) to coordinate the business of the meeting and to stimulate and guide intersessional activities. The motivation for these suggestions is that the current workload of the Scientific Committee and its working groups is too high; some topics are discussed every year, despite not necessarily needing to be addressed at that frequency, and there is a need for increased flexibility.

5.2 The Working Group welcomed the idea of a coordinating body to advise the Scientific Committee and noted that this is a model that is used successfully in other organisations. The Working Group also noted potential costs to the host Member country in a given year of hosting both working group and Scientific Committee meetings. There may be some difficulty for small delegations to cover all issues of interest under this model, although the Working Group also discussed some of the advantages of such a model for small delegations. Previous trials of concurrent working group meetings (WG-EMM and WG-SAM) have had mixed results, although there was insufficient opportunity at those times to coordinate the scheduling of the meetings to accommodate the requirements of Members.

5.3 The Working Group agreed that the way that science flows from the Scientific Committee to the Commission is a key strength of CCAMLR, and that any changes to meeting structures that might risk decoupling the interaction between the Scientific Committee and the Commission would need to be carefully considered. It also noted that changing the timing of WG-FSA and Scientific Committee meetings would have implications for the timing of stock assessments and may affect the data available to inform these.

5.4 The Working Group recommended the following options in terms of progressing ideas for streamlining the work of the Scientific Committee and its working groups:

(i) that an e-group be developed for continuing these discussions in advance of this year's Scientific Committee meeting

(ii) that the working group conveners and the Scientific Committee Chair might prepare a paper for this year's meeting of the Scientific Committee consolidating the discussion from the e-group and providing options for the future

(iii) the paper in (ii) could include draft terms of reference for a coordinating body.

Joint workshops

5.5 Drs Grant and P. Penhale (USA) introduced WG-EMM-15/18 on the proposed Joint SC-CAMLR–CEP Workshop (2016) on climate change and monitoring that was agreed at the CEP and SC-CAMLR meetings in 2014. A Steering Committee – chaired by Drs Grant and Penhale – for this joint workshop has been established, together with terms of reference. A tentative suggestion for the timing and location is in Chile, prior to the CEP meeting in early June 2016. There is an intention to facilitate virtual participation at the workshop through appropriate technology.

5.6 The Working Group considered the scope of the terms of reference in the context of the duration of the workshop (two days). It noted that, while the scope of the 2016 workshop is narrower than the previous joint workshop in 2009, two days will be a short period of time in which to fully address the questions outlined in WG-EMM-15/18. One option to help in making the discussion more tractable might be to focus on a particular region, for example the Antarctic Peninsula region.

5.7 Dr Penhale noted that narrowing the spatial focus of discussions at the workshop may not satisfy the interests of both groups fully, but that certain regions could certainly be used as examples. The Steering Committee would take responsibility for keeping the agenda sufficiently well-focused to match the time frame.

5.8 The Working Group recommended changing the wording of the second draft term of reference from 'Review existing monitoring programs…' to 'Consider existing monitoring programs…'. It noted that there are clear links between this term of reference and work in programs such as SOOS, SCAR and ICED, and that it would be useful to enable observers to attend the joint meeting. Invitations should be extended to those groups that are not represented. However, given the length of time of the workshop, the Working Group did not consider that the cost of invited experts may be warranted.

5.9 The Working Group requested that circulars be used between now and the Scientific Committee's 2015 meeting to advise on further preparatory work for the Joint SC-CAMLR–CEP Workshop.

5.10 Dr T. Kitakado (Japan) provided an update regarding a planned joint SC-CAMLR and IWC SC workshop on ecosystem modelling, in particular focusing on knowledge gaps that have been identified since the last workshop in 2008. He indicated that there is a preference to hold two workshops; the first to review data availability, and the second as a comprehensive discussion of approaches in relation to modelling and monitoring. He raised the question of whether to hold the first workshop in 2016 or to delay it to 2017 to avoid clashes with other meetings and to allow additional time for preparation.

5.11 The Working Group agreed that an extra year would be helpful in providing sufficient time to consider data and information that is outside normal CCAMLR and IWC communities (e.g. through SCAR) and that may also be important for modelling. It suggested that the steering group should consider developing draft terms of reference for the workshop, in particular relating to reviewing outcomes from the first joint workshop and assessing progress and directions. The Working Group agreed on the proposed thematic separation of data collection and modelling and suggested that the workshop steering group consider reflecting this in the draft terms of reference. A paper on the draft terms of reference could then be tabled to the coming meetings of SC-CAMLR and IWC SC for both to consider.

### Workshop reports

5.12 WG-EMM-15/61 reported on 2015 activities of SOOS relevant to the work of CCAMLR, in particular the formation of regional and capability working groups, notably working groups on ecosystems, estimated abundance of pack-ice seals from satellites and acoustics. The development of the SOOS Data Management System and Portal will also be important to CCAMLR.

5.13 The Working Group agreed that SOOS provides a useful opportunity to interact with many other organisations, in particular for addressing climate change and FBM questions and as a vehicle for getting data from fishing vessels into the science community. It also acknowledged a need for SC-CAMLR and its working groups to develop better procedures for reviewing and leveraging outside expertise.

5.14 The Secretariat indicated that it is currently looking at the development of a data portal to facilitate sharing of data with the broader scientific community (subject to restrictions, etc.). It also noted that both the CCAMLR and SOOS Secretariats are located in Hobart and are intending to continue dialogue in relation to data systems.

### Climate change

5.15 The Working Group noted that impacts of climate change were highlighted under several items in the agenda. It was agreed that it is vital to bring climate change considerations into its work now to ensure that scientific studies are designed and time series are built on which long-term analyses can be run and serve the scientific basis for implementation in CCAMLR management approaches, including FBM. The issues that need attention include:

(i) building long time series that enable disentangling climate change impact from natural variability

(ii) designing scientific studies that can predict or uncover changes in ecosystem function at an early stage (e.g. the salp–krill interaction, paragraphs 2.77 and 2.78).

Understanding CCAMLR's approach to management

5.16 Dr Constable provided a summary on work to update documentation around CCAMLR's approach to management (SC-CAMLR-XXXIII, paragraph 3.3). One mechanism to do this might be to use facilities through the CCAMLR website to update and compile 'chapters' on various topics.

5.17 The Working Group recommended that the Scientific Committee should consider developing a communication strategy, as a strategic priority, for informing Commissioners, stakeholders and new participants in its work of the approaches it uses and the history of discussions. This could include updating reference material such as *CCAMLR's Approach to Management*.

FBM

5.18 The Working Group agreed that FBM of the krill fishery was a priority for the coming years and recommended the Scientific Committee review its recommendations for future work in paragraphs 2.159 to 2.178.

Three-year work plan

5.19 The Working Group agreed that the Convener consult with Members and other conveners (paragraph 5.2) in preparing a three-year plan for consideration by the Scientific Committee at its coming meeting, noting the priority for developing FBM for krill.

## Other business

The CCAMLR Scientific Scholarship Scheme

6.1 The Convener of WG-EMM invited the current recipient of the CCAMLR scholarship who was attending the meeting this year, Dr A. Panasiuk-Chodnicka (Poland), to give a presentation to the Working Group on the research that she is undertaking in association with the scholarship scheme.

6.2 Dr Panasiuk-Chodnicka provided an overview of the ecological monitoring program in Admiralty Bay, King George Island, South Shetland Islands, conducted by Poland. This multidisciplinary monitoring includes the collection of geophysical, chemical and biological data in marine and terrestrial environments. Dr Panasiuk-Chodnicka also described how in the conduct of such a program there was a strong requirement for individual scientists to work in a range of roles.

6.3 Dr Panasiuk-Chodnicka also presented an analysis of distribution, ecology and population structure of salps (*S. thompsoni*) in the Antarctic Peninsula/Drake Passage region. Her data indicated the preference of salps for water of +1.5°C. She highlighted the contrasting response of krill and salps to a warming oceanic ecosystem and, in particular, the contracting energy pathways presented to species such as penguins in a salp-dominated ecosystem compared to a krill-dominated system.

6.4 Dr Panasiuk-Chodnicka thanked CCAMLR for the support provided by the scholarship and her mentor Dr M. Korczak-Abshire (Poland) for her support and advice throughout the period of her scholarship. Drs Panasiuk-Chodnicka and Korczak-Abshire both noted their thanks to Dr Siegel for his invaluable help and advice in relation to the work on salps and on wider issues concerning the Southern Ocean ecosystem.

6.5 The Working Group congratulated Dr Panasiuk-Chodnicka on the multidisciplinary nature of her work, including the international collaboration on the role of salps. The Working Group agreed that, while its focus was very often on krill, it was essential to consider alternative pathways for energy flow in Antarctic ecosystems.

6.6 The Working Group agreed that the CCAMLR Scientific Scholarship Scheme was working well, achieving its original objectives and is an integral part of CCAMLR. It encouraged all Members to support the scheme by supporting applications as well as through financial support to ensure the long-term success of the scheme.

6.7 The Working Group noted that the other recipient of a current CCAMLR scholarship, Mr A. Sytov (Russia), was invited to attend WG-EMM but was unable to do so for technical reasons.

## CEMP Special Fund

6.8 The Convener of the CEMP Special Fund Management Group (hereinafter referred to as the 'management group'), Dr Ichii, updated the Working Group on the membership of the group and the consideration of CEMP Fund proposals received this year. The management group (Drs Ichii (Chair), Arata (Senior Vice-Chair), Melbourne-Thomas (Junior Vice-Chair), Godø (Adviser)) evaluated the four proposals during WG-EMM-15:

1. tracking the overwinter habitat use of krill-dependent predators from Subarea 48.1 (Dr Watters)

2. penguin habitat preference and extrapolation to data-deficient colonies to model how krill-dependent predators overlap with krill fishing in Area 48 (Dr Trathan)

3. developing an image-processing software tool for analysis of camera network monitoring data (Dr Southwell)

4. a comparison of penguin diet sampling techniques; the CEMP standard method (stomach lavage) versus DNA sampling of prey remains in penguin guano (Dr C. Waluda (UK)).

6.9 The management group found that all proposals had relevance to the overall objectives of the CEMP Special Fund (SC-CAMLR-XXXII/BG/11; SC-CAMLR-XXXI, Annex 8) as well as enhancing capability and methods in CEMP. Three proposals (1, 2 and 3) were clearer on their contributions to immediate priorities in CCAMLR, particularly as they relate to the development of FBM approaches. The fourth proposal would contribute methodology that might enhance the efficiency of CEMP sampling in the future. The management group identified a set of questions for each proposal. Responses to these questions from the proponents will contribute to a final decision by the next meeting of the Scientific Committee.

6.10 The management group also noted that proposals 1 and 2 exceeded the 500 word limit for project objective and background text. Such overriding of word limits should be avoided as it might alter competition. The guidelines for applications will be updated so that it is clear that figure captions are included in word limits. Proposal 2 contained recruitment of additional experts to the Working Group through the post-doctoral position. While this is not relevant to CEMP objectives, recruitment of young capable experts is important for CEMP activities and hence this should be considered as a positive point in the evaluation.

6.11 Dr Watters, who led the first successful proposal to the CEMP Special Fund in 2014 (SC-CAMLR-XXXIII, paragraphs 3.47 to 3.50), provided an update on progress on that project.

6.12 The Working Group agreed that the lead scientist on CEMP Fund funded projects should be requested to report to WG-EMM annually with a brief update (to describe whether the project is going according to plan, etc.) and to report at project completion presenting the scientific results.

6.13 The Working Group thanked the Republic of Korea for the large donation that it had made to the CEMP Special Fund (COMM CIRC 15/38) and encouraged all Members to consider making contributions to the fund.

### The Antarctic Wildlife Research Fund

6.14 Dr Trathan informed the Working Group that the Antarctic Wildlife Research Fund (AWRF) (www.antarcticfund.org) was launched in February 2015 and is a new partnership between industry, academia and non-government organisations. The fund aims to facilitate and promote research on the Antarctic marine ecosystem, including determining potential impacts from the Antarctic krill fishery. The first call for proposals closed on 16 June 2015 and resulted in 10 proposals, including from a number of scientists with existing links to CCAMLR. Results about which proposals will be funded will be announced by the AWRF in due course, as will a second call for proposals.

*CCAMLR Science*

6.15 The Science Manager, as Editor of *CCAMLR Science*, described the discussion in WG-SAM related to the reduction in the number of papers submitted to, and published in, *CCAMLR Science* in recent years (Annex 5, paragraphs 5.3 to 5.5) and sought the views of the Working Group on whether there was a future for the journal.

6.16 In considering the role of *CCAMLR Science*, the Working Group noted that:

(i) it would be important to consider the reasons why *CCAMLR Science* was originally established and review how best to meet those original objectives

(ii) there needs to be an avenue to publish and publicise science done in support of CCAMLR and to provide recognition for those scientists that make large contribution to that science that contributes to the success of CCAMLR

(iii) there is a role for *CCAMLR Science* in publishing papers, which would be difficult to publish in other peer-reviewed journals, providing a status of more than simply submitting a working group paper

(iv) there could be an important role for CCAMLR promoting the science collaborations between CCAMLR and other organisations, such as SOOS.

6.17 The Science Manager thanked the Working Group for its comments and advice and undertook to prepare a paper to the Scientific Committee on the future options for *CCAMLR Science*.

WG-EMM Convener

6.18 Dr Kawaguchi informed the Working Group that he intended for next year to be his last as Convener and encouraged potential conveners to consider co-convening the Working Group with him next year as this process worked well in the transition to a new convener in 2012.

6.19 The Chair of the Scientific Committee encouraged interested scientists to consider co-convening the Working Group next year.

Author affiliation of working group papers

6.20 The Working Group noted that multi-author papers submitted to the Working Group included the author affiliation (Member) and requested that the Scientific Committee review the need to display the affiliation after the names of authors on the cover page of working group papers.

6.21 The Working Group also noted that it would be useful to have an indication on the cover page of working group papers of the Scientific Committee Representative who was responsible for submitting the paper.

GEF proposal

6.22 The Working Group welcomed the update on the proposal for Global Environment Facility (GEF) funding to support capacity building in the GEF-eligible CCAMLR Members (WG-EMM-15/15 Rev. 1), noting that the Secretariat had agreed to be the lead body in developing this proposal. Scientists from GEF-eligible Members attending the Working Group undertook to engage in discussions with their respective GEF Focal Point and to work with the Secretariat to further develop this proposal.

CCAMLR website

6.23 The Working Group requested that the Secretariat should improve the search facility on the CCAMLR website, as it is not considered to be effective in its current form.

## Adoption of the report and close of the meeting

7.1 On Saturday 11 July 2015 the Working Group visited the Institute of Biochemistry and Biophysics Polish Academy of Sciences and the Department of Antarctic Biology. WG-EMM was welcomed to the Institute by Profs. P. Zielenkiewicz (Director) and P. Jonczyk (Deputy Director, Scientific Affairs). Aspects of the Institute's research were discussed during several short presentations. WG-EMM also visited the Department of Antarctic Biology where Dr K. Chwedorzewska (Head of Department) welcomed the group and hosted a reception. Dr Kawaguchi thanked the institute for hosting the visit and reception, and Dr Korczak-Abshire for coordinating the visit.

7.2 During the second week of the meeting, Vice-Minister K. Plocke and Dr T. Nawrocki (Director, Fisheries Department) of the Ministry of Agriculture and Rural Development also visited the meeting and extended their welcome to WG-EMM. Dr Kawaguchi thanked the ministry for hosting the meeting.

7.3 In closing the meeting, Dr Kawaguchi thanked all participants and the Secretariat for their contributions to the meeting and the work of WG-EMM. He also thanked the subgroup coordinators and rapporteurs, and especially Drs Constable, Trathan and Watters for bringing forward the discussions on FBM. Dr Kawaguchi also thanked Dr Kaniewska-Krolak, Mr L. Dybiec (former Chair of the Commission) and colleagues at the Ministry of Agriculture and Rural Development for the excellent facilities, support and kind hospitality during the meeting.

7.4 Dr Kaniewska-Krolak congratulated the Working Group on a successful meeting and looked forward to welcoming participants back to Warsaw at some time in the future.

7.5 Dr Darby, on behalf of the Working Group, congratulated Dr Kawaguchi for his leadership and guidance during this eventful meeting. The discussions during the past two weeks had marked a turning point for FBM and the work of WG-EMM.

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Table 1: Summary of krill fishery notifications for 2015/16 considered by WG-EMM (see paragraph 2.18).

(a) Expected level of catch of krill, type of product and method for the direct estimation of green weight caught.

| Vessel | Flag | Expected level of catch of krill (tonnes) | | | | | Type of product | Method for green weight estimation (refer to CM 21-03, Annex B) |
|---|---|---|---|---|---|---|---|---|
| | | Overall | Subarea 48.1 | Subarea 48.2 | Subarea 48.3 | Subarea 48.4 | | |
| *Betanzos* | Chile | 25 000 | 17 500 | 2 500 | 5 000 | - | Meal | Flowmeter |
| *Cabo de Hornos* | Chile | 12 000 | 10 000 | 2 000 | - | - | Whole + meal | Flowmeter + Flowscale |
| *Long Teng* | China | 30 000 | 15 000 | 5 000 | 10 000 | - | Whole + meal | Codend volume |
| *Long Fa* | China | 10 000 | 5 000 | - | 5 000 | - | Whole + meal | Codend volume |
| *Long Da* | China | 30 000 | 15 000 | 5 000 | 10 000 | - | Whole + meal | Codend volume |
| *Fu Rong Hai* | China | 50 000 | 28 000 | 12 000 | 10 000 | - | Whole + meal + boiled | Holding tank volume |
| *Kai Li* | China | 18 000 | 10 000 | 3 000 | 5 000 | - | Whole + meal | Plate tray + meal conversion |
| *Kai Yu* | China | 5 000 | 5 000 | - | - | - | Whole + meal | Plate tray + meal conversion |
| *Ming Kai* | China | 26 000 | 12 000 | 6 000 | 8 000 | - | Whole + meal | Plate tray + meal conversion |
| *Viktoriya* | China | 26 000 | 12 000 | 6 000 | 8 000 | - | Whole + meal | Holding tank volume |
| *Sejong* | Korea, Republic of | 60 000 | 20 000 | 20 000 | 20 000 | - | Whole + meal + boiled + peeled | Holding tank volume |
| *Kwang Ja Ho* | Korea, Republic of | 15 000 | 15 000 | - | - | - | Whole + meal + boiled + paste | Holding tank volume |
| *Insung Ho* | Korea, Republic of | 12 000 | 12 000 | - | - | - | Whole | Holding tank volume |
| *Juvel* | Norway | 35 000 | 18 000 | 17 000 | - | - | Oil + hydrosylate + liquid complex | Flowscale |
| *Saga Sea* | Norway | 75 000 | 20 000 | 20 000 | 20 000 | 15 000 | Meal + oil | Flowscale |
| *Antarctic Sea* | Norway | 75 000 | 20 000 | 20 000 | 20 000 | 15 000 | Meal | Flowscale |
| *Saga* | Poland | 25 000 | 12 500 | 12 500 | - | - | Whole + meal | Holding tank volume + meal conversion |
| *More Sodruzhestva* | Ukraine | 45 000 | 25 000 | 10 000 | 10 000 | - | Whole + meal + meat | Codend volume |
| Total notified level of catch | | 574 000 | 272 000 | 141 000 | 131 000 | 30 000 | | |
| Total number of vessels | | 18 | 18 | 14 | 12 | 2 | | |

(b) Net information, mammal exclusion device and acoustic equipment. A – panel across mouth; B – panel in net and escape window.

| Vessel | Flag | Type of fishing | Mouth opening (m) | | Codend mesh size (mm) inner panel | Exclusion device | | Echosounder | | Sonar | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Vertical | Horizontal | | Type | Panel mesh size (mm) | Make | Frequencies (kHz) | Make | Frequencies (kHz) |
| *Betanzos* | Chile | Conventional | 15 | 26 | 16 | A | 125 | Simrad EK70 | 38 | Furuno FCV | 21–27 |
| *Cabo de Hornos* | Chile | Conventional | 15 | 26 | 16 | A | 125 | Simrad EK70 | 38 | Furuno FCV | 21–27 |
| *Long Teng* | China | Conventional | 30 | 40 | 15 | B | 200 | Simrad EK60, Furuno FCV | 38, 70, 120, 15, 200 | Furuno FSV | 50, 60 |
| *Long Fa* | China | Conventional | 30 | 40 | 15 | B | 200 | Furuno FCV | 15, 200 | Furuno FSV | 50, 60 |
| *Long Da* | China | Conventional | 25 | 30 | 15 | B | 200 | Furuno FCV | 50, 60 | Simrad SX | 26 |
| *Fu Rong Hai* | China | Conventional | 30 | 30 | 15 | B | 300 | Simrad EK60 | 38, 70, 120 | JRC JFS | 28, 32, 45 |
| *Kai Li* | China | Conventional | 30 | 29 | 20 | B | 250 | Simrad EK60, Furuno FCV | 38, 68, 70, 120, 200 | Furuno FSV | 50, 60 |
| *Kai Yu* | China | Conventional | 30 | 29 | 20 | B | 250 | Simrad ES60 | 38, 120 | Furuno FSV | 50, 60 |
| *Ming Kai* | China | Conventional | 26 | 28 | 15 | B | 250 | Simrad ES60 | 38 | Simrad SX | 26 |
| *Viktoriya* | China | Conventional | 26 | 28 | 15 | B | 250 | Furuno FCV | 38, 50, 200 | Furuno FSV | 24 |
| *Sejong* | Korea, Republic of | Conventional | 25 | 30 | 15 | A | 240 | Simrad ES70 | 38, 200 | Simrad SX | 26 |
| *Kwang Ja Ho* | Korea, Republic of | Conventional | 50 | 72 | 15 | A | 300 | Simrad ES70 | 38, 120 | Furuno FSV | 38, 120 |
| *Insung Ho* | Korea, Republic of | Conventional | 25 | 60 | 15 | A | 300 | Simrad | tba | Furuno FSV | 24 |
| *Juvel* | Norway | Conventional | 20 | 23 | 11 | A | 200 | Simrad ES60 | 38, 70, 120 | Simrad SH | 26, 116 |
| *Saga Sea* | Norway | Continuous | 20 | 20 | 16 | A | 200 | Simrad ES60 | 38, 120 | Simrad SH | 114 |
| *Antarctic Sea* | Norway | Continuous | 20 | 20 | 11 | A | 200 | Simrad ES70, Furuno FCV | 50, 70, 120, 200 | Furuno FEV | 30, 80 |
| *Saga* | Poland | Conventional | 45 | 45 | 11 | B | 200 | Furuno FCV | 38, 50, 200 | Furuno FCV | 80 |
| *More Sodruzhestva* | Ukraine | Conventional | 25 | 40 | 20 | A | 200 | Simrad ES70 | 200 | Wesmar HD | 110 |

Table 2: Topics that need to be addressed to advance feedback management in Subarea 48.1 so that an approach can be implemented. Additional information is available in WG-EMM-15/04 and 15/33 and from the authors of these papers.

| Element of feedback approach | Topic to be addressed |
|---|---|
| Estimation of base catch limit | The integrated model and its diagnostics to be reviewed by WG-SAM.<br>Revise decision rules for krill.<br>Identify data required from the krill fishery (e.g. standardised acoustic transects and net hauls).<br>Integration of additional data available for assessment (e.g. krill length-frequency data from CEMP). |
| Decision rule to adjust catches up from the base | Design acoustic surveys to be undertaken by fishing vessels.<br>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).<br>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).<br>Evaluation of decision rule. |
| Decision rules to adjust catches down from the base | Identify appropriate groups of SSMUs from penguin tracking data.<br>Determine default 'allocation factors' for groups of SSMUs.<br>Parameterise species-specific decision rules for adjusting catch on the basis of fledging mass and age at crèche.<br>Evaluation of decision rule. |

Table 3: Topics that need to be addressed to advance feedback management in Subarea 48.2 so that an approach can be implemented.

| Phase | Topic to be addressed |
|---|---|
| Phase 1 | Interactions with the fishing industry.<br>Design of acoustic surveys to be undertaken by fishing vessels.<br>Development of the oceanographic model (WG-EMM-14/08) to confirm the location of the contrasting fished areas.<br>Analysis of available data with CEMP-like objectives.<br>Analysis of historical cetacean surveys in IWC Area II to provide context for at-sea observations of cetaceans.<br>Appropriate time period for developing baseline monitoring information (five years). |
| Phase 2 | Evaluation of fishery acoustics to provide krill stock information.<br>Evaluation of the utility of remote camera sites.<br>Evaluation of the need for two areas with contrasting fishing levels.<br>Evaluation of monitoring to identify an effect of fishing given the concentration of the fishery.<br>Evaluation of the use of a constant harvest level, rather than a constant harvest rate to elucidate functional responses between krill and predator performance. |

Table 4: Topics that need to be addressed to advance feedback management at SSMU scales using the ecosystem assessment approach to subdivide area-scale catch into SSMUs and/or to have short-term adjustments within SSMUs, so that these can be implemented.

| Element of feedback approach | Topic to be addressed |
|---|---|
| Approach to subdivide area-scale catch limit into SSMUs (WG-EMM-15/36) | Assemble data suitable for an empirical ecosystem assessment (e.g. WG-EMM-15/36, Table 1a,), including krill biomass and CEMP time series from SSMUs.<br>Consider parameters for predator reproductive performance and how predators relate to krill density.<br>Consider parameters for empirical krill model.<br>Assemble time series of krill density and recruitment strength, predator reproductive performance, catch and its length composition.<br>Estimate availability of krill to predators and fishery.<br>Submit model for review of its structure and diagnostics.<br>Evaluate the properties of the decision rule. |
| Approach for short-term adjustment at SSMU scales (WG-EMM-15/55 Rev. 1) | Establish critical values of krill density for SSMUs, considering predator requirements.<br>Projection model, including how to incorporate estimates of krill density and recruitment, to be reviewed.<br>Estimates of krill density and recruitment.<br>Consider utilisation of CEMP and structured fishing to test the practical application of the decision rule.<br>Evaluate properties of the decision rule in relation to meeting long-term requirements of predators. |

Table 5: Preliminary list of data layers describing objects/features that cross the border between Domain 1 and Domain 3.

| Data layers | References |
|---|---|
| Adélie penguins breeding distribution | Antarctic Site Inventory<br>BAS Inventory<br>IAA-Programa de Monitoreo<br>H. Lynch (unpublished data) |
| Adélie penguins non-breeding distribution | US AMLR Program<br>BAS Inventory<br>IAA-Programa de Monitoreo |
| Killer whales Type B1 and B2 distribution | Robert Pitman, Southwest Fisheries Science Center, NOAA Fisheries |
| Emperor penguin Snow Hill colony | Libertelli and Coria, 2014<br>Ratcliffe and Trathan, 2011<br>Fretwell et al., 2012 |
| Coastal polynyas (pelagic regionalisation) | Kern, 2012<br>Kaleschke et al., 2001<br>Spreen et al., 2008<br>Arndt et al., 2013<br>Timmermann et al., 2009 |
| Krill distribution (adult) | US AMLR Program<br>Atkinson et al., 2004, 2008, 2009<br>Siegel, 1982, 2012<br>Siegel et al., 2013 |
| Krill nursery Weddell Sea gyre | US, Argentinean and German research cruises |
| Satellite-derived surface summer chlorophyll-a (high productivity) | Feldman et al., 2010<br>Moore and Abbott, 2000 |
| Ice-edge position in summer (proxy for ice seals) | US National Snow and Ice Data Center |
| Fish nursery | Marschoff et al., 2012<br>Kock et al., 2012<br>Kock and Jones, 2005<br>Barrera-Oro et al., 2000<br>and others |

Appendix A

## List of Participants

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(Warsaw, Poland, 6 to 17 July 2015)

| | |
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Appendix B

# Agenda

Working Group on Ecosystem Monitoring and Management
(Warsaw, Poland, 6 to 17 July 2015)

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 Issues for the present

        2.1.1 Fishing activities
        2.1.2 Scientific observation
        2.1.3 Krill biology and ecology and management
        2.1.4 Role of fish in the ecosystem

    2.2 Issues for the future

        2.2.1 Feedback management strategy
        2.2.2 CEMP and WG-EMM-STAPP
        2.2.3 Integrated assessment model
        2.2.4 Fishing vessel surveys
        2.2.5 Multinational coordination

3. Spatial management

    3.1 Marine protected areas (MPAs)
    3.2 Vulnerable marine ecosystems (VMEs)

4. Advice to the Scientific Committee and its working groups

5. Future work

6. Other business

7. Adoption of the report and close of the meeting.

Appendix C

## List of Documents

Working Group on Ecosystem Monitoring and Management
(Warsaw, Poland, 6 to 17 July 2015)

| | |
|---|---|
| WG-EMM-15/01 | Net diagrams for Norwegian vessels notified for krill fishery in 2015/16 – Notification ID 86750, 86751, 86780 and 86781<br>Delegation of Norway |
| WG-EMM-15/02 | Net diagrams for Chinese vessels notified for krill fishery in 2015/16 Notification ID 86733, 86772 and 86773<br>Delegation of the People's Republic of China |
| WG-EMM-15/03 | Net diagrams for Chilean vessels notified for krill fishery in 2015/16 Notification ID 86795, 86796 and 86797<br>Delegation of Chile |
| WG-EMM-15/04 | Within season feedback management system – a pro forma for discussion at WG-EMM 2015<br>C.S. Reiss, G.M. Watters, J. Hinke and D. Kinzey (USA) |
| WG-EMM-15/05 | Winter habitat selection by Antarctic krill will increase krill–predator–fishery interactions during ice free years<br>C.S. Reiss, A. Cossio, C.D. Jones, A. Murray, G. Mitchell, J. Santora, K. Dietrich, E. Weiss, C. Gimpel, J. Walsh and G.M. Watters (USA) |
| WG-EMM-15/06 | Species identification illustrated guide of the Southern Ocean – CCAMLR Convention Area 48, 58, and 88<br>Delegation of the Republic of Korea |
| WG-EMM-15/07 Rev. 1 | CEMP Indices: 2015 update on data submissions and analyses<br>CCAMLR Secretariat |
| WG-EMM-15/08 | Net diagrams and MED of CM 21-03 for Korean krill fishing vessels<br>Delegation of the Republic of Korea |
| WG-EMM-15/09 | Scotia Sea Pygoscelid Penguin Tracking and Habitat Analysis Workshop<br>P.N. Trathan (United Kingdom), J.T. Hinke (USA) and B. Lascelles (BirdLife International) |

| | |
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| WG-EMM-15/10 | Possible options for the future management of the Antarctic krill fishery in Subarea 48.2<br>P.N. Trathan (United Kingdom), O.R. Godø (Norway) and S.L. Hill (United Kingdom) |
| WG-EMM-15/11 | A critical issue for feedback management – how do we determine the level of functional overlap between krill fishing operations and penguin foraging activity?<br>P.N. Trathan, J.R.D. Silk, S.L. Hill (United Kingdom) and H.J. Lynch (USA) |
| WG-EMM-15/12 | Introduction of the recent Korean research activity and future plan on penguin breeding and behavior<br>Delegation of the Republic of Korea |
| WG-EMM-15/13 | Acoustic and catch data collected by the fleet – relevance for feedback management<br>O.R. Godø, T. Klevjer and G. Skaret (Norway) |
| WG-EMM-15/14 | Antarctic krill; assessment of mesh size selectivity and escape mortality from trawls<br>B.A. Krafft (Norway), L.A. Krag (Denmark), B. Herrmann, A. Engås, I. Bruheim and S. Nordrum (Norway) |
| WG-EMM-15/15 Rev. 1 | Progress report 1: Proposal for GEF (Global Environment Facility) funding to support capacity building in the GEF-eligible CCAMLR Members<br>CCAMLR Secretariat |
| WG-EMM-15/16 | Variability in krill length distribution in 48.1 derived from data collected by scientific observers<br>P. Ziegler, S. Kawaguchi D. Welsford and A. Constable (Australia) |
| WG-EMM-15/17 Rev. 1 | A biomass estimate of Antarctic krill (*Euphausia superba*) at the Balleny Islands<br>M.J. Cox (Australia), Y. Ladroit, P. Escobar-Flores and R.L. O'Driscoll (New Zealand) |
| WG-EMM-15/18 | Joint CEP/SC-CAMLR workshop (2016) on climate change and monitoring<br>S. Grant (UK) and P. Penhale (USA) |
| WG-EMM-15/19 | Estimation of the green weight of krill caught<br>CCAMLR Secretariat |
| WG-EMM-15/20 | Vacant |

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| WG-EMM-15/21 | Notes of hydrobiologist "*Akademik Fedorov*" (the 60th RAE Expedition) East Antarctica (December 2014 – February 2015)<br>A.M. Sytov (Russia) |
| WG-EMM-15/22 | Preliminary report on krill survey off the coast of East Antarctica (Enderby Land to Prydz Bay) February–March 2015<br>S. Kawaguchi, A. Constable, L. Emmerson, C. Southwell, R. King, K. Westwood and K. Swadling (Australia) |
| WG-EMM-15/23 | Chiller killers – first steps towards identifying krill pathogens<br>K. Bateman, R. Hicks, G. Tarling, M. Söffker and G. Stentiford (United Kingdom) |
| WG-EMM-15/24 | Why does it necessary to consider krill flux for developing the feedback management strategy for krill fishery in the Area 48?<br>S. Kasatkina and V. Shnar (Russia) |
| WG-EMM-15/25 | Using vessel acoustics to detect diving patterns of krill foraging predators automatically: Development of a novel method for quantifying impact of krill fishing on seals and penguins<br>T.A. Klevjer, O.R. Godø and B. Krafft (Norway) |
| WG-EMM-15/26 | Special features of the current krill fishery dynamics in the Southern Atlantic (Subareas 48.1, 48.2 and 48.3) during 2008–2014<br>S. Kasatkina and P. Gasyukov (Russia) |
| WG-EMM-15/27 | Key considerations for planning a large-scale krill survey<br>S. Hill, J. Watkins (United Kingdom), O.R. Godø (Norway), S. Kawaguchi (Australia), D. Kinzey, C. Reiss (USA), V. Siegel (Germany), P. Trathan (United Kingdom) and G. Watters (USA) |
| WG-EMM-15/28 | Updating the Antarctic krill biomass estimates for CCAMLR Subareas 48.1 to 48.4 using available data<br>S. Hill, A. Atkinson, C. Darby, S. Fielding (United Kingsom), B. Krafft, O.R. Godø, G. Skaret (Norway), P. Trathan, J. Watkins (United Kingdom) |
| WG-EMM-15/29 | Net diagrams for Russian vessel notified for krill fishery in 2015/16<br>Delegation of the Russian Federation |
| WG-EMM-15/30 | Krill Fishery Report<br>CCAMLR Secretariat |
| WG-EMM-15/31 | Citizen science for large-scale data extraction from a citizen science network<br>T. Hart, C. Black (United Kingdom), L. Emmerson (Australia), J. Hinke (USA) and C. Southwell (Australia) |

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| WG-EMM-15/32 | Important Bird Areas (IBAs) in Antarctica<br>P.A. Penhale (USA) |
| WG-EMM-15/33 | Feedback management pro forma based on WG-EMM-12/44<br>G. Watters and J. Hinke (USA) |
| WG-EMM-15/34 | Report of a domestic workshop to identify U.S. stakeholders' objectives and protection priorities for one or more marine protected areas in Planning Domain 1<br>G. Watters (USA) |
| WG-EMM-15/35 | Development of the fishing gear library<br>CCAMLR Secretariat |
| WG-EMM-15/36 | An ecosystem-based management procedure for krill fisheries: a method for determining spatially-structured catch limits to manage risk of significant localised fisheries impacts on predators<br>A. Constable and S. Candy (Australia) |
| WG-EMM-15/37 | Seasonal variation in the diet of *Arctocephalus gazella* at 25 de Mayo/King George Island, South Shetland Islands, Antarctica<br>A. Harrington, G.A. Daneri, A.R. Carlini, D.S. Reygert and A. Corbalán (Argentina) |
| WG-EMM-15/38 Rev. 1 | Scientific background document in support of the development of a CCAMLR MPA in the Weddell Sea (Antarctica) – Version 2015 – Part A: General context of the establishment of MPAs and background information on the Weddell Sea MPA planning area-<br>K. Teschke (Germany) on behalf of the Weddell Sea MPA (WSMPA) project team |
| WG-EMM-15/39 | Scientific background document in support of the development of a CCAMLR MPA in the Weddell Sea (Antarctica) – Version 2015 – Part B: Description of available spatial data<br>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-15/40 | On amendments to Conservation Measure 51-07 (2014) dealing with interim distribution of the trigger level in the fishery for *Euphausia superba* in Statistical Subareas 48.1, 48.2, 48.3 and 48.4<br>Delegation of Ukraine |

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| WG-EMM-15/41 | Changes of population structure in common benthic species of the proposed Stella Creek MPA in the vicinity of the Akademik Vernadsky Station, Galindez Island, Antarctica<br>Delegation of Ukraine |
| WG-EMM-15/42 | Report of the Second International Workshop for identifying Marine Protected Areas (MPAs) in Domain 1 of CCAMLR (Palacio San Martín, Buenos Aires, Argentina, 25 to 29 May 2015)<br>Second WS-MPA Domain 1 |
| WG-EMM-15/43 | Information on Japan's plan for krill surveys in East Antarctic<br>Delegation of Japan |
| WG-EMM-15/44 | The importance of standardising and validating new methods for CEMP to maintain the robustness of long-term time series<br>C. Southwell and L. Emmerson (Australia) |
| WG-EMM-15/45 | Direct ageing of Antarctic krill (*Euphausia superba*) – potential utility of eyestalk sections for age determination<br>C. Reiss (USA), R. Kilada (Canada) and S. Kawaguchi (Australia) |
| WG-EMM-15/46 | Scientific background document in support of the development of a CCAMLR MPA in the Weddell Sea (Antarctica) – Version 2015 – Part C: Data analysis and MPA scenario development<br>K. Teschke, H. Pehlke, M. Deininger, L. Douglass and T. Brey on behalf of the German Weddell Sea MPA project team |
| WG-EMM-15/47 | Admiralty Bay (South Shetland Islands) – long-term marine monitoring program<br>A. Panasiuk-Chodnicka, M. Korczak-Abshire, M.I. Żmijewska, K. Chwedorzewska, E. Szymczak, D. Burska, D. Pryputniewicz-Flis and K. Łukawska-Matuszewska (Poland) |
| WG-EMM-15/48 | Unmanned Aerial Vehicles based monitoring of indicator species populations on King George Island (Subarea 48.1)<br>M. Korczak-Abshire, A. Zmarz, R. Storvold, M. Rodzewicz, K. Chwedorzewska, A. Kidawa and A. Znój (Poland) |
| WG-EMM-15/49 | Net diagrams for Ukrainian vessel notified for krill fishery in 2015/16 – Notification ID 86703, 86755 and 86757<br>Delegation of Ukraine |
| WG-EMM-15/50 | UAV for monitoring environmental changes on King George Island (South Shetland Islands) Antarctica: preliminary study on wildlife disturbance<br>A. Kidawa, M. Korczak-Abshire, A. Zmarz, R. Storvold, M. Rodzewicz, K. Chwedorzewska, S.-R. Karlsen and A. Znój (Poland) |

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| WG-EMM-15/51 Rev. 1 | Estimating future krill catches that meet the CCAMLR and alternative decision rules for FAO Subarea 48.1 using an integrated assessment model<br>D. Kinzey, G.M. Watters and C.S. Reiss (USA) |
| WG-EMM-15/52 | Activity, seasonal site fidelity, and movements of Type-C killer whales between the Ross Sea, Antarctica and New Zealand<br>R. Eisert (New Zealand), G. Lauriano, S. Panigada (Italy), E.N. Ovsyanikova, I.N. Visser, P.H. Ensor, R.J.C. Currey, B.R. Sharp and M.H. Pinkerton (New Zealand) |
| WG-EMM-15/53 | Predation release of Antarctic silverfish (*Pleuragramma antarctica*) in the Ross Sea<br>M.H. Pinkerton, P. Lyver, D. Stevens, J. Forman, R. Eisert and S. Mormede (New Zealand) |
| WG-EMM-15/54 | Evaluation of Antarctic krill biomass and distribution off the South Orkney Islands 2011–2015<br>G. Skaret, B.A. Krafft, L. Calise (Norway), J. Watkins (UK), R. Pedersen and O.R. Godø (Norway) |
| WG-EMM-15/55 Rev. 1 | A candidate process for managing the krill fishery at a local scale for krill predators, particularly in the early phases of the development of the krill fishery<br>A. Constable, S. Kawaguchi, C. Southwell, L. Emmerson, W. de la Mare, P. Ziegler, D. Welsford and J. Melbourne-Thomas (Australia) |
| WG-EMM-15/56 | New Zealand-Australia Antarctic Ecosystems Voyage<br>R.L. O'Driscoll (New Zealand) |
| WG-EMM-15/57 Rev. 1 | Analysis of the scientific observer program on the krill fishery<br>J.A. Arata and F. Santa-Cruz (Chile) |
| WG-EMM-15/58 | Comparative analysis of flow meter and codend volume method for estimating green weight in '*Betanzos*'<br>Delegation of Chile |
| WG-EMM-15/59 | Streamlining the work of the Scientific Committee for the Conservation of Antarctic Marine Living Resources (SC-CAMLR)<br>G. Watters (USA), A. Constable and D. Welsford (Australia) |
| WG-EMM-15/60 | Notification of intent to participate in a fishery for *Euphausia superba*<br>Delegation of Poland |

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| WG-EMM-15/61 | Report on 2015 Activities of the Southern Ocean Observing System relevant to the work of CCAMLR<br>A. Constable (Australia), O.R. Godø (Norway) and L. Newman (SOOS) |

Other Documents

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| WG-EMM-15/P01 | Marine ecosystem acoustics (MEA): quantifying processes in the sea at the spatio-temporal scales on which they occur<br>O.R. Godø, N.O. Handegard, H.I. Browman, G.J. Macaulay, S. Kaartvedt, J. Giske, E. Ona, G. Huse and E. Johnsen<br>*ICES J. Mar. Sci*., 71 (8) (2014): 2357–2369 |
| WG-EMM-15/P02 | Re-constructing historical Adélie penguin abundance estimates by retrospectively accounting for detection bias<br>C. Southwell, L. Emmerson, K. Newbery, J. McKinlay, K. Kerry, E. Woehler and P. Ensor<br>*PLoS ONE*, 10 (4) (2015): e0123540,<br>doi: 10.1371/journal.pone.0123540 |
| WG-EMM-15/P03 | Remotely operating camera network expands Antarctic seabirds observations of key breeding parameters for ecosystem monitoring and management<br>C. Southwell and L. Emmerson<br>*J. Nat. Conserv*., 23 (2015): 1–<br>8, http://dx.doi.org/10.1016/j.jnc.2014.11.002 |
| WG-EMM-15/P04 | Spatially extensive standardized surveys reveal widespread, multi-decadal increase in East Antarctic Adélie penguin populations<br>C. Southwell, L. Emmerson, J. McKinlay, K. Newbery (Australia), A. Takahashi, A. Kato (Japan), C. Barbraud, K. Delord and H. Weimerskirch (France)<br>*PLoS ONE* (in review) |
| WG-EMM-15/P05 | The reliability of VHF telemetry data for measuring attendance patterns of marine predators: a comparison with Time Depth Recorder data<br>A.D. Lowther, H. Ahonen, G. Hofmeyr, W.C. Oosthuizen, P.J. Nico De Bruyn, C. Lydersen and K. Kovacs<br>*Mar. Ecol. Progr. Ser*. (in review) |
| WG-EMM-15/P06 | A small unmanned aerial system for estimating abundance and size of Antarctic predators<br>M.E. Goebel, W.L. Perryman, J.T. Hinke, D.J. Krause, N.A. Hann, S. Gardner and D.J. LeRoi<br>*Polar Biol*., (2015), doi: 10.1007/s00300-014-1625-4 |

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| WG-EMM-15/P07 | Selectivity and two biomass measures in an age-based assessment of Antarctic krill (*Euphausia superba*)<br>D. Kinzey, G.M. Watters and C.S. Reiss<br>*Fish. Res.*, 168 (2015): 72–84. |
| WG-EMM-15/P08 | Antarctic's pelagic ecosystem: how environmental change will affect Salpidae population structure<br>A.W. Słomska, A.A. Panasiuk-Chodnicka, M.I. Żmijewska and M.K. Mańko (Poland)<br>*Polish Polar Research* (in review) |

**Report of the Working Group**
**on Fish Stock Assessment**
(Hobart, Australia, 5 to 16 October 2015)

## Contents

**Report of the Working Group**
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## Opening of the meeting

1.1 The meeting of WG-FSA was held in Hobart, Australia, from 5 to 16 October 2015. The Convener, Dr M. Belchier (UK), opened the meeting and welcomed participants (Appendix A). Mr A. Wright (Executive Secretary) extended the Secretariat's warm welcome to all participants.

1.2 The Working Group was saddened by the passing of Dr Konstantin Shust (Russia) in August 2015. Dr Shust had a long and productive association with CCAMLR, starting with his participation in the 1988 meeting of WG-FSA where two papers he co-authored were discussed. He went on to author a total of 34 meeting papers and participated in WG-FSA until 2010. The Working Group expressed its condolences to Dr Shust's family and colleagues.

## Organisation of the meeting and adoption of the agenda

2.1 The work plan for WG-FSA at this meeting was focused on providing:

- updated stock assessment advice for all established fisheries for mackerel icefish (*Champsocephalus gunnari*) and Patagonian (*Dissostichus eleginoides*) and Antarctic toothfish (*D. mawsoni*) in the Convention Area

- robust scientific advice relating to exploratory fisheries for *Dissostichus* spp. notified under Conservation Measure (CM) 21-02, including data-poor fisheries, and scientific research fishing notified under CM 24-01 for 2015/16 and taking account of the advice provided by WG-SAM-15 (Annex 5).

2.2 The Working Group also reviewed and developed advice on bottom fishing activities and vulnerable marine ecosystems (VMEs), CCAMLR's Scheme of International Scientific Observation (SISO), incidental mortality and catches of non-target species in CCAMLR fisheries, including marine mammals and seabirds, depredation and biology and ecology of target and by-catch fish species.

2.3 The Working Group reviewed and adopted the agenda without change (Appendix B).

2.4 Components of WG-FSA's work were developed during the meeting by two subgroups:

- Subgroup on Assessments (coordinator: Dr C. Darby, UK)
- Subgroup on Research Plans for Data-poor Fisheries and Areas (coordinator: Dr C. Jones, USA).

2.5 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.

2.6 In this report, paragraphs dealing with advice to the Scientific Committee and other working groups have been highlighted. These paragraphs are listed under Item 12. 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).

2.7 The report was prepared by A. Constable (Australia), R. Currey (New Zealand), C. Darby and T. Earl (UK), I. Forster (Secretariat), N. Gasco (France), E. Grilly (Secretariat), C. Jones and D. Kinzey (USA), K.-H. Kock (Germany), K. Large, S. Mormede and S. Parker (New Zealand), D. Ramm, K. Reid and L. Robinson (Secretariat), R. Sinegre (France), M. Söffker (UK), D. Welsford and P. Ziegler (Australia).

## Review of available information

Data from the current fishing season

3.1 The Working Group reviewed data submitted to the Secretariat from CCAMLR fisheries and fishery-based research in 2014/15, including information relevant to stock assessments. These data were used in the assessments described in Items 4 and 5 and other work conducted during the meeting.

3.2 The Working Group noted the total catches in fisheries for *Dissostichus* spp., *D. eleginoides*, *D. mawsoni*, *C. gunnari* and Antarctic krill (*Euphausia superba*) in the Convention Area in 2014/15 (Table 1) and of *D. eleginoides* captured outside the Convention Area (Table 2).

3.3 The Working Group noted that approximately 12 tonnes of *C. gunnari* and 1 tonne of *Dissostichus* spp. were reported as by-catch in the krill fisheries in Subareas 48.1–48.3 (SC-CAMLR-XXXIV/BG/01). This relatively small catch by weight may nonetheless represent a substantial number of fish due to the small size of individuals generally taken as by-catch in krill fisheries.

3.4 The Working Group recognised that observer data on the by-catch from the krill fisheries potentially contain valuable information on the biology and distribution of juvenile *C. gunnari* and *Dissostichus* spp. The Working Group agreed that greater interactions and coordination was required with WG-EMM in order to make progress on matters related to by-catch in krill fisheries and other issues of relevance, including by-catch mitigation measures such as move-on rules which may need to be applied in krill fisheries, to both working groups. WG-FSA noted that the Scientific Committee will give these matters further consideration at SC-CAMLR-XXXIV.

3.5 The Working Group noted that management areas in five fisheries for *Dissostichus* spp. were closed by the Secretariat in 2014/15 (CCAMLR-XXXIV/BG/02). These closures were triggered by catches of *Dissostichus* spp. approaching the relevant catch limits. With the exception of the fishery in Subarea 88.2, the closures resulted in catches reaching 97–99% of their respective catch limits. However, in Subarea 88.2, the catch limits for SSRU 882H and the whole fishery were exceeded by 8 and 5 tonnes respectively. The total catch in SSRU 882H reached 208 tonnes (104% of the catch limit).

3.6 The Secretariat advised that two vessels had fished in SSRU 882H in 2014/15 and their fishing operations appeared to have been constrained by patchy sea-ice in that region. A closure notice for SSRU 882H had been issued two days prior to the closure date and at the time of issue the catch was 89% of the catch limit; however, high catches in the final two days resulted in an 8 tonne overrun of the catch limit.

3.7 The Working Group discussed the significance of the 8-tonne overrun, and agreed that such an overrun was unlikely to impact the long-term status of the stock in Subarea 88.2. However, the Working Group agreed that overruns of catch limits should not be ignored and further consideration needs to be given to operational approaches which reduce the likelihood of overruns. The Secretariat noted that the management of catch limits means minor overruns and underruns are likely to happen and are part of normal process (see also CCAMLR-XXXI, paragraph 7.21).

3.8 The Working Group noted that an overrun in the fishery for *Dissostichus* spp. in Subarea 48.4 in 2014/15 had been avoided following the release of a large number of tagged fish by the only vessel fishing immediately prior to the closure. The Working Group discussed the application of this option in the exploratory fisheries, and recalled its advice that tagging rates in areas where tagging data are used in assessments should generally be maintained at a constant rate to avoid introducing bias in the stock assessment and its related advice (e.g. SC-CAMLR-XXXI, Annex 7, paragraph 5.47). The Working Group also noted that the release of tagged fish above the recommended tagging rate during the final stage of fishing may impact a vessel’s tag-overlap statistic and increase the risk of tagging fish which may be less likely to survive.

3.9 The Working Group noted that other options may be available to avoid catch overruns, such as effort limitation or real-time reporting. The Working Group encouraged the Scientific Committee to further consider such options.

3.10 The Working Group also noted that in Subarea 88.1, a total of nine vessels fished in small-scale research units (SSRUs) B, C and G and those SSRUs were closed by the Secretariat on 7 December 2014. That closure was implemented seven days after the start of fishing and may indicate a situation where the catch limit could potentially be taken before sufficient data are available with which to forecast a closure (paragraphs 4.58 to 4.60).

3.11 The Working Group noted that 13 VME-indicator notifications were submitted in 2014/15 in accordance with CM 22-07 (CCAMLR-XXXIV/BG/02): 1 notification in SSRU 5841C (the first notification made in that division) and 12 notifications in SSRU 881H. These notifications ranged from 5 to 47 VME-indicator units and resulted in the declaration of one VME risk area in Division 58.4.1 and 10 new VME risk areas in Subarea 88.1.

3.12 Since 2008, the Secretariat has received a total of 169 VME-indicator notifications from exploratory bottom fisheries: 1 notification in Subarea 48.2, 2 in Subarea 48.6, 1 in Division 58.4.1, 116 in Subarea 88.1 and 49 in Subarea 88.2. No notification has been received from exploratory fisheries in Divisions 58.4.2, 58.4.3a and 58.4.3b. These VME-indicator notifications led to the declaration of 75 VME risk areas: 1 risk area in

Division 58.4.1, 58 risk areas in Subarea 88.1 and 16 risk areas in Subarea 88.2. In addition, nine VME fine-scale rectangles have been identified: seven VME fine-scale rectangles in Subarea 88.1 and two in Subarea 88.2 (www.ccamlr.org/node/85695).

### Quarantined data

3.13 The Working Group noted that the Secretariat had implemented the Scientific Committee's advice from 2013 and 2014 that the fishery and observer data from certain vessels were unsuitable for analysis and should be quarantined (SC-CAMLR-XXXII, paragraph 3.228 and SC-CAMLR-XXXIII, paragraph 3.232). These data included the data from the *Yantar 35* in the Weddell Sea (Subarea 48.5 in 2013 and 2014); other data from that vessel had not been quarantined.

3.14 The Working Group noted that the Commission had endorsed the recommendation that all the data collected by the *Yantar 35* be quarantined until the Scientific Committee can make clear conclusions and provide advice (CCAMLR-XXXIII, paragraph 5.66). The Working Group noted that there had been differences in the interpretation of this advice from the Commission in respect of the years and management areas to which data from this vessel were to be applied and referred this matter to the Scientific Committee for further consideration.

3.15 The Working Group noted that the quality of the data which is used in stock assessments is critical for management advice, as applicable to the Ross Sea toothfish stock assessment (paragraph 4.77) in this instance. It recommended that data from the *Yantar 35* in areas outside Subarea 48.5 be investigated in this light in order to provide further advice to the Scientific Committee.

### Exploratory fishery notifications in 2015/16

3.16 The Working Group noted Members' notifications to fish in exploratory fisheries for *Dissostichus* spp. in 2015/16 (Table 3, details of vessels, including withdrawn notifications, can be viewed at www.ccamlr.org/en/fishery-notifications/notified). These notifications followed a pattern similar to recent seasons. Notifications were received from nine Members for a total of 20 vessels in Subarea 88.1, eight Members and 19 vessels in Subarea 88.2, two Members and two vessels in Division 58.4.3a, three Members and three vessels in Subarea 48.6, five Members and five vessels in Division 58.4.1 and five Members and five vessels in Division 58.4.2. There were no notifications submitted for the exploratory fishery in Division 58.4.3b or for new fisheries.

3.17 The Working Group noted that the research plans for notified data-poor fisheries in Subareas 48.6 and 58.4 were submitted to WG-SAM-15 for review. In addition, the Secretariat had uploaded the shape files for the research blocks proposed in papers submitted to WG-FSA-15 (Annex 5, paragraph 6.6). These files were available from the CCAMLR GIS (gis.ccamlr.org) under 'Community data' for registered users only and the Working Group thanked the Secretariat for providing this facility and encouraged its continued use.

## Research fishing in closed areas in 2015/16

3.18 The Working Group considered various proposals for research fishing in closed areas in 2015/16 (Table 4). These proposals had been submitted to WG-SAM-15 for review and were further discussed at WG-FSA-15 in paragraphs 5.34 to 5.43 (Subarea 48.2), paragraphs 5.44 to 5.54 (Subarea 48.5), paragraphs 5.84 to 5.87 (Division 58.4.4.b) and paragraphs 5.88 to 5.91 (Subarea 88.3).

## Redevelopment of the CCAMLR database

3.19 The Secretariat presented an update on the redevelopment of the CCAMLR database (WG-FSA-15/03). This is a major multiyear project to update CCAMLR data holdings and associated IT and data infrastructure. This work began in 2013 and involves the implementation of an Enterprise Data Model, a new data warehouse and a process to extract, transform and load (ETL) data, as well as improvements in the data workflow and quality assurance. The user community can expect to notice significant improvements in data quality, database documentation and ease of use as the new system begins a process of acceptance testing from late 2015. Consequential changes will be required in requested data extracts to reflect the new data model and nomenclature.

3.20 Following acceptance testing (see also Annex 5, paragraph 2.51 and Annex 6, paragraph 2.12), the Working Group noted that the Secretariat will stage the rollout of the new data warehouse, and each stage will be accompanied by supporting documentation. The Working Group requested the Secretariat to develop user training materials and conduct workshops to facilitate the rollout of the new structure, including details on how the data fields from the old database would map to the new database, as well as training for those responsible for data inputs to allow standardisation.

3.21 The Working Group thanked the Secretariat for the updates on data management processes and noted that some aspects of this work had already provided improvements in quality assurance and feedback to data providers.

## Marine debris

3.22 WG-FSA-15/15 presented a summary of the data on marine debris, including from beach surveys, debris associated with seabird colonies and entanglement of marine mammals, from Subareas 48.1, 48.2 and 48.3 (with additional data from Subarea 58.7) submitted to the Secretariat. Overall, there was no evidence of trends in the occurrence of marine debris but the data highlighted the continued presence of man-made marine debris in the Convention Area.

3.23 The Working Group noted that the issue of plastics in the marine environment is being increasingly highlighted in the media and scientific literature. The Working Group requested that the Secretariat contact other organisations (e.g. SCAR, CEP, IMO and the IWC) to investigate potential collaboration on data collection and analysis of marine debris data.

3.24 The issue of debris being transported into the Convention Area by ocean currents and long-ranging marine predators such as albatrosses means that there are difficulties in attributing the source of the debris. The Working Group recommended that the Scientific Committee consider the issue of marking hooks with vessel-specific identification marks so that the hooks found in seabird colonies could be traced back to the source.

### Toothfish released untagged

3.25 In response to discussions originating in WG-FSA-14 (SC-CAMLR-XXXIII, Annex 7, paragraph 5.42) and a subsequent request for further consideration of the issue from the Commission (CCAMLR-XXXIII, paragraph 7.22), the Secretariat presented a summary of the frequency and location of the releases of live untagged *Dissostichus* spp. in exploratory fisheries (CCAMLR-XXXIV/07).

3.26 The Working Group acknowledged that, while there was no length data available for the toothfish that had been released untagged, it was likely that these were small fish (approx. 50 cm length). The Working Group agreed that all fish, regardless of size, should be treated in the same way (i.e. there should be no release of live untagged fish), including in respect of collection of biological and tagging data.

### Offal discharge

3.27 In response to a request from New Zealand (COMM CIRC 15/15), the Secretariat assembled data from CCAMLR observer reports, vessel monitoring system (VMS) records and other information the Secretariat has available, related to reported incidences of offal discharge in the Ross Sea (CCAMLR-XXXIV/BG/10). VMS data was examined to identify all vessels that had been recorded within 10 km of the reported location from which offal was reported during the five days preceding the date of the report.

3.28 The Working Group thanked the Secretariat and expressed its concern that offal appeared to be discharged in an area where such a discharge was prohibited, noting especially that hooks in the offal presented a particular risk for seabirds and that discharge of offal may also have implications for the likelihood of depredation. Experts in the Working Group noted that the photograph of a fish head recovered in the offal (CCAMLR-XXXIV/BG/10, Figure 2) was in fact of a ling (*Genypterus blacodes*) and that this must have been transported in from outside the Convention Area as bait or food.

3.29 Noting that some of the offal reported still had hooks attached, the Working Group noted that this was another case for introducing vessel-specific marking of hooks (paragraph 3.24).

### VMS data quality assurance

3.30 The Secretariat presented SC-CAMLR-XXXIV/BG/19 on the potential use of CCAMLR VMS data for compliance and data quality assurance by the Secretariat. In particular, the paper presented an algorithm to determine an appropriate spatial and temporal overlap where a VMS location would be expected within a radius of 20 n miles and within four hours of the reported time of the fishing event.

3.31 The Working Group noted that the minimum frequency that the VMS position data is required to be provided is every four hours and that there was currently a proposal to change the reporting frequency to every one hour and that such a change would reduce the radius of the overlap range to 5 n miles. The Secretariat assured the Working Group that it could accommodate VMS data for all vessels at a higher frequency than currently required and noted that the generally recognised best practice of recording VMS data was at a frequency of every 15 minutes.

3.32 The Working Group agreed that it was vital that the locations of the catch data that were used in stock assessments were accurate and agreed that using the VMS data at appropriate resolution (at 15-minute intervals) was the best method for the data quality assurance processes. The Working Group also noted that this use of VMS data, and the required data quality assurance processes for the VMS data itself, would improve the utility of the VMS data for the Commission. The Working Group encouraged the Secretariat to implement the data quality assurance processes and recommended this issue be brought to the attention of the Standing Committee on Implementation and Compliance (SCIC).

### Conversion factors

3.33 In response to the request from WG-FSA in 2014 (SC-CAMLR-XXXIII, Annex 7, paragraph 7.7v), the Secretariat presented a review of the product to green weight conversion factors used in the toothfish fishery (WG-FSA-15/02). The review was based on 46 638 records in C2 data that contained a conversion factor and product code as well as 69 974 fish measured by observers before and after processing to measure conversion factors.

3.34 The most frequently used processing code was 'head, gutted and tailed' (HGT), however, even within this one processing code there was considerable inter-vessel variability in the conversion factors used.

3.35 The Working Group noted that even within single processing methods such as HGT there were many factors that could influence the actual conversion factor, including the type (location) of cut used and how this changes over time depending on market forces and the equipment available on board to weigh pre-processed fish.

3.36 The Working Group agreed that it was important to highlight how variability in conversion factors could affect the green weight estimation and the consequences of this for the stock assessment and reconciliation of C2 and CDS data and recommended that additional information on the specific details of how the fish are actually processed is required.

3.37 The Working Group agreed that, in addition to the reporting of the product code, observers be tasked with providing a detailed description of the shape and distance from the front of the head of the cut used to remove the head of toothfish. The Working Group welcomed the offer from Mr C. Heinecken (South Africa) for South African observers to implement a trial collection of this additional conversion factor data in 2016 and to provide feedback in order for the required changes to be made to the observer logbooks and cruise reports for implementation in 2017. The Secretariat undertook to circulate the revised version of the observer logbook, cruise report and instructions to technical coordinators in June 2016 in order that the new requirements could be included in the training of observers prior to deployment for the 2017 season.

3.38 Conversion factors used for the fisheries for *D. eleginoides* in Division 58.5.1 and Subarea 58.6 were presented in WG-FSA-15/77. A number of variables were found to significantly influence the conversion factor. The paper emphasised the need to calculate conversion factors with a sub-sample of the catch that is representative of the total catch on board a vessel, taking account of the size of the fish, location of fishing and time of year. The variability in processing between different vessels should also be considered.

3.39 The application of cumulative conversion factors was presented. The Working Group noted that individual conversion factors calculated during a trip did not necessarily relate to each other. However, if the conversion factor was applied in a cumulative series during the progression of the trip, it provided a far more robust conversion factor to calculate green weight.

## IUU fishing

3.40 The Working Group noted that the summary of reports of illegal, unreported and unregulated (IUU) fishing submitted to the Secretariat, presented in CCAMLR-XXXIV/37, indicated that IUU activity (either vessels and/or gear) had been detected in 2014/15 in similar areas to those where it had been reported in previous years (Division 58.4.1 (SSRU E and H) and Subarea 48.6).

3.41 The Working Group also considered CCAMLR-XXXIV/BG/18 that provided detailed information on the gear used, the amount of catch taken and the depth distribution that the catch was taken from the logbooks of the IUU vessel *Kunlun*. It was noted that there was sufficient information in this paper to estimate the quantity of catch, selectivity and hauling speed of IUU fishing as well as information on the size of the fish, but unfortunately no by-catch data were recorded.

3.42 The Working Group also considered the information on efforts to combat IUU fishing presented in CCAMLR-XXXIV/32 and noted that there was additional information available that could allow the size and weight of catch to be estimated from surveillance videos.

3.43 The Working Group noted that most of the IUU catch appeared to be large fish and this may be due to the depth of the gillnet sets, or the mesh size which was likely to be 18−22 cm. The Working Group expressed great concern regarding the use of gillnet gear and especially on the ongoing impact that ‘ghost fishing’ of this gear has in the marine environment.

3.44 The Chair of the Scientific Committee drew the attention of the Working Group to SC-CAMLR-XXXIV/BG/12 that used expert industry analyses of the available information on IUU vessel sightings and landings to produce an estimate of IUU catch in 2015 of between 1 264 and 1 500 tonnes. The Working Group noted that this was the only paper submitted to CCAMLR this year that had attempted to provide an estimate of the total IUU catch in the Convention Area in 2015. Although the estimates are preliminary at this stage, it was agreed that they are likely to be an underestimate of total removals by IUU fishing, as the analyses are confined to the catch of those three vessels that were actually detected and they do not include mortality associated with lost IUU gillnets.

3.45 The Working Group discussed the range of data available on IUU activity, including information collected by the Sea Shepherd organisation during 2014/15, which includes data on IUU gear used, toothfish length and weights and by-catch details, suggesting that other data previously collected during at-sea and port inspections could be used in order to assess product types and length–weight measurements to better understand the removals by IUU vessels. The Working Group also noted that counting the number of dead toothfish in recovered gillnets, either recovered by other vessels or recorded in the video footage such as that from the New Zealand Navy patrol vessel, could provide estimates of gear selectivity and the removals arising from IUU fishing.

3.46 The Working Group noted the increased attention given to the issue of IUU fishing in 2015 and drew the attention of the Scientific Committee and SCIC to its consideration of this issue.

3.47 The Working Group recommended that the Secretariat develop a form to provide organisations combatting IUU fishing with information on what data should be gathered that would be useful to CCAMLR in estimating IUU fish removals (e.g. specifications of gear recovered, specific biological information of fish recovered, etc.).

## Stock assessments for fisheries for *Dissostichus eleginoides* in Subareas 48.3 and 48.4 and Division 58.5.2, for *D. mawsoni* in Subarea 48.4, for *Dissostichus* spp. in Subareas 88.1 and 88.2 and for *Champsocephalus gunnari* in Subarea 48.3 and Division 58.5.2

### Assessment by management area

#### *Champsocephalus gunnari* Subarea 48.3

4.1 The fishery for *C. gunnari* in Subarea 48.3 operated in accordance with CM 42-01 and associated measures. In 2014/15, the catch limit for *C. gunnari* was 2 695 tonnes. Fishing early in the season was conducted by two vessels using midwater trawls and the total reported catch was 277 tonnes as of 16 September 2015. Details of this fishery and the stock assessment of *C. gunnari* are contained in the Fishery Report (www.ccamlr.org/node/75667).

4.2 The Working Group noted that the fishing effort deployed in Subarea 48.3 has been low in recent years and that this has resulted in the low uptake of quota by the fishery. High variability in the availability of icefish in the water column to the pelagic fishery was also noted.

4.3 WG-FSA-15/25 presented a preliminary assessment of *C. gunnari* in Subarea 48.3. The assessment was based on a random stratified bottom trawl survey of the South Georgia and Shag Rocks shelves that the UK undertook in January 2015 as part of its regular monitoring program (WG-FSA-15/30). A total catch of 7.2 tonnes was reported from the research survey.

4.4 The Working Group agreed that the length-based assessment for icefish should be used in Subarea 48.3, following the methodology presented in WG-FSA-15/25.

4.5 A bootstrap procedure was applied to the survey data to estimate the demersal biomass of *C. gunnari* in this subarea. The bootstrap estimated the median demersal biomass at 59 081 tonnes, with a one-sided lower 95% confidence interval of 36 530 tonnes. The harvest control rule, which ensures 75% biomass escapement after a two-year projection period, yielded a catch limit of 3 461 tonnes for 2015/16 and 2 074 tonnes for 2016/17.

#### Management advice

4.6 The Working Group recommended that the catch limit for *C. gunnari* should be set at 3 461 tonnes for 2015/16 and 2 074 tonnes for 2016/17 based on the outcome of the short-term assessment and forecast.

### *C. gunnari* Heard Island (Division 58.5.2)

#### Research surveys

4.7 The Working Group noted that Australia had undertaken a random stratified trawl survey in Division 58.5.2 during May 2015 (WG-FSA-15/11). It noted that catches per haul of most finfish species were within 1 standard deviation of the mean of the estimates from the equivalent surveys undertaken between 2006 and 2014, with the exception of toothfish, unicorn icefish (*Channichthys rhinoceratus*) and macrourid species which were all more abundant than the long-term mean. These data were included in the preliminary assessments for *C. gunnari* (WG-FSA-15/12 Rev. 1), *C. rhinoceratus* (WG-FSA-15/50), *Macrourus caml* (WG-FSA-15/63) and *D. eleginoides* (WG-FSA-15/52) in Division 58.5.2 (paragraphs 8.10 to 8.28).

4.8 The fishery for *C. gunnari* in Division 58.5.2 operated in accordance with CM 42-02 and associated measures. In 2014/15, the catch limit for *C. gunnari* was 309 tonnes. Fishing was conducted by two vessels and the total reported catch up to 20 September 2015 was 4 tonnes. Details of this fishery and the stock assessment of *C. gunnari* are contained in the Fishery Report.

4.9 The results of the bottom trawl survey undertaken in May 2015 were summarised in WG-FSA-15/11. The Working Group noted that *C. gunnari* catch rates were close to the long-term average from 2006 to 2014. The length–weight relationship was updated using the survey data; other biological parameters were unchanged from previous assessments. The best fit of CMIX to the survey length distribution was achieved when the population was estimated to consist of four year classes from 1+ to 4+, with the 2+ cohort containing the largest number of fish, and estimated to make up 69% of the biomass.

4.10 A short-term assessment was conducted in the generalised yield model (GYM), using the one-sided bootstrap lower 95% confidence bound of total biomass of 3 048 tonnes of age 1+ to 3+ fish from the 2015 survey and fixed model parameters.

4.11 Estimates of yield indicate that 482 tonnes of icefish could be taken in 2015/16 and 357 tonnes in 2016/17 allowing 75% escapement of biomass after two years.

### Management advice

4.12 The Working Group recommended that the Scientific Committee consider a catch limit for *C. gunnari* in 2015/16 of 482 tonnes and of 357 tonnes in 2016/17.

### *Dissostichus eleginoides* Subarea 48.4

4.13 The catch limit for *D. eleginoides* in 2014/15 for Subarea 48.4 was 42 tonnes. The total reported catch was 42 tonnes.

4.14 WG-FSA-15/28 presented an updated integrated stock assessment for *D. eleginoides* in Subarea 48.4. Compared to the last assessment in 2014 this model was updated with observations for the 2014/15 season, revised tagging and recapture data for the full time series, a maturity ogive from Subarea 48.3 since insufficient data on maturity from Subarea 48.4 was available and changes to the assumed tag growth retardation period from 0.5 years to 0.75 years (WG-SAM-14/35; WG-FSA-14/49 and 14/50).

4.15 The Working Group noted the model estimated year-class strength (YCS) after 2007 although these year classes were not observed in the catch-at-age data. In addition, all years of tag recaptures were included for each tag-release year. During the meeting, the model was rerun with fixed YCS from 2008 to 2015.

4.16 This model estimated the unfished spawning stock $B_0$ at 1 476 tonnes (95% CI 1 241–1 781 tonnes) and spawning stock status in 2015 at 83% (95% CI 78–89%). The long-term catch limit that satisfied the CCAMLR decision rules was 47 tonnes. Model results and figures are provided in the Fishery Report.

4.17 The Working Group recalled the discussions on stock structure and potential links between the *D. eleginoides* stocks of Subareas 48.3 and 48.4 at WG-SAM-15 (Annex 5, paragraphs 2.46 and 2.47). Different growth rates and maturity suggested that there is no regular exchange between the two areas, but tag-recapture data show a small number of toothfish moving from Subarea 48.4 to Subarea 48.3 and genetic analysis indicated that both stocks belong mostly to the same genetic population. The Working Group recommended that the two areas are assessed separately until further information is available, as this is the most precautionary approach given the limited knowledge.

4.18 The assessment model estimated that the time series of YCS indicated two strong peaks in 1994 and 1997, followed by a period of lower recruitment. Considering that recruitment in Subarea 48.4 seems to be dominated by sporadic strong recruitment pulses, the Working Group discussed the applied approach of using lognormal recruitment variability with a CV = 1.0 for the projections and recommended that alternative approaches be explored such as resampling from the historical time series and including autocorrelation in the projected recruitment.

4.19 In addition, the Working Group recommended further work on only including data from fish recaptured within four years of release (WG-FSA-11/33 Rev. 1).

### Management advice

4.20 The Working Group agreed that the stock assessment in Subarea 48.4 meets the criteria described in SC-CAMLR-XXVI (paragraph 2.11) and, therefore, the assessments could be performed on a biennial cycle without incurring significant additional risk.

4.21 The Working Group recommended that the catch limit for *D. eleginoides* in Subarea 48.4 should be set at 47 tonnes for 2015/16 and 2016/17 based on the results of this assessment.

## *D. mawsoni* South Sandwich Islands (Subarea 48.4)

4.22 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 2014/15 was 28 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.

4.23 WG-FSA-15/31 reported on a tag-recapture-based population assessment for *D. mawsoni* in Subarea 48.4 using the method agreed at WG-FSA-14, while WG-FSA-15/44 provided a general review of the Chapman tag-based stock estimation method. The review identified two main issues, namely the appropriate catch–weight correction application of the Chapman estimation method when applied to estimate low tag-recapture rate population abundance and the misidentification of species at release in Subarea 48.4.

4.24 The Working Group agreed that the proposed correction for the average weight of an individual fish should be applied as has been used in other tag-based assessments in the CCAMLR area and that the corrections applied for toothfish identified to species at recapture was appropriate.

4.25 The Working Group discussed the problems associated with zero values in low tag-recapture fisheries in which low levels of catches are taken as presented in WG-FSA-15/44. The high proportion of zero values to which 1 is added within the Chapman correction can increase abundance estimates in years for which no data is available. Some zeros are due to the low probability of expected recaptures, while others are due to violation of assumptions from the tagging program, such as high tag-release mortality, migration out of the area of the fishery, lack of mixing or a lack of overlap in the spatial distribution of tagged fish and fishing effort. The Working Group requested that this subject be reviewed and discussed at WG-SAM.

4.26 The Working Group reviewed tag-based stock estimation methods used in CCAMLR fisheries, particularly the number of tags available within research areas (paragraph 5.64) and concluded that the Chapman estimation method that uses an assumption of a single population of tags in each year of recapture should be applied, and which therefore reduces the influence of zeros in the assessment process.

4.27 The Subarea 48.4 assessment 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 estimated population estimates across years, a geometric mean of the relatively short time series was used as the basis for the final stock abundance of 1 014 tonnes. At a harvest rate of $\gamma = 0.038$, this would indicate a 2015/16 yield of 39 tonnes for *D. mawsoni* in Subarea 48.4.

### Management advice

4.28 The Working Group recommended that the catch limit for *D. mawsoni* in Subarea 48.4 should be set at 39 tonnes for 2015/16 based on the results of this analysis.

### *Dissostichus eleginoides* Subarea 48.3

4.29 The fishery for *D. eleginoides* in Subarea 48.3 operated in accordance with CM 41-02 and associated measures. In 2014/15, the catch limit for *D. eleginoides* was 2 400 tonnes. Fishing was conducted by six vessels using longlines and the total reported catch was 2 194 tonnes.

4.30 WG-FSA-15/59 presented an updated integrated assessment for *D. eleginoides* in Subarea 48.3. Compared to the last assessment in 2013, this model was updated with available data from 2013/14 and 2014/15 and revised tagging data received from the CCAMLR database from earlier fishing seasons.

4.31 The assessment estimated unfished spawning biomass at 85 900 tonnes (95% CIs: 81 600–91 300 tonnes) and spawning stock biomass (SSB) status in 2015 at 0.52 (95% CIs: 0.50–0.54). The long-term catch limit that satisfied the CCAMLR decision rules was 2 750 tonnes.

4.32 The Working Group noted that, while the median SSB was estimated to have fallen below the target level of 50% of the pre-exploitation median SSB from 2009 to 2012 (Figure 1), it was above the target level in 2015 and did not fall below the target for the remainder of the projection period under the recommended yield (paragraph 4.37). This was the first time that an assessment had shown that the stock may have fallen below the target level in the historical time period.

4.33 The Working Group noted that this was due to changes in the estimation of the virgin biomass $B_0$ and not changes in the abundance of the recent biomass estimates which were relatively consistent between assessments.

4.34 The Working Group noted that the model fitted the observed tag-recapture data very well. However, there were trends in lack of model fits to the commercial age composition data and the survey biomass index, with the model generally underestimating observations up to 2006 and overestimating observations after 2006. In addition, the observed age composition contracted after 2006.

4.35 The Working Group recommended further work exploring the underlying causes for this lack of model fits, including the effects of increased data weighting of the survey. The Working Group also noted that the planned ageing of the survey samples and future use of survey age proportions may improve the estimation of YCS.

4.36 In addition, the Working Group recommended a consistent application of the dispersion parameter for tagging data and an evaluation of alternative approaches to data weightings of all observations.

#### Management advice

4.37 The Working Group recommended that the catch limit for *D. eleginoides* in Subarea 48.3 should be set at 2 750 tonnes for 2015/16 and 2016/17 based on the results of this assessment.

### *D. eleginoides* Kerguelen Island (Division 58.5.1)

4.38 The fishery for *D. eleginoides* in Division 58.5.1 is conducted in the French EEZ. In 2014/15, the catch limit for *D. eleginoides* was 5 100 tonnes. Fishing was conducted by seven vessels using longlines and the total reported catch up to 31 July 2015 was 2 884 tonnes.

4.39 WG-FSA-15/68 presented an updated stock assessment of *D. eleginoides* at Kerguelen Island (Division 58.5.1 inside the French EEZ), which included recommendations from WG-FSA-14 and the first ageing data and growth curve from the area. Preliminary results of a sex-based model were also presented at the meeting, showing less females than males were caught in the deep longline fishery. This result was in line with habitat modelling of the plateau (WG-FSA-14/42).

4.40 The Working Group noted that the fish growth parameters estimated for this division suggest that fish grow faster and to larger sizes than in the adjacent Division 58.5.2, and that the overall growth model is biased towards female growth. The Working Group recommended inter-laboratory comparisons of fish age estimates from otoliths and further work on growth estimation.

4.41 The Working Group also recommended further work on:

(i) update estimations of whale depredation (WG-FSA-06/63) using methods like the comparative catch-per-unit-effort (CPUE) analysis from WG-FSA-14/10 and include these estimates in the stock assessment

(ii) investigate the use of a uniform-log prior for $B_0$, a lognormal prior for YCS, double-normal plateau selectivities and application of YCS variability in stock projections when it has not been estimated in the model

(iii) further explore the sex-based model.

### Management advice

4.42 The Working Group agreed that model R1 with fixed YCS, as described in WG-FSA-15/68, could be used to provide management advice for 2015/16. Although the long-term precautionary yield was not calculated, the catch limit set for 2015/16 by France of 5 300 tonnes satisfied the CCAMLR decision rules.

4.43 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 2015/16.

## *D. eleginoides* Crozet Islands (Subarea 58.6)

4.44 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 2014/15 the catch limit for *D. eleginoides* was 850 tonnes. Fishing was conducted by seven vessels using longlines and the total reported catch up to 31 July 2015 was 433 tonnes.

4.45 WG-FSA-15/69 presented an updated stock assessment of *D. eleginoides* at Crozet Islands (Subarea 58.6 inside the French EEZ). The model included estimated levels of depredation by killer whales from generalised additive model (GAM) analyses of the fishery data and 10% of total catch depredation by killer whales in the predictions.

4.46 The Working Group noted that the recommendations it made for the Kerguelen stock assessment (paragraph 4.41) also applied to the Crozet stock assessment. It further recommended that the annual depredation calculations be presented in future stock assessments papers.

### Management advice

4.47 The Working Group agreed that model R1 with fixed YCS, as described in WG-FSA-15/69, could be used to provide management advice for 2015/16. The Working Group noted that a catch limit of 1 780 tonnes would satisfy the CCAMLR decision rules. It noted that France had set a catch limit of 1 000 tonnes for 2015/16.

4.48 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 2015/16.

## *D. eleginoides* Heard Island (Division 58.5.2)

4.49 The fishery for *D. eleginoides* in Division 58.5.2 operated in accordance with CM 41-08 and associated measures. In 2014/15, the catch limit for *D. eleginoides* was 4 410 tonnes. Fishing was conducted by six vessels using bottom trawls and longlines, and the total reported catch up to 20 September 2015 was 2 675 tonnes. Details of this fishery and the stock assessment of *D. eleginoides* are contained in the Fishery Report.

4.50 WG-FSA-15/55 provided an update of the tagging and ageing program for *D. eleginoides* in Division 58.5.2. Tagging rates have been increased from 2 tags per 3 tonnes in previous fishing seasons to 2 tags per tonne in the current season, and since 2010 the tag-overlap statistic for the longline fishery increased from around 60% to over 90%. The Working Group recalled that there is a need to evaluate the bias introduced into stock assessment when fishing effort, tag distribution and underlying stock distribution is spatially heterogeneous, and recalled that Australia is currently undertaking a project to address these issues for toothfish stocks on the Kerguelen Plateau (WG-SAM-15/37). The Working Group recommended that sensitivities be run to investigate the impact, if any, of the change in tagging rate on the stock assessment and its advice.

4.51 Since WG-FSA-14, an additional 2 559 fish have been aged for fish captured during the 2014 and 2015 random stratified trawl survey, commercial fishing in 2013/14 and archived otoliths from tagged and recaptured fish from the 2009/10 to 2013/14 seasons, including a substantial number of fish over 30 years. Estimates of the age–length relationship derived from these samples are used in the assessment presented in WG-FSA-15/52.

4.52 WG-FSA-15/52 presented an updated assessment for *D. eleginoides* in Division 58.5.2 with data until the end of July 2015 and tag data from 2012 to 2015. Compared to the last assessment in 2014, the assessment also updated fish growth parameters, changed the priors on survey catchability $q$ (as recommended by WG-SAM-15), $B_0$ and YCS, and split the trawl fishery into two periods of 1997–2004 and 2005–2015.

4.53 The estimated $B_0$ was strongly influenced by including recaptures in 2014 and partial recaptures in 2015, while updating the growth model and changing model priors for survey catchability $q$, $B_0$ and YCS, and splitting the trawl fishery into two periods had relatively little effect on the estimated $B_0$.

4.54 The updated assessment model leads to a smaller estimate of the virgin spawning stock biomass $B_0$ than that obtained in 2014, with a Markov chain Monte Carlo (MCMC) estimate of 87 077 tonnes (95% CI: 78 500–97 547 tonnes). Estimated SSB status in 2015 was 0.64 (95% CI: 0.59–0.69). The long-term catch limit that satisfied the CCAMLR decision rules was 3 405 tonnes.

4.55 The Working Group welcomed the progress made on the stock assessment. It noted the difference made by the update in the growth function, the difference in *D. eleginoides* growth functions between areas and recommended calculation of growth parameters is a focus topic for WG-SAM. The Working Group further recommended that sensitivities be run including the tag data from 2010 to 2012, with an investigation of the diagnostics. The Working Group noted that depredation was currently minimal (WG-FSA-15/53) and recommended that monitoring continues and depredation be included in the model should depredation increase.

### Management advice

4.56 The Working Group noted that, although estimates of unexploited biomass have been variable over the last few years, estimates of stock status had been very consistent at about 0.65, and the biomass was above target, and that the assessment could be performed on a biennial cycle without incurring significant adverse risk (SC-CAMLR-XXVI, paragraphs 2.11 and 14.6).

4.57 The Working Group recommended that the catch limit for *D. eleginoides* in Division 58.5.2 should be set at 3 405 tonnes for 2015/16 and 2016/17 based on the outcome of this assessment.

## *Dissostichus* spp. Subarea 88.1

### Capacity

4.58 WG-FSA-15/09 presented an update of the metrics of capacity and capacity utilisation as 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 metrics showed the same pattern as when collated up to 2013 and do not indicate an excess capacity in the fishery.

4.59 A measure of potential daily fishing capacity as a function of the catch limit for an area indicates that for some management areas with low catch limits in Subareas 88.1 and 88.2 the notified fishing capacity is in excess of the level that would allow the Secretariat to forecast a closure date and issue a closure notice using the currently accepted approach.

4.60 The Working Group agreed that, while it was evident that an excess capacity of notified vessels could impact the management of the fishery, this situation had not yet actually occurred. Nevertheless, the Working Group noted that it was important to highlight potential situations where an excess of fishing capacity might make closure forecasting difficult in order that potential solutions can be prospectively evaluated, rather than introduced in response to a problem.

### *Dissostichus* spp. Subarea 88.1

4.61 The exploratory fishery for *Dissostichus* spp. in Subarea 88.1 operated in accordance with CM 41-09 and associated measures. In 2014/15, the catch limit for *Dissostichus* spp. was 3 044 tonnes, including 68 tonnes set aside within the SSRUs 881J and L catch limit for the sub-adult survey and 200 tonnes set aside for the survey of the northern parts of SSRUs 882A–B.

4.62 WG-FSA-15/35 provided a 2015 update of the analysis summarising the impacts of sea-ice on demersal longlining in Subarea 88.1. It highlighted that 2014/15 was the third-worst ice year since the fishery began.

4.63 The Working Group noted the analysis was informative and agreed that ice analysis summaries could be included in the Fishery Reports. The Working Group highlighted the potential for collaboration with the work of the Council of Managers of National Antarctic Programs (COMNAP). It noted the constraining effect of sea-ice on the operations of the fishery and the risk that such conditions may worsen with the effects of El Niño and climate change. The Working Group highlighted the value of spatial models as tools to assess the effects of ice on assessments.

4.64 WG-FSA-15/36 presented an updated characterisation of the toothfish fishery in Subareas 88.1 and 88.2 from 1997/98 to 2014/15, summarising timing, depth and location of fishing effort together with biological characteristics of the catch of *D. mawsoni* up to, and including, the 2015 season.

4.65 The Working Group noted that SSRUs 881I and K in the Ross Sea slope were significantly constrained by sea-ice and this was reflected in the uneven distribution of catch across the three slope SSRUs. There had been a marked increase in the proportion of males in the Ross Sea north fishery throughout the series, but little change in other areas. Median length is still decreasing in slope and north Ross Sea areas (driven by the change in sex ratio) and the highly variable length frequency in SSRUs 882C–G may be due to spatial variation in fishing effort.

4.66 WG-FSA-15/37 presented a descriptive analysis of the toothfish tagging program in Subareas 88.1 and 88.2 from 2000/01 to 2014/15. Over 40 000 tagged fish have been released in the Ross Sea with over 2 500 recaptures. The two-year research plan in SSRUs 882C–G has resulted in 1 128 tagged fish released with 24 recaptures. These data, and data from the 2016 fishery, would be incorporated into developing a two-area model for SSRUs 882C–H.

4.67 The Working Group discussed the spatial pattern of tag availability relative to the distribution of fishing effort and recalled the need for a spatial overlap metric to index the bias on the assessment.

4.68 The Working Group noted that quarantined tagging data can result in a number of analytical effects and referred the question of the use of quarantined data in stock assessments to the Scientific Committee.

4.69 WG-FSA-15/40 presented a proposal to update the data collection plan for the Ross Sea fishery. As in the previous data collection plan discussed in 2010 (SC-CAMLR-XXIX, Annex 8, paragraph 6.31), it focused on ongoing yearly requirements for toothfish as well as intermittent targeted sampling for the key by-catch species, including skates, macrourids and other species (icefish, eel cods, deep-sea cod, etc.).

4.70 The Working Group welcomed the review of the data collection plan for the Ross Sea and its consideration of how to manage the many pressures on the workload of observers. The Working Group agreed that the quality and quantity of observer data was critical to the work of the Commission and that a priority needed to be placed on developing identification guides, instructions and sampling protocols to collect the information requested. It noted the discussions of by-catch data reporting (paragraphs 8.1 to 8.8) and referred further discussion to the Scientific Committee.

4.71 The Working Group noted the desire of many Members not listed in WG-FSA-15/40 to undertake fisheries research in the Ross Sea and that mechanisms need to be provided for their participation in the data collection plan and for refining the plan. It also noted the implementation of such plans will require time to ensure uptake and effective data collection by all Members.

4.72 WG-FSA-15/38 provided an update of the Bayesian sex- and age-structured population stock assessment for *D. mawsoni* in the Ross Sea region (Subarea 88.1 and SSRUs 882A–B). The diagnostic plots for the model fits were presented in WG-FSA-15/39, including the input data, maximum of the posterior density (MPD) and MCMC outputs. The assessment was updated to include catch, catch-at-age and tag-recapture data from 1997/98 to 2014/15 and the results from the Ross Sea shelf survey (WG-FSA-15/34). The assessment model estimates of stock dynamics were consistent with the 2013 assessment. Tag residuals showed year effects that appear to result from the concentration of effort in the year of recapture. This could be the result of ice coverage in those years and an analysis to quantify overlap between fishing and tagged fish release locations is being undertaken. Sensitivity analysis also revealed that the data from the Ross Sea shelf survey were essential to estimate relative YCS. YCS were estimated from 2003 to 2009 and showed one strong year class and two weak year classes. Exclusion of the quarantined age and tag data from the *Insung No. 7* in 2011 and the *Yantar 35* in 2013, 2014 and 2015 (total catches were retained), resulted in negligible changes to the assessment fit and forecast catch as no tagged fish reported by these vessels as released had been recaptured in the fishery. When included as a sensitivity, quarantined data resulted in down-weighting of the data. Despite this minor difference to the estimated stock and fishery trends, the Working Group requested the Scientific Committee to provide guidance on the inclusion or exclusion of the quarantined data for the *Yantar 35* (paragraphs 3.13 to 3.15).

4.73 The Working Group noted that the model diagnostics showed that the model was expecting longer mean length for tagged fish recoveries than observed in all years. This raised questions in respect to the value used for growth retardation from tagging, inaccuracy in estimating $k$ in the von Bertalanffy growth model, or higher tag-related mortality in larger toothfish. The Working Group noted that this was a useful diagnostic and reasons for this lack of fit should be further investigated in future studies.

4.74 The yield, using the CCAMLR decision rules and current relative catch distribution between the shelf, slope and north areas of the Ross Sea region, was either 2 855 tonnes or 2 870 tonnes from the two reference case model runs R1 (including quarantined data) and R2 (excluded).

4.75 The Working Group investigated the current allocation of catches by SSRU using mean CPUE and fishable area (SC-CAMLR-XXVII, Table 4), which had 13% from the shelf SSRUs, 74% from the slope SSRUs and 13% from the northern SSRUs and determined that as the CPUE showed no trend (WG-FSA-15/36), the proportional allocation by SSRU should remain as applied in the current conservation measure.

4.76 WG-SAM-15 requested an investigation of the effect of differing catch allocations from the Ross Sea shelf, slope and northern offshore areas (Annex 5, paragraph 4.26). This analysis showed that reallocating the total catch into one of these three locations resulted in a difference to the long-term yield of less than 10%. The Working Group agreed that the spatial population model (SPM), while still being developed as results from the research projects in

Subareas 88.1 and 88.2 become available, may be able to provide advice to the Scientific Committee and the Commission. It noted, however, that methods for presenting diagnostics of such results remain to be determined and will need to be developed to accompany advice that may arise. The Working Group agreed that exploring allocation factors other than seabed area and CPUE, such as other ecosystem features, predator–prey overlap, ice dynamics, etc. would be valuable toward potential future refinement of the subdivision of the catch limit into SSRUs in the Ross Sea.

### Management advice

4.77 The Working Group recommended that the catch limit for *D. mawsoni* in Subarea 88.1 should be set at either 2 855 tonnes (with quarantined data) or 2 870 tonnes (without quarantined data) for 2015/16 and 2016/17, depending on the outcomes of a decision on whether quarantined data should be used in assessments. It further recommended that the proportional allocation by SSRU should remain as applied in the current conservation measures, whilst taking into account the research survey proposals below.

### Data collection proposals

4.78 Data collection proposals to collect information consistent with the medium-term research plan objectives (CCAMLR-XXXIII, paragraph 5.52) were as follows: (i) a winter survey proposal in the north of Subarea 88.1 (WG-SAM-15/47); (ii) a research proposal in the north of SSRUs 882A–B (WG-FSA-15/32; paragraphs 4.97 to 4.107); and (iii) a research proposal for the south of SSRUs 882A–B (WG-FSA-15/27; paragraphs 4.108 to 4.114).

4.79 WG-FSA-15/47 had been reviewed at WG-SAM-15 with no specific requests to modify the proposal brought forward to WG-FSA. Annex 5, paragraphs 4.27 to 4.29, described the survey design, and paragraph 4.29 requested the Commission to consider how the catch limit should be allocated.

4.80 The New Zealand proposal for the winter survey in SSRUs 881B–C was outlined for June 2016 and future years, with the potential for other Members to provide vessels for future years having suitable safety qualifications. For a catch limit, 100 tonnes (~3 100 fish) was requested – sufficient for 60 sets over 2–3 strata with at least 10 sets per strata. A catch limit would be set by stratum to ensure multiple strata sampled. This catch limit was required to obtain adequate samples while maintaining an incentive for a suitable vessel to participate.

4.81 The Working Group considered that the first year was a proof of concept as a foundation for future work, which would provide important insights into the toothfish biology within the northern area in winter. It endorsed the advice from WG-SAM-15 that the survey would address CCAMLR-agreed priorities and the request for the Commission to consider how the catch limit should be allocated from the Ross Sea catch limit.

4.82 WG-FSA-15/34 presented a research proposal to continue the southern Ross Sea shelf survey (formerly known as the sub-adult survey) for the next two years, 2016 and 2017. The survey is intended to focus primarily on estimating the relative abundance of sub-adult (<110 cm TL) toothfish in the core strata (A, B, C) in SSRUs 881J and L so as to provide a time series of recruitment of toothfish. The survey is a continuation of the time series of CCAMLR-sponsored research surveys of these strata carried out from 2012 to 2015, which is fitted within the Ross Sea assessment model (WG-FSA-15/09) and enables the model to estimate recent recruitment abundance. A nominal catch limit of 40 tonnes was requested for each survey year. Following the recommendations of WG-SAM-15 and WG-EMM-15, an additional secondary survey objective was added to monitor larger (sub-adult and adult) toothfish in McMurdo Sound and Terra Nova Bay, where toothfish are believed to form an important part of the diet of Type C killer whales and Weddell seals. The Working Group noted that these strata had relatively high standard errors, so that they would be only able to detect relatively large changes in relative toothfish abundance in these areas.

4.83 The Working Group noted that the McMurdo Sound and Terra Nova strata are also areas with relatively high predator concentrations, and that WG-EMM-15 (Annex 6, paragraph 2.86) had noted the importance of conducting monitoring in this area to monitor abundance, spatial distributions and interactions. The Working Group noted that the timing of the surveys had been aligned with the ice-based ecosystem monitoring work undertaken on these three species by Italian, New Zealand and US scientists in these two areas (WG-FSA-15/33). It is proposed to conduct a vessel-based survey in McMurdo Sound in 2016 and Terra Nova Bay in 2017 to match the timing and location of the sea-ice based work. The results of the 2016 survey, and trends in the time series, will be presented to WG-FSA for review in 2016 and that a full review be completed and presented to WG-EMM, WG-SAM and WG-FSA in 2017.

4.84 The Working Group recommended that the Ross Sea shelf survey go ahead with a catch limit of 40 tonnes for each of 2015/16 and 2016/17 and that, as in previous years, the catch be taken from the catch limit on the shelf.

4.85 WG-FSA-15/P01 and 15/33 presented the background context and a proposal for a standardised ice-based survey for *D. mawsoni* in McMurdo Sound.

4.86 Results from a new monitoring program for *D. mawsoni* and other top predators carried out in McMurdo Sound in 2014 have shown toothfish catch rate, fish size and fish age similar to those observed prior to 2002. The results suggest that either large old fish have returned to McMurdo Sound following a temporary environmentally driven absence or that they remained locally present but were not detected in the areas sampled. These studies highlighted the importance of continued standardised monitoring for detecting the potential effects of fishing on the Ross Sea ecosystem, a proposal for which was outlined in WG-FSA-15/33. The proposal indicated that a maximum of 75 fish would be sampled biologically each year (12 fish were sampled in the 2014 research) with others tagged with conventional and electronic tags and released.

4.87 The Working Group noted that monitoring McMurdo Sound for the effects of fishing requires information on the abundance, distribution and interactions of toothfish, their predators and their prey, and that collecting this information was the first step in monitoring for the effects of fishing on these ecosystem components.

4.88 The Working Group noted that large fish appear to be prevalent in McMurdo Sound and in other areas such as SSRU 882G, which is unusual because in other shelf areas toothfish are generally much smaller and younger. The Working Group noted that the information gathered by this sampling program could be used to further inform SPMs and to monitor for the effects of fishing on top predators through the collaborative work on toothfish predators and prey.

4.89 The Working Group agreed that in the long term it would be useful to determine what role these areas play in toothfish dynamics, how much movement of toothfish into these areas is needed to sustain the predators, and how these interactions may affect how we model natural mortality rates in the assessment models. While these questions are of interest in defining the ecological role of toothfish in the ecosystem and would lead to better spatial management advice, the Working Group noted that the research was unlikely to directly impact the assessment of the status and dynamics of the overall Ross Sea stock, which was driven by the fishery removals, tag-recapture data and larger-scale population processes.

4.90 WG-FSA-15/42 presented a spatially explicit population model of *D. mawsoni* in the Ross Sea region to investigate the effects of a proposed marine protected area (MPA) on the status of the toothfish population using several metrics. The study indicated that the MPA design proposed in 2013 is likely to result in a small increase in the catch limit under existing management rules, as well as a large increase in the proportion of the Ross Sea area with low levels of local depletion of the population and no increase in the area with higher levels of depletion.

4.91 The Working Group noted that it would be useful to update the SPM with recent data to determine its sensitivity to additional data. The Working Group agreed that the influence of sea-ice on the distribution of fishing effort was unlikely to influence the size structure of toothfish in the area, but that sea-ice would influence the distribution of fishing effort under various MPA scenarios.

4.92 The Working Group agreed that the approach used in WG-FSA-15/42 for evaluating the likely effects of alternative MPA scenarios, and the consequent redistribution of fishing effort on the toothfish population, may also be useful for the development of management strategy evaluations in the region. The Working Group requested that the Scientific Committee consider priority issues and scenarios that may utilise this approach.

4.93 WG-FSA-15/08 discussed a proposal to release 10 archival tags during the 2016 shelf survey being conducted by New Zealand. Tags have been obtained from two different companies that provide data on depth, temperature and light level or magnetic field to potentially characterise geolocation. The initial one-year pilot study will be used to evaluate which tags provide the most useful data. Later studies will be planned in context of the US and New Zealand MPA proposal with 50 archival tags released within the proposed general protection zone and special research zone. It is hoped that this will allow data to be collected and reported within two years of release. Fish will be double-tagged in addition to the archival tag which will be marked with contact details.

4.94 The Working Group noted that in previous tagging studies information on the archival tags had not been circulated sufficiently to the industry and one had been recaptured and remained on a vessel without being reported. It also noted that the proponent will endeavour to contact the 20 vessels notified to fish in the area prior to the fishing season and will contact Members and technical coordinators.

### *Dissostichus* spp. Subarea 88.2

4.95 In 2014, the Scientific Committee and the Commission agreed to a two-year research plan in Subarea 88.2 in which the catch limit for SSRU 882H was 200 tonnes, and fishing in SSRUs 882C–G was restricted to the four research blocks with a combined catch limit for SSRUs 882C–G in 2015 of 419 tonnes, with no more than 200 tonnes to be taken from any one of the research blocks. In addition, a multi-Member research survey was agreed by the Scientific Committee and the Commission for SSRUs 882A–B for 2014/15 and 2015/16. The Commission agreed a catch limit of 50 tonnes per vessel and four vessels participated in 2014/15.

4.96 In 2015, the total reported catch of *Dissostichus* spp. in Subarea 88.2 (SSRUs 882C–H) was 624 tonnes. This was divided between research blocks 882_2 (188 tonnes), 882_3 (146 tonnes), 882_4 (82 tonnes) and SSRU H (208 tonnes). In addition, 109 tonnes were taken from the two research blocks in SSRUs 882A (82 tonnes) and 882B (27 tonnes) (Table 1). For 2016, eight Members with a total of 19 vessels have notified their intention to participate in the exploratory fishery for *Dissostichus* spp. in Subarea 88.2.

#### SSRUs 882A–B north

4.97 WG-FSA-15/32 provided the results of the first year of the two-year multi-Member longline survey for toothfish in the northern Ross Sea region (SSRUs 882A–B) as well as the proposed operations for the second year, combining and updating the separate Member-specific papers submitted to WG-SAM-15 (WG-SAM-15/17, 15/31, 15/32, 15/41, 15/42 and 15/46). The survey had variable but generally high catch rates, almost exclusively of *D. mawsoni*, with low levels of by-catch. Most fish were mature, with an age structure in each research block comparable to cell-specific estimates from the Ross Sea region SPM (Mormede et al., 2014). The survey proponents recommended minor modifications for the second year of operations to aid in the achievement of the objectives, including specification of data collection requirements, bathymetric survey requirements, research block-specific catch limits (25 tonnes per research block) to ensure a greater spread of effort, and a higher level of scientific oversight of survey operations to ensure optimal scientific design and data collection.

4.98 The Working Group recalled the discussion of the survey at WG-SAM-15 (Annex 5, paragraphs 4.30 to 4.36). It noted the value of updating the SPM with the biological and bathymetric data collected during the survey, given the potential influence of bathymetry on the expected distribution and age structure within the research blocks.

4.99 The Working Group recommended that vessels return to the same four blocks sampled in 2015 to enable the recapture of tagged fish and improve estimates of age composition, following this, any remaining effort could be used to sample new research blocks to improve the characterisation of the area.

4.100 Dr S. Kasatkina (Russia) noted that WG-FSA-15/32 provided the CPUE data as kg toothfish per km line set (WG-FSA-15/32, Table 2). However, data from the SSRUs 882A–B north survey revealed variability in the number of hooks per km line set (from 1 521 to 1 042 hooks per 1 km line set) between vessels participating in the survey and from trip set to trip set.

4.101 The Working Group agreed that CPUE data normalised to 1 000 hooks would be more suitable for the SSRUs 882A–B north survey in 2015. It further agreed that the variability of hooks per km line set requires attention to ensure standardised gear is used during the SSRUs 882A–B north survey.

4.102 Dr Kasatkina noted that results of the longline surveys for toothfish in the northern Ross Sea region (SSRU 882A–B) in 2015 revealed high values of CPUE which amounted to 3 500 kg per 1 km line set or to 5 000 kg per thousand hooks and with considerable variation in catches.

4.103 The Working Group agreed it was important to investigate the source of the high CPUE as CPUE is valuable data for understanding fish distribution patterns and for inclusion in the SPM.

4.104 Dr Kasatkina proposed to undertake further analysis for consideration by WG-SAM of the data collected from the SSRUs 882A–B north survey in 2015, with a particular focus on:

(i) reconciling the VMS data with reported haul locations
(ii) the relationship between hauling speed and number of fish caught per unit effort
(iii) the relationship between hauling time and catches.

4.105 The Working Group requested that the survey proponents provide support for this process by conducting an analysis of CPUE variability, haul duration and haul speed for WG-SAM-16 and include a comparison with all exploratory fisheries and closed areas.

4.106 The Working Group noted that a Norwegian vessel would not be able to participate in the survey this year (Table 1). It recalled the recommendation of WG-SAM-15 (Annex 5, paragraph 4.36) and requested that the Scientific Committee consider contingency plans for research survey proposals this year to enable alternative vessels with appropriate gear configurations to be substituted to ensure necessary data collection and continuity of the research survey. It noted that another similar allocation mechanism was proposed for Divisions 58.4.1 and 58.4.2 (WG-FSA-15/54).

4.107 The Working Group recommended the second year of the survey proceed applying the agreed design with a maximum of 6 900 hooks per set and 17 250 hooks per cluster, a minimum cluster separation of 10 n miles and a total effort limit of 244 950 hooks set per vessel and a tagging rate of 3 fish per tonne of catch. The Working Group agreed that a catch limit of 50 tonnes per vessel, and no more than 25 tonnes per research block, deducted from the catch limit from the Ross Sea region, was appropriate. It recommended that all survey participants complete the data collection requirements and bathymetric survey requirements and provide daily data summaries, as described in WG-FSA-15/32.

### SSRU 882A south

4.108 WG-FSA-15/27 described the Russian research program on resource potential and life cycle of *Dissostichus* species from SSRU 882A from 2015 to 2018 and presented an updated version of the survey proposal from 2014 to incorporate recommendations from the Scientific Committee (SC-CAMLR-XXXIII, paragraph 3.226) and WG-SAM (Annex 5, paragraphs 4.41 and 4.42).

4.109 Dr Kasatkina recalled the discussion of the survey proposal at WG-SAM-15 (Annex 5, paragraphs 4.37 to 4.42). She noted that the recommendations of both SC-CAMLR-XXXIII and WG-SAM-15 have been addressed in the updated version of the Russian research program (WG-FSA-15/17):

(i) the catch limit for this research fishing should be subtracted from the Ross Sea catch limit (SC-CAMLR-XXXIII, paragraph 3.226)

(ii) an alternative vessel with appropriate gear configuration has been notified to participate in the research fishing. The longline vessel *Palmer*, which deploys the autoline system, will carry out the Russian research program in the southern region of SSRU 882A. Moreover, there is opportunity to invite scientists from other Member countries to take part in the Russian survey: a Ukrainian researcher is planned to be on board in 2015/16.

4.110 Dr Kasatkina 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 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.

4.111 The Working Group noted that the design of a multiyear survey by Russia (surveying period, fishing gear) provides the possibility for combining data in the southern region of SSRU 882A with the SSRUs 882A–B north survey, consistent with the advice of SC-CAMLR-XXXIII (Annex 5, paragraph 4.20).

4.112 The Working Group noted the potential of the Russian research program to provide data to be used by the SPM of the Ross Sea region and to better understand toothfish movement and distribution relative to the remainder of the Ross Sea stock, as well as to support the fishery-dependent data collection plan for the Ross Sea region.

4.113 The Working Group noted that the research proposal had common objectives with the work in SSRUs 882A–B north and recalled its longstanding recommendation for collaborative research proposals. It noted that the proposed research survey addresses research priorities consistent with those identified for the proposed Special Research Zone in the revised Ross Sea region MPA proposal (CCAMLR-XXXIV/29; SC-CAMLR-XXXIV/BG/31).

4.114 The Working Group recommended that the proposal proceed and be undertaken with a catch limit of 100 tonnes taken from the Ross Sea region catch limit. It agreed that the proposed research catch limit should be subdivided, with a catch limit of 60 tonnes inside the main box and a catch limit of 40 tonnes taken from one of the three optional boxes (see WG-FSA-15/27; SC-CAMLR-XXXIII, paragraph 3.226).

General advice on stock assessment

4.115 The Working Group considered that when the SSB status is close to the target level, it is to be expected that SSB status will fluctuate around the target level over time as a result of: (i) variability in YCS, (ii) more information on the stock that may change model estimates such as those for $B_0$, current stock status and YCS, and (iii) as a function of adjustments using the CCAMLR decision rule.

4.116 The Working Group requested that the Scientific Committee include in its considerations for the priorities for WG-SAM the need to evaluate the expected behaviour of the stock status for all stocks when they are near the target level, with particular focus on what time period SSB status would typically be below the target level and by how much it would fluctuate around the target level given variability in, for example, YCS.

4.117 The Working Group recognised a number of issues discussed across stock assessments, and requested that the Scientific Committee consider the following as potential focus topics for WG-SAM:

(i) methods to estimate fish growth functions and simulations of the impact of sampling procedures on the growth curve estimates

(ii) the effect of applying single-sex versus sex-based assessment models and the impact on management advice

(iii) alternative data weighting approaches within a stock assessment model

(iv) methods to quantify the level of spatial overlap between tagged fish and subsequent fishing effort, and evaluation of the potential bias introduced into stock assessments and tag-based biomass estimates when the distributions of tagged fish, fishing effort and the underlying stock distribution are spatially heterogeneous

(v) the expected behaviour of the stock status for stocks which are near the target level, with particular focus on the uncertainty in $B_0$ estimation, the time period SSB status might be below the target level and by how much it would fluctuate around the target level given variability in, for example, YCS

(vi) evaluation of decision rules for stocks with an uncertain catch history, e.g. for stocks that had experienced IUU catches prior to the time when the assessment time series starts and thus the $B_0$ estimated by an assessment may not represent an unfished $B_0$

(vii) decision rules for the application of tag-based estimates of stock size without a corresponding estimate of $B_0$ (i.e. Chapman estimates).

Model diagnostics

4.118 WG-FSA-15/60 presented the model diagnostics and results from an integrated stock assessment model for *E. superba* in Subarea 48.1. In addition to the 'base-case' configuration of the krill model from WG-EMM-15/51 Rev. 1, seven alternative configurations based on different data weightings evaluated the influence of different data sources on the model estimates.

4.119 The Working Group noted that it was appropriate to discuss this paper in WG-FSA, given the expertise in stock assessment models present at the Working Group, but recommended that further developments of this assessment model be presented to both WG-SAM for review of the model structure and diagnostics, and to WG-EMM for management implications.

4.120 The Working Group considered that the model diagnostics were helpful to understand model fits to the data and the ability of the model to estimate all model parameters, including unfished recruitment $R_0$, the steepness of the stock–recruitment relationship and natural mortality. The likelihood profiles for unfished recruitment and recruitment steepness indicated that there was conflicting information in the data to estimate some of the correlated parameters concurrently with great confidence.

4.121 Dr Kasatkina indicated that some uncertainty in the presented model diagnostics for the *E. superba* assessment in WG-FSA-15/60 was associated with input data that were derived from acoustic and trawl samples. Dr Kasatkina noted that during the study period catch samples were obtained using different gear constructions. The latter should lead to high variability in gear characteristics (catchability, selectivity and swept volume) between research and commercial trawls and, as a result, should impact on krill length compositions and biomass density, or CPUE induces removed from catch samples. Moreover, estimates of krill biomass densities removed from acoustic and trawl samples are not comparable. Dr Kasatkina noted that there is no clear understanding of how the abovementioned uncertainty in data could impact on the real uncertainty associated with estimating krill population parameters in Subarea 48.1 from the proposed model. She expressed concerns regarding the risk to underestimate the real uncertainty provided by the proposed model diagnostics.

4.122 The Working Group recommended the following work to refine the assessment:

(i) evaluate models where some of the correlated parameters are fixed at different starting values while estimating only the remaining ones to determine boundary values and general model trends that could be important for management advice

(ii) present further model diagnostics on the prior and posterior distributions of model estimates, including boundary values

(iii) clarify how the median and variability of the pre-exploitation spawning biomass is estimated, noting that the biomass at the beginning of the estimated time series is not the same as the pre-exploitation median spawning biomass

(iv) account for, and evaluate, model uncertainty derived from the variability in length-frequency distributions and biomass density estimates of krill due to different gear selectivities and trawl types. Different gear constructions can lead to high variability in catchability, selectivity and swept volume of used gears especially between researches trawl (IKMT, RMT8) and commercial trawls, as well as between commercial trawls. In addition, estimates of krill biomass densities removed from acoustic and trawl samples may not be directly comparable.

## Generic issues

Fishery nomenclature and the CCAMLR regulatory framework

5.1 The Working Group discussed the regulatory framework as it related to the development of assessments in areas with different fishery status (e.g. exploratory or closed), as described in CCAMLR-XXXIV/17 Rev. 1. The Working Group agreed that, while the regulatory framework was mainly a Commission issue, the confusion caused by the implementation of research plans using commercial fishing vessels as research platforms in areas designated as closed or with a prohibition against fishing, made the administration of research plans in these areas confusing.

5.2 In particular, the Working Group noted that several research plans implemented in ‘closed’ areas under CM 24-01, are identical in design and purpose to those implemented in data-poor fisheries under CM 21-02.

5.3 The Working Group recommended that nomenclature could be adapted to align with the status of either being an exploratory fishery with an assessment, or an exploratory fishery with a research plan progressing towards an assessment. Closed fisheries would then become those that had a catch limit set to zero.

5.4 The Working Group recalled that some management areas have a prohibition on directed fishing under CM 32-02 and that these prohibitions may reflect the result of depleted fish stocks, toothfish overfishing due to IUU activity, or an absence of catch limits in other conservation measures. In addition, the Working Group recalled that there were also management areas (SSRUs and divisions) where there was not a prohibition in CM 32-02 but a catch limit of 0 tonnes was applied to exploratory fisheries for toothfish. The Working Group noted that understanding the reason why such prohibitions and zero-tonne catch limits arose had important implications for providing future management advice for those fisheries.

5.5 Dr Kasatkina expressed concern that the recommendations set out in CCAMLR-XXXIV/17 Rev. 1 have the potential to have significant impacts on CCAMLR fisheries. She noted that proposed recommendations for streamlining fishery status requires special considerations with a particular focus on: (i) how the status of some fisheries should be changed and which of new/revised conservation measure(s) would be required; (ii) which of ensuing consequences for CCAMLR fisheries would be provided by streamlining fishery status. Dr Kasatkina proposed to discuss CCAMLR-XXXIV/17 Rev. 1 in the intersessional period and conduct a workshop. The results of the workshop will be presented to WG-EMM and WG-FSA.

Research plans

5.6 The review of research plans by WG-SAM-15 was summarised in a self-assessment table and presented in WG-FSA-15/14, along with recommendations to help streamline the review process and improve the likelihood that research plans will reach their objectives.

5.7 The Working Group agreed that it would be more efficient to only review ongoing research plans by exception and to have standardised reporting on an annual basis to WG-FSA instead.

5.8 The Working Group noted the value of summaries of the status of fisheries, the need for overarching data collection plans specific to management areas (area, subarea or division specific) and the need for summaries of individual research proposals.

5.9 The Working Group agreed that an effective way to collate the required summaries was for the Secretariat to augment the existing Fishery Reports to ensure that a Fishery Report is available for each management area where toothfish are taken (either in research or commercial fishing). The Working Group recommended that the Fishery Reports include the following (in addition to the information currently contained in the existing fishery reports): an assessment annex (where there is an assessment) and a data collection plan, which will summarise research for the area. The data collection plan would then have appended summaries of the individual research proposals (along the lines of the research summary in CM 41-10, Annex 41-10/B), which would include hyperlinks to the original research proposals (and any revisions) as well as details of any amendments to that version of the proposal that were introduced in the most recent version of the plan prior to agreement by the Commission.

5.10 The Working Group recalled that for some exploratory fisheries, data collection plans had been developed and agreed by the Scientific Committee and the Commission (SC-CAMLR-XXXIII, paragraph 3.209; CCAMLR-XXXIII, paragraph 5.52). It agreed that, where such plans exist, they could be readily appended to the Fishery Report.

5.11 The Working Group recommended that as research plans are developed and reviewed, milestones related to providing estimates of local abundance, stock structure, natural mortality, age–length keys (growth), maturity ogive, selectivity and impacts on dependent and related species, should be agreed and used to evaluate the progress of research plans.

5.12 The Working Group further noted that the milestones specified would best be divided into at-sea and shore-based components in order to emphasise the need to develop analyses and stock assessments in addition to collecting catch, tagging and biological data as part of the steps required to develop a stock assessment to meet the objectives of the Convention (Table 5).

5.13 The Working Group noted that multi-Member research plans should be encouraged and that submission of a single research plan for multiple Members could be efficiently organised. The Working Group further noted that the analytical support necessary to develop a robust stock assessment is significant and that the workflow necessary to develop and maintain a robust stock assessment, as described in Table 5, is required to ensure the objectives of Article II are met.

5.14 The Working Group discussed whether the previous performance of survey proponents should be considered in evaluating the likelihood that survey proposals would be able to provide useful scientific information and achieve the survey objectives. The Working Group recommended that the Scientific Committee consider how previous performance of nominated proponents could be assessed and considered when evaluating future survey proposals.

Mark-recapture data analysis

5.15 The Working Group welcomed the development of R code to estimate the uncertainty of Chapman biomass estimates using a bootstrap method described in WG-FSA-15/49. The Working Group noted that in the current configuration, the Chapman biomass estimate is not made if no recaptures of tagged fish were found in the bootstrap calculations (paragraph 4.26) and requested additional analysis to determine the best analytical approach to address seasons where no recaptures were reported.

5.16 The Working Group discussed the analysis of tagging data within the research plans and suggested that the process of calculating biomass estimates could be reviewed by WG-SAM-16 with the aim of developing a 'best practices' document that Members could refer to when developing these types of analyses. The topics could include the recommended methods for treating seasons with no recaptures, methods to pool estimates among years, methods to estimate uncertainty, methods to determine the number of tagged fish at liberty, gear-specific effects on tag detection (e.g. to account for loss of tags if cachaloteras were used) and methods to determine the number of recaptured fish for biomass estimation.

5.17 The Working Group recommend that the Secretariat provide an updated revision of the summary table of local biomass estimation methods and recommended research catch limits in research blocks, catch reported in 2015, number of tagged fish available and the expected and observed recaptures (see SC-CAMLR-XXXIII, Annex 7, Table 5), with details of the methods used to calculate all values presented in the table provided in a document to WG-SAM-16.

5.18 As an initial component of the 'best practices for toothfish mark-recapture analysis' document, the Working Group discussed the method to determine the number of tagged fish at liberty and developed a process that could be used to calculate local estimates of indicative biomass. The process includes a mechanism to discount the number of tagged fish released by tagging mortality, natural mortality and tag shedding, and the criteria used to identify tagged fish available for recapture to include in Chapman biomass estimation or in the estimation of expected recaptures (such as treatment of tagged fish release data from quarantined trips, or the use of tagged fish released from trips with poor tag-overlap statistics).

5.19 The Working Group noted that natural mortality and tag-loss rate can be applied to the number of tagged fish available in any time-step. Although some fisheries show a highly seasonal pattern in recapture effort, resulting in an annual application of natural mortality and tag-loss rates, in some fisheries effort is distributed throughout the year. The Working Group noted that appropriate time-steps over which to apply mortality and tag-loss rate, as well as assumptions of mixing and equal probability of recapture associated with mark-recapture approaches, should be considered if using time-steps of less than a year.

5.20 After considering the additional analyses presented by the Secretariat that showed the frequency distribution of the time at liberty of tagged fish, the Working Group agreed that, while some fish had been recaptured after seven years, most tagged fish were recaptured within the first three years after release. Additionally, the Working Group noted that the retention of tagged individuals appeared to vary among areas, with research block 486_2 displaying a similar pattern to Subarea 88.2, where the current hypothesis included the reduction of the tag-recapture rate due to immigration of untagged fish in the area.

5.21 The Working Group had previously recommended that only tagged fish releases from vessels that have had a tagged fish recaptured should be used in mark-recapture analysis as a data quality assurance measure (SC-CAMLR-XXXII, Annex 6, paragraph 6.13). The Working Group reviewed tagged fish release and recapture data and noted that since 2009 all vessels have had at least one tagged fish recaptured (with the exception of 48 tagged fish released in the Ross Sea by the *Argenova XXI*).

5.22 The Working Group agreed that all tagged fish released in years, beginning in 2009, should be considered suitable for inclusion for the purposes of estimating biomass and expected recaptures in Subareas 48.6 and 58.4, unless there are specific reasons for their exclusion. The Working Group further agreed that all tags available for recapture be included in both biomass estimation analyses and in calculations of the number of recaptures expected in the coming season.

5.23 The Working Group considered factors, other than immigration, that were not currently accounted for that could potentially explain the apparently lower than expected rates of recaptures of tagged fish. These included the factors that influence the spatial pattern of fishing relative to the availability of tagged fish (paragraph 4.25), the effort that had been deployed to recapture tagged fish and the potential for gear and/or vessel-specific differences in tag-detection rates (paragraph 5.16).

5.24 The Working Group discussed the operational issues that might be preventing the data collection elements of research plans from being completed, as indicated by the research catch not being fully utilised for catch-limited research in some areas. The Working Group requested that the Scientific Committee consider that a possible solution to this may be, in the first instance, to give priority to research fishing in a particular block or area for a three-year time period to ensure that data that was necessary to perform an integrated stock assessment would be collected. The Working Group agreed that Subarea 48.6 would be a good candidate area if this approach of focusing research effort is implemented.

### Provision of management advice in data-poor fisheries affected by IUU fishing

5.25 The Working Group recalled that there had been substantial IUU fishing for *D. eleginoides* in many of the divisions and subareas of the Convention Area during the 1990s, which had led to varying levels of depletion of these stocks and in some cases had led the Commission to close fisheries (e.g. Division 58.4.4). The Working Group further noted that IUU fishing for *D. eleginoides* had continued more recently in some of these stocks and that there had been a displacement of IUU fishing to *D. mawsoni* over the past decade. Recent sighting data suggest that this is a particular issue in the data-poor fisheries in Subareas 48.6 and 58.4 (paragraphs 3.40 to 3.47). Estimates of IUU catches were made for these fisheries up until 2011 based on vessel sightings, but with the recent move to gillnets and the uncertainties associated with making estimates of IUU catches, the catches of *Dissostichus* spp. have not been estimated over the past five years.

5.26 The use of the current CCAMLR decision rules for providing management advice requires knowledge of the stock status at the beginning of the assessment period and knowledge of subsequent removals from the fishery. If IUU fishing had already reduced the stock size before the regulated fishery took place, then the estimate of unexploited SSB from the stock assessment would be underestimated. Consequently, exploiting a stock to 50% of an initial biomass estimate that had previously been over-exploited would not be consistent with CCAMLR Article II.

5.27 The Working Group agreed that, where estimates of IUU catches are available, they should be used in the assessment and that sensitivity analyses could be carried out to detect the effect of varying levels of these IUU catches on the results. However, where IUU fishing is known to have occurred, or still be occurring, and estimates of catches are unavailable, alternative methods for providing management advice need to be developed.

5.28 The Working Group recalled that an alternative way of providing management advice for these fisheries is to multiply an estimate of current vulnerable biomass by a precautionary exploitation rate where the exploitation rate would have high confidence in not reducing the stock further.

5.29 The Working Group recalled previous simulation work carried out to examine the effect of research catches on the recovery of depleted stocks by Welsford (2011). This analysis showed that even small research catches could delay the recovery of stocks which had been severely depleted. It also recalled previous discussions on this topic based on WG-SAM-13/37 at the 2013 WG-SAM meeting (SC-CAMLR-XXXII, Annex 4, paragraph 2.7viii) stating 'Combined catch limits for all research blocks in a stock or SSRU should be evaluated to ensure that the combined catch is lower than a precautionary exploitation rate. The Working Group recognised that exploitation rates of 3–4% of $B_{current}$ (at the scale of the stock or SSRU) are appropriate for stocks with current status ranging from 20% to 100% $B_0$, consistent with previously utilised methods (SC-CAMLR-XXX, Annex 7, paragraphs 5.22 and 5.34) to ensure that research catches do not delay recovery for depleted stocks (Welsford, 2011).' However, it was also noted that this advice was based on research fishing only being for five years with no fishing thereafter.

5.30 The Working Group agreed that further simulations would be useful to evaluate appropriate exploitation rates which include parameters specific to particular fisheries and stock–recruit relationships at various levels of stock status.

## Circumpolar *D. mawsoni* habitat model

5.31 The Working Group considered WG-FSA-15/64, presented by the Secretariat, detailing work on modelling the circumpolar habitat suitability of *D. mawsoni* using the Maxent method. The paper presented two methods of selecting background data that included a random selection within the Convention Area and targeted selection of background that was restricted to where toothfish fishing had occurred. The results showed that model parameterisation and predictions were highly sensitive to the background selection method used, but that model predictions from the target group background approach that was primarily driven by temperature, performed well in the regions where data had been collected. A post-processing method was applied to the target group model to constrain the predictions to regions that had suitable bathymetry that presented the most realistic predictions.

5.32 The Working Group welcomed this analysis and agreed that it provided a useful approach to understanding spatial differences in the habitat suitability of *D. mawsoni* and had also developed a useful approach to utilising fisheries data in a circumpolar scale model. The Working Group suggested that the model could be used to make inferences about the relative species composition of IUU catches associated with sightings data, such as those presented in CCAMLR-XXXIV/BG/12.

5.33 The Working Group encouraged further development of the spatial habitat modelling, including the consideration of other methods including presence–absence and abundance methods, testing the model predictions with independently derived data in time and or space, including testing predictions using the data that would be collected in the proposed research block 486_4 in areas of marginal habitat such as on Macquarie Ridge.

## Management area research reviews

### Subarea 48.2

5.34 WG-FSA-15/43 Rev. 1 provided a summary on the longline survey results in Subarea 48.2 undertaken by Ukraine in 2014/15. This survey was the first year of a three-year investigation aimed at estimating the status of *Dissostichus* spp. in this subarea. The Working Group noted that information collected included the ratio of the species *D. mawsoni* and *D. eleginoides* in the studied area and that both *D. mawsoni* and *D. eleginoides* are encountered in the northern regions, whilst only *D. mawsoni* were found in southern regions.

5.35 WG-FSA-15/43 Rev. 1 presented a plan by Ukraine to continue longline survey research activities in Subarea 48.2 for 2015/16. The Working Group noted that there were no changes to the research plan from that set out in WG-SAM-15/40. The Working Group noted the proposal to stratify the survey by area by dividing the survey region into the northern bank and the southern seamount area. The Working Group also noted that a reduction of the tagging rate to 3 fish per tonne was proposed in the southern seamount stratum as a result of the density of longline sets in this area being higher than in the northern banks region.

5.36 WG-FSA-15/10 presented a proposal by Chile to undertake a three-year program of toothfish research fishing in Subarea 48.2, which was an update of WG-SAM-15/53. The Working Group noted the similarity in the survey design, station locations and area presented in the proposal with that proposed by Ukraine.

5.37 The Working Group noted that neither of the proposals included a timeline to develop assessments, either by mark-recaptures or other preliminary stock assessment methods. The Working Group agreed that this should be developed and presented for review.

5.38 The Working Group noted the scientific benefits of having more than one vessel participating in the research, although there is the potential for interference between the plans set out in WG-FSA-15/43 Rev. 1 and 15/10. The Working Group recommended that Ukraine and Chile coordinate on the research, including deliverables and milestones with respect to sampling efforts at sea, laboratory work and analytical work in view of the common aim of an integrated stock assessment for the area.

5.39 Drs K. Demianenko and L. Pshenichnov (Ukraine) recalled that the three-year research plan submitted by Ukraine had been considered by WG-FSA-14 and approved by the Scientific Committee and the Commission. The next season (2015/16) will be the second year of the three-year research plan and Ukraine indicated that it has all preconditions for completing the research plan.

5.40 In light of the new research plan by Chile, Drs Demianenko and Prof. P. Arana (Chile) requested that the Scientific Committee consider an appropriate catch limit for each research vessel ensuring that there is adequate spatial coverage in accordance with each research survey plan.

5.41 Consistent with other data-poor regions in the Convention Area, the Working Group agreed that the current catch levels should not increase with the increase in the number of participants undertaking the research, but that it would be desirable to coordinate spatial and temporal sampling of the area. This coordination should be undertaken by the two proponents. It was noted that the plans as set out with respect to laboratory and analytical intentions are very ambitious and undertaking work toward these objectives will require substantial determination by the proponents.

5.42 The Working Group noted that there are differences between tagging rates in the southern region of the research area (3 fish per tonne vs 5 fish per tonne). It was agreed that tagging at the higher rate of 5 fish per tonne would be more desirable as long as the condition of the fish allowed tagging at this higher rate.

5.43 The Working Group agreed that, as this is a closed area with very little historical longline fishing for *D. mawsoni*, it was important to collect as much information as possible on target, by-catch and other components of the ecosystem. The Working Group noted that there are genetic studies underway to determine potential linkages between the southern Subarea 48.4 and Subarea 48.2 stocks of *D. mawsoni*.

### *Dissostichus* spp. Subarea 48.5

5.44 WG-FSA-15/29 described the revised Russian research plan to undertake research for *Dissostichus* spp. in Subarea 48.5 (Weddell Sea) from 2015/16 to 2019/20.

5.45 The Working Group noted both the review of research activities undertaken in 2012/13 (WG-SAM-15/22) and an earlier version of the proposal set out in WG-SAM-15/18 (Annex 5, paragraphs 4.8 to 4.16). The Working Group noted that the primary difference in the revised proposal was that the number of vessels notified to undertake the research was reduced to one.

5.46 The Working Group further requested a rationale for why a five-year, rather than a three-year, time frame for this research is specified in the revised proposal.

5.47 Dr Kasatkina recalled the Scientific Committee recommendation that a future Russian research program in the Weddell Sea would need to be consistent with the original research objectives approved in 2012 (SC-CAMLR-XXXIII, paragraph 3.233) and that WG-FSA-15/29 presented the original research program in the Weddell Sea adopted by the Scientific Committee in 2012 (WG-FSA-12/12; SC-CAMLR-XXXI, paragraph 9.16) with some revisions to incorporate the comments of WG-SAM-15 (Annex 5, paragraph 4.13).

5.48 Dr Kasatkina noted that WG-SAM-15 raised no objections, other than the number of vessels (two vessels) that participated in research fishing and concern about vessel safety in the Weddell Sea, given potentially heavy ice conditions. She also noted that one vessel was notified for research fishing. Moreover, there is the opportunity to invite scientists from other Member countries to provide full transparency of the research fishing. A Ukrainian researcher will be on board in 2015/16. She noted that analysis of ice conditions in the Weddell Sea from 2003 to 2015 provided evidence that three different spatial options could be undertaken depending on where ice conditions would be favourable.

5.49 The Working Group recalled the advice from WG-SAM in relation to the survey in this area (Annex 5, paragraphs 4.8 to 4.16). It recalled that during 2012/13 Russia fished in the area and reported that the catch limit was reached after the deployment of eight lines.

5.50 The Working Group agreed that once the analysis of the quarantined 2012/13 and 2013/14 data was complete, the strategy recommended to achieve the research objectives may change and, therefore, the Working Group cannot evaluate if the proposed design is appropriate at this time to reach the original objectives agreed by the Scientific Committee (SC-CAMLR-XXXIII, paragraphs 3.232 and 3.233).

5.51 Dr Kasatkina also noted that the proposal fully meets the requirements of CMs 21-01, 21-02 and 41-01 and that the catch limit was adopted by the Commission in 2012 (CCAMLR-XXX, paragraph 5.42). Dr Kasatkina emphasised that the Convention and conservation measures raise no objections against providing research investigations in the Weddell Sea and the quarantined data analysis requested by the Scientific Committee in parallel is an unrelated processes.

5.52 The Working Group agreed that it was unable to provide any further advice to that provided by the Scientific Committee in 2014 (SC-CAMLR-XXXIII, paragraphs 3.230 and 3.231).

5.53 The Working Group requested an update on the progress of the analysis of the data collected in 2012/13 and 2013/14 on the *Yantar 35* that both the Scientific Committee and WG-SAM had requested from Russia.

5.54 The Working Group noted that WG-SAM had agreed that the report from Russia (WG-SAM-15/22), describing the Russian analysis of the 2012/13 Subarea 48.5 fishing survey, be brought to the attention of SCIC. Some Members consequently requested that the Secretariat undertake an analysis of the quarantined data from research activities in Subarea 48.5 and provide a report to the working groups for further consideration in 2016. The Working Group agreed that the results of this and previous Secretariat analyses should be available to WG-SAM and WG-FSA in 2016 before it is able to make recommendations in respect of the research proposal going forward.

Research plans for data-poor exploratory fisheries in Subarea 48.6

5.55 The current limits on the exploratory fishery for *Dissostichus* spp. in Subarea 48.6 are described in CM 41-04. In 2014/15 the catch limit was revised to 538 tonnes and applied to the suite of research blocks shown in Figure 1 (see Fishery Report).

5.56 For 2016 a total of three vessels, one each from Chile, Japan and South Africa, had notified their intention to participate in the exploratory fishery for *Dissostichus* spp. in Subarea 48.6.

5.57 The Working Group noted that WG-SAM had reviewed research proposals by Japan (WG-SAM-15/06) and South Africa (WG-SAM-15/39) to continue research to develop stock assessments for toothfish in Subarea 48.6. It also noted the advice on developing an assessment in research block 486_2 and developing new research blocks in this subarea (Annex 5, paragraphs 3.2 to 3.5).

5.58 The Working Group noted that no fishing had occurred since WG-SAM and, therefore, there was no data available to update estimates of biomass from those presented at WG-SAM-15. Hence, South Africa's research plan was unchanged from that presented in WG-SAM-15/39. Japan provided a revised research plan (WG-FSA-15/16 Rev. 1) that incorporated a proposal to extend research block 486_4 to the west. Furthermore, during the meeting Dr K. Taki (Japan) used the method in WG-FSA-15/49 to provide bootstrap confidence intervals for the Chapman tag-recapture biomass estimates. The Working Group welcomed this analysis as it provided a basis to compare the precision of CPUE and tag-based biomass estimation, as well as enabling estimating bounds on the numbers of tags expected to be caught in the next season.

5.59 The Working Group noted that WG-FSA-15/24 proposed an extension of research block 486_4. The Working Group welcomed the analysis of sea-ice and other environmental conditions in this paper. It further noted that it was not proposed to increase the catch limit to account for the increased seabed area in the extension. It further noted that the proposed area was contiguous with an area where tags had been successfully released and recaptured, therefore there was a higher likelihood of detecting movement along the shelf in the proposed area than for research blocks separated by large distances.

5.60 The Working Group noted that there was uncertainty in the rate of mixing of toothfish in this region and this would need to be taken into account when using tag recaptures (or the lack thereof) in the proposed extension area in estimating biomass, for example, by doing separate estimates for research block 486_4 and the proposed extension. It therefore encouraged the vessels fishing in this area to endeavour to fish in the main area as a priority to ensure that a consistent time series of data is maintained.

5.61 The Working Group endorsed the extension to research block 486_4, noting that it was desirable to fish in the original research block as a priority (Figure 2).

5.62 WG-FSA-15/66 provided a summary of the data available for developing an assessment in research block 486_2, as requested by WG-SAM-15 (Annex 5, paragraph 3.3). The Working Group noted that a time series of tag recaptures has been collected, as well as reproductive, catch-at-length and length-at-age data. It noted that with the development of otolith ageing programs in South Africa and Japan a preliminary integrated assessment should be developed and submitted to WG-SAM-16 for review.

5.63 The Working Group noted that younger fish seemed to be absent in catches from research block 486_2 and encouraged the collection of length-at-age estimates to enable the estimation of the lower limb of the von Bertalanffy growth function. It also requested that research be developed to determine likely sources of recruits to this research block. It further noted that, given the time series of tag recaptures from this area, and the comprehensive sampling of the fishable area by the fishery, it was important to move away from using CPUE by seabed area biomass estimates for this research block.

5.64 The Working Group reviewed revised estimates of biomass for the research blocks in this area, taking into account new estimates of available tags, which included all tags released in the research blocks since 2008. Due to the observation that tagged fish in research block 486_2 seem to remain resident in the area for less than four years, only those tagged fish released and at liberty for less than four years in that area should be considered as being available (as is the case in SSRU 882H).

5.65 Given that the estimate of expected tag recaptures in 2015/16 was considered adequate and none of the current catch limits exceeded 4% of the mean predicted biomass in any research block, the Working Group agreed that catch limits should remain unchanged for 2015/16.

### *Dissostichus* spp. Divisions 58.4.1 and 58.4.2

5.66 The precautionary catch limit for the exploratory fishery for *Dissostichus* spp. in Division 58.4.1 in 2015 was 724 tonnes and this was applied to research fisheries in SSRUs, including research blocks within those SSRUs. The fishery was limited to one Korean and one Spanish flagged vessel using longlines. The Republic of Korea was the only Member that conducted research fishing during the season and undertook research fishing in Division 58.4.1 with a total catch of 123 tonnes, taken as follows:

- 3 tonnes in research block 5841_1
- 16 tonnes in research block 5841_2
- 68 tonnes in research block 5841_3
- 10 tonnes in research block 5841_4
- 26 tonnes in research block 5841_5.

For 2016, a total of five vessels, one each from Australia, France, Japan, Korea and Spain, have notified their intention to participate in the exploratory fishery for *Dissostichus* spp. in Division 58.4.1.

5.67 The precautionary catch limit for the exploratory fishery for *Dissostichus* spp. in Division 58.4.2 in 2015 was 35 tonnes in SSRU E and the fishery was limited to one Korean and one Spanish flagged vessel using longlines. Only the Korean-flagged vessel undertook research fishing activity in Division 58.4.2 with a total reported catch of 11 tonnes. For 2016 a total of five vessels, one each from Australia, France, Japan, Korea and from Spain, have notified their intention to participate in the exploratory fishery for *Dissostichus* spp. in Division 58.4.2.

5.68 The Working Group considered eight papers from five Members describing research plans and a plan for the allocation of catches in Divisions 58.4.1 and 58.4.2. The Working

Group discussed the plans independently and considered how the research conducted for each plan may be harmonised to ensure the objectives of the Convention are met for the divisions overall.

5.69 A proposal by Spain (WG-FSA-15/05), proposals by Japan (WG-FSA-15/17 and 15/18), proposals by France (WG-FSA-15/73 and 15/74) and a proposal by Australia (WG-FSA-15/47 Rev. 1) for work in both Divisions 58.4.1 and 58.4.2, plus a proposal by Korea (WG-FSA-15/56) for work in Division 58.4.1 all incorporated the minor design changes requested by WG-SAM-15 (Annex 5, paragraphs 3.6 to 3.19). The Working Group noted that the presentation of standardised CPUE data for these areas should also include diagnostic plots and fits as developed for stock assessment input data (Annex 5, paragraphs 2.36 to 2.43). The Working Group also pointed out that the research capability by France may be impacted by the availability of the author named in the research plan.

5.70 The Working Group encouraged direct collaboration among Members and noted that different Members may bring different capabilities in analysis, biological study, or modelling to the effort. The Working Group also recognised that the different plans had been in effect for different amounts of time and that changes in individual research plans may influence the overall research plan design in the future. The Working Group suggested that an overarching research plan with measurable milestones for the divisions be developed intersessionally among the proponents to meet the Convention's objectives.

5.71 The Working Group noted that Members will need to coordinate vessels to work together to obtain the required samples and to conduct the appropriate analyses.

5.72 The Working Group noted the catch allocation plan presented in WG-FSA-15/54, where the catch limit in each research block was allocated among Members with the exception of Spain, which fishes outside research blocks as part of its experimental design. The allocation plan avoids Olympic fishing by allocating catch to each Member in a transparent fashion while allowing flexibility by reallocating catch after a threshold date of 30 January, or by notification that a Member no longer intends to fish.

5.73 The Working Group discussed how the allocation of catches among Members may impact the success of each individual research project and the overall objective of developing a stock assessment for the area. For example, with different objectives, catch data and biological samples may be spread among a subset of participating Members and require collaborative analysis or result in risk of not reaching the objectives of the research plan. Alternatively, vessels that change the timing or order of their fishing could impact the timing and availability of catch for other vessels. In addition, the Working Group noted that the scientist named in the French proposal was not present to discuss and advance coordination of the research plans.

5.74 The Working Group recalled that improved seabed area estimates were now available using International Bathymetric Chart of the Southern Ocean (IBCSO) data and developed in WG-SAM-15/01. The resulting changes in seabed area in each research block were used to scale the existing catch limits. The Working Group noted that the allocation of catch limits among Members for all the areas (with the exception of Spain) resulted in individual Members with small catch limits within a research block (Table 6).

5.75 Following additional consultations by Australia, the Republic of Korea and Spain, the revised catch limits were tentatively agreed as in Table 6 (noting that France was not involved in these discussions). The Working Group noted that further discussions about the catch arrangements among Members should be deferred to the Scientific Committee and that although many objectives may be specified in the plans, the priority objective is to obtain data needed to develop a stock assessment. The Working Group encouraged further intersessional coordination to optimise the research design.

5.76 The Working Group noted that with the reduction in catch limit resulting from the seabed area adjustment, it was appropriate that the Australian proposal's grid design be modified from a 5 × 5 km grid to a 4 × 4 km grid to enable an entire grid to be completed within the expected catch limit.

5.77 The Working Group noted that the additional in-season adjustment of catch allocation and the need for near real-time coordination will require enhanced communication and coordination by the Secretariat and routine coordination among vessels for the management of small catch limits.

5.78 The Working Group recommended that the proponents further coordinate the operations of their research efforts for all five research plans and that the adjusted catch limits in Table 6 for 2015/16 were appropriate for the current research objectives. The Working Group further recommended that these research plans be well coordinated and that there were opportunities to share data and biological samples to meet research objectives they have in common.

### *Dissostichus* spp. Division 58.4.3a (Elan Bank)

5.79 Papers considered under this item included:

(i) WG-FSA-15/19 and 15/78, describing plans for research in 2015/16 to support the development of a stock assessment for toothfish in this division by Japan and France

(ii) WG-FSA-15/22, describing an updated stock assessment using CASAL.

5.80 The precautionary catch limit for *Dissostichus* spp. in the exploratory fishery in 2015 was 32 tonnes, and fishing was limited to one French and one Japanese flagged vessel using longlines in research block 5843a_1. At the time of updating this report, only the French-flagged vessel had conducted research fishing in Division 58.4.3a and less than 1 tonne of *D. eleginoides* was caught. For 2016, one vessel from France and one from Japan notified their intention to participate in the exploratory fishery for *Dissostichus* spp. in Division 58.4.3a.

5.81 The Working Group noted that the revised assessments have improved relative to those presented at WG-SAM-15. However, the Working Group also noted the very high age at maturity estimated for this area. Work undertaken during the meeting included using the maturity key and parameters for the von Bertalanffy growth curve as used in the

Division 58.5.2 assessment. The Working Group agreed that the stock assessment was currently not sufficiently robust to provide management advice using the CCAMLR decision rules.

5.82 The Working Group recommended that the points noted above for the preliminary assessments of Divisions 58.4.4a and 58.4.4b also be considered for developing assessments for this division. It further recommended that growth and maturity parameters be further developed for this area.

5.83 In the absence of information to update its advice, the Working Group recommended that the catch limit for this division remain unchanged at 32 tonnes for 2015/16.

### *Dissostichus* spp. Divisions 58.4.4a and 58.4.4b (Ob and Lena Banks)

5.84 Papers considered under this item included:

(i) WG-FSA-15/20 and 15/67, describing plans for research in 2015/16 to support the development of a stock assessment for toothfish in research blocks C and D in this division by Japan and France

(ii) WG-FSA-15/21, describing biological information of toothfish with special reference to by-catch, depredation and spawning dynamics in Divisions 58.4.4a and 58.4.4b by the *Shinsei Maru No. 3* (Japan) from 2008 to 2014

(iii) WG-FSA-15/23, describing updated stock assessments using CASAL of the toothfish in research block C.

5.85 The Working Group welcomed the updated assessments. It noted that the revised assessments have improved relative to those presented at WG-SAM-15. Further work was undertaken during the meeting. However, this was unable to be progressed to the point of providing management advice using the CCAMLR decision rules.

5.86 The Working Group further noted that the Ob and Lena Bank area, as many areas in the Convention Area, has been subject to unquantified IUU fishing and, therefore, the relative status of the stock cannot be estimated (paragraphs 5.25 to 5.30).

5.87 In the absence of information to update its advice, the Working Group 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 2015/16.

### *Dissostichus* spp. Subarea 88.3

5.88 WG-FSA-15/65 presented a revised three-year research plan for the closed fishery for *Dissostichus* spp. in Subarea 88.3 in 2015/16 by the Republic of Korea. The Working Group noted that the recommendations as set out by WG-SAM (Annex 5, paragraphs 4.20 and 4.21) had been incorporated into the revised research plan.

5.89 The Working Group agreed that the research blocks within Subarea 88.3 should be prioritised. It agreed that the two primary factors that should be taken into account when prioritising research blocks are sea-ice conditions and areas where tagged fish had been released in the past.

5.90 The Working Group noted that research blocks 883_1, 883_3 and 883_4 have historically had more tagged fish released than research block 883_2. The Working Group examined an ice analysis of Subarea 88.3 and noted that research block 883_4 had the least amount of annual sea-ice, followed by research block 883_3 (Figure 3). Research blocks 883_1 and 883_2 appeared to have heavy sea-ice that may restrict access and impede the ability to conduct research.

5.91 The Working Group recommended that the priority for research should be research blocks 883_3 and _4 given the previous tagging in those areas. Research block 883_5 would be a secondary priority, with research blocks 883_1 and _2 a tertiary priority, should ice conditions allow. Dr S.-G. Choi (Republic of Korea) indicated that Korea was not planning to fish in the other research blocks in 2016.

## Bottom fishing activities and vulnerable marine ecosystems (VMEs)

6.1 In 2014, the Scientific Committee requested working groups consider how advice could be routinely reported on the potential impacts on dependent and related species for proposed exploratory fisheries in order that the requirements for exploratory fisheries under CM 21-02 can be satisfied and for helping to ensure that fisheries are consistent with Article II (SC-CAMLR-XXXIII, paragraphs 3.154 and 3.155). It also requested Members to submit analyses for consideration (SC-CAMLR-XXXIII, paragraphs 5.8 to 5.10).

6.2 WG-FSA-15/62 Rev. 1 presented a generalised method for rapidly assessing spatial scales of interactions of fishing gear with user-definable ecological features and Antarctic marine living resources. The purpose of the method is to enable automatic and rapid assessments of potential spatial overlap of fishing with ecological features, for example, bioregionalisation categories, attributes of habitats, foraging areas of predators, or spatial distributions of by-catch species. The method is provided in R-markdown and uses standard R libraries for geographical and spatial analyses. It has the following automated method based on the procedures described in WG-FSA-14/P06.

6.3 WG-FSA-15/62 Rev. 1 also provided a preliminary assessment of interactions of bottom fishing with bathymetric features (depth class inside or outside canyons were identified as categories of habitats) in the east Antarctic (Divisions 58.4.1 and 58.4.2) to illustrate the method and a suite of summary statistics on the level and pattern of interactions. Results show that longline activity has occurred in few patches (contiguous areas of a depth class in or out of canyons) and that the proportion of individual patches affected was mostly less than 10% with most categories of habitats having a total interaction of less than 1%. The degree of aggregation of fishing within patches is variable.

6.4 The Working Group thanked the authors for their work and agreed that the method in WG-FSA-15/62 Rev. 1 provides a useful methodology for rapidly undertaking initial assessments of the interaction of fishing with ecological features of importance to CCAMLR. It noted the following:

(i) as in risk assessments globally, the rapid assessment can help identify potential areas of concern and where further research or management actions may be needed

(ii) this method does not replace the impact assessment method adopted for VMEs which calculates the areal extent and likely mortality resulting from possible impacts of longlines on VMEs

(iii) data layers would need to be chosen for their relevance to objectives of the risk assessment

(iv) as the method tabulates the numbers and proportions of grid cells influenced by fishing, it is dependent on the size of grid cells chosen for the analysis – the size of grid cells needs to be set relative to the scale of the interaction expected from the fishing gear in the specific case being examined

(v) inputs, calculations and results would need to be reviewed by relevant working groups as needed if they are to be presented as advice.

6.5 The Working Group agreed that the risk area tables and the maps of accumulated impact should be updated annually as part of the VME registry (SC-CAMLR-XXXIV/BG/02).

## Scheme of International Scientific Observation (SISO)

7.1 Data collected by scientific observers on longline and finfish trawl vessels operating in the Convention Area during 2014/15, based on data received up to 9 October 2015 (WG-FSA-15/01 Rev. 1), were presented by the Secretariat. It was noted that seabird by-catch figures were the lowest on record and that the publishing of observer names on the CCAMLR website in an honour roll, as recommended by the SISO review panel, had been completed. The Working Group thanked all SISO observers for their contribution. The Secretariat also requested Members' advice on any format and content changes to the current annual summary paper to better present observer summary information.

7.2 Dr Söffker presented WG-FSA-15/07 on the identification of depredation marks by predator species in Southern Ocean fisheries.

7.3 WG-FSA-15/13 considered options for the hosting of observer by-catch guide information, Members' preferences for reviewing materials submitted to the Secretariat and how currently listed material should be incorporated into any updated guides. There was consensus from the Working Group on the Secretariat hosting a repository for materials. The Working Group recommended:

(i) the Secretariat collate currently available species guides online, and develop and moderate an open e-group/forum for these and any future materials' contents

(ii) the Secretariat will analyse observer data, and develop an ID guide of the most frequent by-catch and target catch taxa for review on the forum

(iii) that materials developed for by-catch identification be kept concise for use in the field by SISO observers and vessel crews.

7.4 Mr Gasco presented a series of developments in the French observer program on better training and identification of seabird species at sea (WG-FSA-15/70 and 15/75), cetacean photo ID catalogues (WG-FSA-15/71), methods to record depredation (WG-FSA-15/72) and a tool for standardised renaming of observer photographs (WG-FSA-15/76). The Working Group welcomed the developments that would potentially be useful for SISO.

7.5 The Working Group noted that the tool for training observers at sea in seabird species identification (WG-FSA-15/75) could easily be expanded to include general observer identification tasks such as by-catch species or gonad stage and has the potential to become a useful tool for use in all CCAMLR subareas within SISO, both as a training tool and as a debriefing tool to evaluate observer data accuracy and quality. The Working Group encouraged its further development and requested that the Scientific Committee consider how this can be progressed.

7.6 Dr Jones gave a short presentation to the Working Group on SC-CAMLR-XXXIV/BG/23 which presents the findings of the Technical Peer Review Group (TPRG) on the submission of the Australian observer program for CCAMLR Observer Training Program Accreditation Scheme (COTPAS) accreditation. The TPRG endorsed the findings of the Secretariat review of the Australian program and recommended the final stage of assessment by the Accredited Review Panel be undertaken. Dr Welsford thanked the members of the TPRG for their work.

## Non-target catch in CCAMLR fisheries

Fish and invertebrate by-catch

By-catch

8.1 WG-FSA-15/04 Rev. 1 presented an update to a meta-analysis of by-catch in the Ross Sea toothfish fishery that was considered by WG-SAM-15 (WG-SAM-15/23). Following the presentation of that paper at WG-SAM-15 (Annex 5, paragraphs 2.25 to 2.32), the Secretariat requested via SC CIRC 15/44 information from Members in order to develop a better understanding of how by-catch data are collected and reported on the C2 forms.

8.2 The Working Group noted that the responses received to SC CIRC 15/44 indicated that there are different approaches to fulfilling the CCAMLR data collection and reporting requirements on longline vessels in the Ross Sea. Arising from these differences, there was a distinct relationship between the allocation of the task of data collection for the C2 forms and the relative by-catch rates. In particular, vessels from Flag States where the task of data collection and completion of the C2 forms (either for catch and/or by-catch) is undertaken by observers, have a mean by-catch rate that is approximately 50% lower than those vessels where the task is under the remit of the crew.

8.3 The Working Group thanked Australia, France, Japan, the Republic of Korea, New Zealand, Russia, South Africa, Spain, Ukraine and the UK for providing detailed information in response to SC CIRC 15/44 but noted that not all Members that had participated in

CCAMLR fisheries had provided the requested information. The Working Group wished to draw the attention of the Scientific Committee to the need for all Members to respond to CIRCs requesting information that is essential to the work of CCAMLR.

8.4 The Working Group agreed that data on by-catch in CCAMLR fisheries are fundamental to the aims of Article II of the CAMLR Convention and expressed its concern that these data were not being provided in a way that would allow by-catch levels in those fisheries to be addressed. Furthermore, the apparent lack of consistent reporting of by-catch data has implications for the application and compliance with elements of conservation measures that relate to by-catch, such as move-on rules and overall by-catch limits.

8.5 In considering the apparent inconsistencies in reporting of by-catch, the Working Group recognised that there needs to be a consideration of how the existing data can be used to assess by-catch rates in CCAMLR fisheries, i.e. is it possible to develop some correction factor to account for methodological difference in data collection.

8.6 The Working Group also noted that none of the Members that responded to SC CIRC 15/44 provide instructions to vessels on how the C2 data form should be completed and requested the Scientific Committee to consider how this should be achieved to ensure that reliable and accurate data can be collected and reported in the future.

8.7 In addition to providing a standard set of instructions, the Working Group recognised that there may also need to be a consideration of alternative methods for the collection of catch data, including the use of electronic/video monitoring and automated reporting systems.

8.8 The Working Group recalled that it is the responsibility of the Flag State to comply with catch reporting in conservation measures and not the responsibility of the scientific observer. It further recalled that the role of the scientific observer is to collect data on attributes (such as the fish length, weight, age etc.) of samples from that catch. The Working Group also agreed that it was not possible for observers to collect all data on catch and by-catch and conduct the range of tasks required under SISO. Furthermore, when the responsibility for the collection and reporting of C2 data on the vessel is given to the observer, that undermines the expectation of independence of observer data collected as part of SISO. The Working Group recommended that the issue of inconsistent data in the C2 forms should be directed to SCIC.

8.9 Dr Kasatkina highlighted the importance to develop a detailed manual on by-catch sampling throughout CCAMLR longline fisheries. She noted that there should be a clear understanding on how by-catch data should be collected and reported in practice. She proposed that the draft manual should be submitted for consideration by WG-SAM and WG-FSA.

8.10 WG-FSA-15/50 presented results from recent work on updating biological parameters of *C. rhinoceratus* in Division 58.5.2. The updated parameters were then used to calculate two-year and 35-year projections of *C. rhinoceratus* biomass under continuous fishing pressure as by-catch in the *C. gunnari* and toothfish trawl fishery. These calculations showed that a maximum yield of 2 208 tonnes for 2015/16 and 1 689 tonnes for 2016/17 would meet the CCAMLR decision rules in the short term. For the long-term projection, a maximum yield of 1 663 tonnes per year would meet the decision rules. These estimated limits were not expected to be reached as CM 33-02 prohibits directed fishing for *C. rhinoceratus* in

Division 58.5.2. The paper further recommended that a limit based on 1% of the biomass estimate from the survey stratum with the lowest density of *C. rhinoceratus* would be appropriate to set as a trigger level for *C. rhinoceratus* move-on rules. This would change the trigger level from 2 tonnes to 5 tonnes in Division 58.5.2.

8.11 The Working Group recommended that the move-on rule trigger limit be changed from 2 tonnes to 5 tonnes for *C. rhinoceratus* in Division 58.5.2.

8.12 The Working Group concluded that the short-term projections were consistent with the CCAMLR decision rules. After thorough examination of the long-term projections in relation to biomass estimates, the Working Group also concluded that the suggested 1 663 tonne maximum catch limit for *C. rhinoceratus* satisfied both CCAMLR decision rules and would not put the stock at risk over the projected period, thus the by-catch limit in CM 33-02 should be revised accordingly.

8.13 The Working Group recalled that the three strategies for dealing with by-catch within CCAMLR are to firstly avoid, secondly mitigate and, should these first two strategies fail, finally to develop risk assessments and that this paper formed part of that risk assessment. The Working Group stressed that this risk assessment was only an option that would be used if strategies for avoidance and mitigation failed and that it was unlikely that this maximum limit would not be taken as a by-catch of the fisheries within the projection period. A regular review of the risk assessment was suggested.

8.14 The Working Group noted that a scientific analysis and review of by-catch level limits set in exploratory research blocks should be encouraged.

8.15 WG-FSA-15/51 presented an update on the biological parameters of the grey rockcod (*Lepidonotothen squamifrons*) in Division 58.5.2. The improved ageing estimates indicated an increase in the maximum age to 24 years. Three populations with distinct geographical distribution were found in the division.

8.16 The Working Group welcomed the paper and the updated biological parameters of this formerly exploited species. The results from this initial work indicated slow but steady stock recovery, although at different rates within the three identified geographical populations. This apparent heterogeneity of the subpopulations is consistent with previous observations in this species such as highlighted in Gregory et al. (2014) for Subarea 48.3.

8.17 In WG-FSA-15/63 the biological parameters of the grenadier species *M. caml* were updated based on recent (2015) survey and longline by-catch data in Division 58.5.2. The paper presented a risk assessment for the longline by-catch, derived from a GYM for this by-catch species based on the trawl survey.

8.18 The Working Group commended the effort to scientifically evaluate the currently set by-catch limits for Macrouridae in Division 58.5.2 and noted that an assessment similar to that presented here for *M. caml* was currently not possible for the remaining macrourid species due to lack of biological data. As *M. caml* formed the vast majority of Macrouridae in the trawl survey, this species was brought through a full risk assessment, however, the remaining species were rarely caught in the survey and thus biological data was not available in sufficient quantity.

8.19 The Working Group noted that although the majority of Macrouridae caught in the trawl survey was *M. caml*, the composition of by-catch in the longline fishery is uncertain. Data from a single longline trip estimated that most Macrouridae by-caught were bigeye grenadier (*M. holotrachys*), and that *M. caml* contributed a small proportion to the longline by-catch. The Working Group thus raised concerns as to whether the maximum yield calculated for *M. caml* based on the trawl survey could be applied directly to all Macrouridae caught in the longline fishery in addition to 150 tonnes for non-identified *Macrourus* spp., given the difficulty in identifying individuals to species in this taxon.

8.20 The Working Group noted that, although the identification to species in Macrouridae is known to be difficult (see WG-FSA-02/29), the distinction into the two morphs comprising sister species is possible for crew reporting C2 data. The two morphs comprise *M. caml* and Whitson's grenadier (*M. whitsoni*) in one group, and *M. holotrachys* and ridge-scaled grenadier (*M. carinatus*) in the second group.

8.21 The Working Group reviewed the new assessment based on *M. caml* in Division 58.5.2 and compared it to the previous assessment derived from estimates of *M. carinatus* from Division 58.4.3b (SC-CAMLR-XXII, Annex 5, paragraphs 5.244 to 5.249). It concluded that the previous assessment is applicable to *M. carinatus* and its sister species *M. holotrachys* due to the likely latitudinal separation of the two grenadier morph groups, and the low likelihood that sister species *M. caml* or *M. whitsoni* were misidentified in this survey.

8.22 The Working Group agreed that the use of locally estimated life history parameters for a given by-catch species was more appropriate than the use of globally derived parameters of similar species. The Working Group agreed that the risk assessment shows no current risk to *M. caml* as by-catch in the longline fishery in Division 58.5.2. The Working Group further agreed that the long-term projections for *M. caml* under the proposed maximum catch limit of 409 tonnes would satisfy both CCAMLR decision rules.

8.23 Following the review of the risk assessment presented in WG-FSA-15/63 and the previous assessment in SC-CAMLR-XXII, Annex 5, paragraphs 5.244 to 5.249, the Working Group recommended that the maximum by-catch limit for grenadiers in Division 58.5.2 in 2015/16 be set separately for the two morphs. The limit derived from the risk assessment in WG-FSA-15/63 of 409 tonnes should apply for *M. caml* and *M. whitsoni* combined and the limit derived from the previous assessment in SC-CAMLR-XXII, Annex 5, paragraphs 5.244 to 5.249, of 360 tonnes should apply for *M. holotrachys* and *M. carinatus* combined. The morph-specific limits proposed for 2015/16 should be reviewed at WG-FSA as new by-catch information becomes available.

8.24 Stressing that the aim for by-catch management is primarily avoidance and mitigation, the Working Group noted that existing by-catch mitigation methods should be reviewed if the catch limits set for by-catch are regularly reached.

8.25 The Working Group encouraged future work planned by the authors on by-catch of *Macrourus* species representation in the Division 58.5.2 longline fishery including:

(i) historic catch composition based on genetic identification of archived otoliths

(ii) morph-specific catch composition and spatial distribution within the Division 58.5.2 longline fishery in 2015/16

(iii) validation of observer identification based upon genetic identification of otoliths collected within the Division 58.5.2 longline fishery in 2015/16.

8.26 The Working Group agreed that the change of the move-on trigger level to 3 tonnes per line for all species combined as *Macrourus* spp. is appropriate in Division 58.5.2 and should be revised accordingly in CM 33-02.

8.27 The Working Group noted the issue of autolines connected by floating sections of rope as shown in Figure 7 of WG-FSA-08/60. Each section of fishing line from anchor to anchor is currently recorded as single line in the C2 data. There is concern that this is being used as a method of circumventing the by-catch trigger level.

8.28 The Working Group recommended a review of the definition of a set line to the Scientific Committee in order for by-catch levels to be recorded and move-on rules be triggered appropriately.

### Marine mammal and seabird by-catch

8.29 Australia presented WG-FSA-15/48 regarding a review of results from fishing during the season extension trials in 2013/14 and 2014/15. The paper detailed that 2.4 million hooks have been set during the season extension between 15 and 30 April, that the majority of setting occurred at night, and that one seabird was caught during the season extension trial. Australia proposed to extend the step-wise pre-season trial to include 1 to 14 April with both day and night setting allowed. The proposed criteria for assessing the effectiveness of mitigation during the new season extension are that at least 500 000 hooks have been set during daylight, with a cumulative total seabird catch not exceeding three birds per vessel over this period. Similarly, Australia proposed that a post-season extension trial continue under the condition that no more than three seabirds are caught from 500 000 hooks set in the period 15 to 30 November. If the limit of three by-caught birds per vessel is reached in either season extension, the trial will be terminated.

8.30 The Working Group noted that the recent experience of a single high seabird by-catch incident in Subarea 48.3 during the season extension trial in early April suggests that birds may be more vulnerable during this period and recalled the suggestion made in WG-FSA-14/28 to avoid setting in daylight and within three hours of nautical dusk/dawn where possible. Therefore, if this is also found to be the case in Division 58.5.2, then additional mitigation, such as night setting only, may be required in the season extension.

## Biology and ecology of Antarctic fish

9.1 WG-FSA-15/08 described an initiative to monitor *D. mawsoni* movement and habitat preferences in the Ross Sea utilising pop-up archival (MiniPAT) tags deployed in January 2016 on fish within the General Protection Zone (GPZ) and Special Research Zone (SRZ) in the Ross Sea Region MPA proposal (CCAMLR-XXXIV/29).

9.2 The Working Group welcomed this initiative and was looking forward to receiving first results of this study in 2017.

9.3 From 2001 to 2013, the number of breeding pairs of Adélie penguins (*Pygoscelis adeliae*) at breeding colonies in the southern Ross Sea more than doubled from 235 000 to more than half a million. WG-FSA-15/41 tested the hypothesis that predation release of Antarctic silverfish (*Pleuragramma antarctica*) due to fishing of one of its predators, *D. mawsoni*, could have contributed to this increase.

9.4 The analysis in WG-FSA-15/41 found only a weak link between changes in toothfish biomass and changes to the biomasses of silverfish and Adélie penguins. Even if toothfish diet was composed of 100% silverfish, it was still not sufficient to explain the observed increase in the number of Adélie penguins in the southern Ross Sea.

9.5 WG-FSA-15/41 encouraged the development of further specific hypothesis mechanisms by which fishing could affect the wider Ross Sea ecosystem. The paper considered that understanding the ecosystem effects of the toothfish fishery on the demersal fish community of the Ross Sea slope, and on Weddell seals and Type C killer whales, is of high priority.

9.6 The Working Group noted that WG-EMM had considered WG-EMM-15/53 at its 2015 meeting (see Annex 6, paragraphs 2.89 and 2.90) and that the updated paper was provided to WG-FSA for information.

9.7 The Working Group noted that the biomass of silverfish was derived from acoustic observations during the 2008 International Polar Year (IPY) survey in the Ross Sea.

9.8 WG-FSA-15/46 described age determination conducted on *D. eleginoides* and *D. mawsoni* using otoliths collected during the scientific program on board the Ukrainian vessel *Simeiz* in Subarea 48.2 in 2015. Preliminary results of age determinations suggested that individuals of 15 to 35 years prevailed for both species. The Working Group welcomed this data from an area which had previously not been studied for toothfish and noted how rapidly ageing information had been made available.

9.9 WG-FSA-15/57 provided detailed information on the diet and feeding strategy of *D. mawsoni* in Divisions 58.4.1 and 58.4.2. Macrouridae were the dominant prey item in the size classes (121–140, 141–160 and 161–180 cm). Results underlined results from earlier studies that *D. mawsoni* is an opportunistic predator feeding overwhelmingly on fish.

9.10 The Working Group noted the value of such detailed studies which included the occurrence of a petrel and a penguin foot. The Working Group was reluctant to speculate where those were originating from. An apparent misidentification was *G. blacodes*, but see paragraph 2.37.

9.11 *P. antarctica* is the dominant pelagic fish in the continental shelf waters of the high Antarctic region where it plays a key role in the food web. A monitoring program was launched by Italy to obtain a better understanding of the first phases of life of *P. antarctica*. It also allowed obtaining new information on life cycle of *P. antarctica* and their early development stages. Links to toothfish ecology, under the ice, and how it relates to *P. antarctica* were drawn. DNA mapping to identify spawning grounds were undertaken (WG-FSA-15/58 and 15/61).

9.12 The Working Group underlined the key position of *P. antarctica* in the high-Antarctic food webs. As such, the species had been initially considered as a species for the CCAMLR Ecosystem Monitoring Program (CEMP). The Working Group also noted that a book is currently in preparation in Italy summarising the results of a wide range of studies on *P. antarctica* in various regions around the Antarctic continent. A number of scientists from CCAMLR Members are contributing to the book.

9.13 WG-FSA-15/06 reported preliminary age determination of *D. mawsoni* from Division 58.4.1. Comparative age readings suggest that results did not differ substantially from those of other readers such as Horn et al. (2003). Age ranged from 5+ to 26+ years. A set of reference otoliths will be made available to the authors intersessionally. Validation experiments will be continued in 2016 by comparative readings by four readers.

9.14 The Working Group recommended that the authors continued cross reading of the same set of otoliths with other laboratories to continue validation of the age readings. The high proportion of otoliths considered to be unreadable was higher than in other studies and may have been caused by readers being relatively inexperienced in reading *D. mawsoni* otoliths. Growth of males and females was found to be similar while the age of males and females of *D. eleginoides* started to diverge after attaining sexual maturity, with females growing faster and attaining a greater $L_\infty$.

## Future work

10.1 The Chair of the Scientific Committee drew the attention of the Working Group to SC-CAMLR-XXXIV/14 that presented a summary from each of the conveners of the priorities for each working group for the next four years. This paper is intended to provide the basis of the discussion at the Scientific Committee on the prioritisation and streamlining of its work.

10.2 In respect of the priorities for WG-FSA, the Convener of WG-FSA clarified that they remained the provision of advice on the assessed fisheries and the development of assessments in other management areas where research was currently being undertaken. He also noted that the process of biennial review of assessments should provide greater scope to review other priority issues. In particular, he highlighted the very important discussions surrounding many aspects of by-catch, from the reporting of data, the application of limits and move-on rules and the assessment of status of by-catch species. He also emphasised the cross-cutting nature of fish by-catch in the krill fishery and the potential for a joint meeting of WG-FSA and WG-EMM to address the theme of by-catch in all CCAMLR fisheries.

10.3 The Working Group agreed that the potential scope of work that could be undertaken was very broad and there was a need to manage expectations of the ability to undertake work and deliver results in a timely a manner. In progressing the work identified as important during this meeting, there was a need to identify a single issue for focus topics, noting that there are long lists of possibilities and to ensure that an appropriate sequence of tasks is put in place to maximise delivery of advice.

10.4 The Working Group agreed that it was important to identify those areas of its work where there was a standing expectation of advice to the Scientific Committee, such as on catch limits in fisheries, in order to ensure that these issues can continue to be delivered in addition to addressing those important cross-cutting issues such as by-catch, depredation, tagging and toothfish diet that had been identified by WG-FSA.

### Review and coordination of research plans

10.5 The Working Group recognised the benefit of performing a focused review of one or two specific research plans next year to assess the status of data relative to informing an assessment, to develop an overall data collection plan for the management area and to set specific milestones for future work conducted under the research plan. Subarea 48.6 and Division 58.4.4 were considered to be potentially suitable regions for a focused review at WG-FSA-16. The Working Group agreed that the outcomes of such a review would assist with developing data collection plans in all closed and exploratory fisheries in the following year.

10.6 The Working Group noted the importance of survey coordination. It noted that Members nominate chief scientists for their survey proposals and that coordination among Members could be facilitated by establishing an e-group for chief scientists involved in multi-Member surveys.

### External activities in support of CCAMLR

10.7 Dr Constable informed the Working Group of a number of activities that would be of interest to the Working Group and the Scientific Committee in the coming year:

(i) Southern Ocean Observing System (SOOS)

SOOS has developed a strategic and implementation plan now available for comment (www.soos.aq). A number of elements of this plan, which were reported to WG-EMM, will be of use to CCAMLR (WG-EMM-15/61; Annex 6, paragraphs 5.12 to 5.14). Members of the Working Group are encouraged to participate in the work of SOOS to develop essential variables for monitoring change in biota, such as for habitats, krill, finfish and predators (CEMP) and to participate in regional working groups as appropriate.

(ii) Integrating Climate and Ecosystem Dynamics in the Southern Ocean (ICED)

ICED is developing end-to-end ecosystem models to support management of marine ecosystems. They have been undertaking stakeholder consultations (with WWF and the krill fishing industry), developing agreed climate change and ocean acidification scenarios for use in evaluating ecosystem changes for the future and developing a toolbox of models for use by the scientific community to explore the implications of these scenarios and recovery of whales, seals and fish for Antarctic marine ecosystems as a whole. Part of their work is oriented towards models that facilitate evaluation of management strategies, such as for krill, and the consequences for human kind of long-term change in Antarctic marine ecosystems.

10.8 A conference on assessing status and trends of habitats, key species and ecosystems in the Southern Ocean will be held in Hobart, Australia, in the first half of 2018 (SC-CAMLR-XXXIV/BG/22). It has four main themes:

(i) assessments
(ii) responses of species to changing habitats
(iii) modelling and other methods for assessing status and trends
(iv) design and implementation of an observing system to estimate dynamics and change.

These themes are of direct relevance to CCAMLR. Members are encouraged to be involved in the working groups supporting these themes over the coming two years. This work aims to support the Scientific Committee on Antarctic Research Advisory Group on Antarctic Climate Change and the Environment (SCAR ACCE) and the Intergovernmental Panel on Climate Change (IPCC) processes and also provide scientific input on species and ecosystems to CCAMLR and the Committee on Environmental Protection (CEP).

## Other business

11.1 Dr R. Leslie (South Africa) drew the attention of the Working Group to WG-SAM-15/51, which proposes a change to the boundary between Subareas 58.6 and 58.7 and the Working Group noted that boundaries for management areas should delineate stocks rather than split them.

## Advice to the Scientific Committee and its working groups

12.1 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.

12.2 The Working Group provided advice to the Scientific Committee and other working groups on the following topics:

(i) Information requirements –

(a) capacity and catch limit overruns (paragraph 3.9)

(b) quarantined data (paragraphs 3.14 and 3.15)

(c) marine debris (paragraph 3.23)

(d) release of live untagged toothfish (paragraph 3.26)

(e) VMS data quality assurance (paragraph 3.32)

(f) conversion factors (paragraph 3.36)

(g) IUU fishing (paragraphs 3.46 and 3.47).

(ii) Assessed fisheries –

(a) *C. gunnari* in Subarea 48.3 (paragraph 4.6)

(b) *C. gunnari* in Division 58.5.2 (paragraph 4.12)

(c) *D. eleginoides* in Subarea 48.3 (paragraph 4.37)

(d) *D. eleginoides* in Subarea 48.4 (paragraphs 4.20 and 4.21)

(e) *D. mawsoni* in Subarea 48.4 (paragraphs 4.25 and 4.28)

(f) *D. eleginoides* in Division 58.5.1 (paragraph 4.43)

(g) *D. eleginoides* in Division 58.5.2 (paragraphs 4.56 and 4.57)

(h) *D. eleginoides* in Subarea 58.6 at Crozet Islands (paragraph 4.48)

(i) *D. eleginoides* at Prince Edward and Marion Islands (no advice)

(j) *Dissostichus* spp. in Subarea 88.1 (paragraphs 4.68, 4.70, 4.76, 4.77, 4.79, 4.81, 4.84 and 4.92)

(k) *Dissostichus* spp. in Subarea 88.2 SSRUs A–B north (paragraphs 4.99, 4.106 and 4.107)

(l) *Dissostichus* spp. in Subarea 88.2 SSRU A south (paragraph 4.114)

(m) general advice on stock assessment (paragraphs 4.116 and 4.117).

(iii) Generic issues with research plans to inform current and future assessments in 'data-poor' fisheries –

(a) research plans (paragraph 5.14)

(b) mark-recapture data analysis (paragraphs 5.17, 5.22 and 5.24).

(iv) Management area research plan reviews for –

(a) *Dissostichus* spp. in Subarea 48.6 (paragraphs 5.61 and 5.65)

(b) *Dissostichus* spp. in Divisions 58.4.1 and 58.4.2 (paragraph 5.78)

(c) *Dissostichus* spp. in Division 58.4.3a (paragraph 5.83).

(v) Research fishing in other areas –

(a) *Dissostichus* spp. in Subarea 48.2 (no advice)

(b) *Dissostichus* spp. in Subarea 48.5 (paragraph 5.50)

(c) *Dissostichus* spp. in Divisions 58.4.4a and 58.4.4b (paragraph 5.87)

(d) *Dissostichus* spp. in Subarea 88.3 (paragraph 5.91).

(vi) Scheme of International Scientific Observation –

(a) hosting observer by-catch guide and related information (paragraphs 7.3i–iii)

(b) observer training at sea (paragraph 7.5).

(vii) By-catch –

(a) coordination between WG-EMM and WG-SAM (paragraph 3.4)

(b) fish and invertebrate by-catch reporting (paragraphs 8.3, 8.6 and 8.8)

(c) Division 58.5.2 and proposed modifications to CM 33-02 (paragraphs 8.11, 8.12, 8.23 and 8.26)

(d) review of 'set line' definition to aid move-on rule triggers (paragraph 8.28).

## Adoption of the report

13.1 The report of the meeting was adopted.

## Close of meeting

14.1 In closing the meeting, Dr Belchier thanked all the participants for their contributions to constructive engagement in the Working Group's work and the subgroup coordinators who had led discussions on a range of difficult and lengthy issues. He also thanked the rapporteurs and the Secretariat for their support to the work of WG-FSA-15.

14.2 On behalf of the Working Group, Dr Jones thanked Dr Belchier for his leadership in steering the Working Group through a large, and at times challenging, work program and thanked him for the leadership he had provided over four years of serving as WG-FSA Convener.

## References


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Welsford, D., M. Sumner and G. Ewing. 2014. Estimates of the multi-gear footprint of the toothfish fishery at HIMI. In: Welsford, D.C., G.P. Ewing, A.J. Constable, T. Hibberd and R. Kilpatrick (Eds). *Demersal fishing interactions with marine benthos in the Australian EEZ of the Southern Ocean: An assessment of the vulnerability of benthic habitats to impact by demersal gears*. Australian Antarctic Division and the Fisheries Research and Development Corporation Kingston, Australia.

Mormede, S., A. Dunn, S. Hanchet and S. Parker. 2014. Spatially explicit population dynamics models for Antarctic toothfish in the Ross Sea region. *CCAMLR Science*, 21: 19–37.

Welsford, D.C. 2011. Evaluating the impact of multi-year research catch limits on overfished toothfish populations. *CCAMLR Science*, 18: 47–55.

Table 1: Total reported catches (tonnes) of target species in fisheries in the Convention Area in 2014/15 (to 16 September 2015 unless otherwise indicated, refer to the *Statistical Bulletin* for previous years). CM – conservation measure.

| Target species | Region | CM | Catch (tonnes) of target species | | Reported catch (% limit) |
|---|---|---|---|---|---|
| | | | Limit | Reported | |
| *Champsocephalus gunnari* | 48.3 | 42-01 | 2 659 | 277 | 10 |
| | 58.5.2[a] | 42-02 | 309 | 4 | 1 |
| *Dissostichus eleginoides* | 48.3 | 41-02 | 2 400 | 2 195 | 91 |
| | 48.4 | 41-03 | 42 | 42 | 100 |
| | 58.5.1 French EEZ[a] | n/a | 5 100 | 2 884 | 57 |
| | 58.5.2[a] | 41-08 | 4 410 | 2 530 | 57 |
| | 58.6 French EEZ[a] | n/a | 760 | 433 | 57 |
| | 58 South African EEZ[b] | n/a | 575 | 205 | 46 |
| *Dissostichus mawsoni* | 48.4 | 41-03 | 28 | 28 | 100 |
| *Dissostichus* spp. | 48.6 | 41-04 | 538 | 189 | 35 |
| | 58.4.1 | 41-11 | 724 | 123 | 17 |
| | 58.4.2 | 41-05 | 35 | 11 | 31 |
| | 58.4.3a | 41-06 | 32 | <1 | 2 |
| | 58.4.3b | 41-07 | 0 | - | - |
| | 88.1 | 41-09 | 2 844[c] | 2 724 | 96 |
| | 88.2 | 41-10 | 819[c] | 733 | 90 |
| *Euphausia superba* | 48.1, 48.2, 48.3, 48.4 | 51-01 | 620 000 | 221 048 | 36 |
| | 58.4.1 | 51-02 | 440 000 | No fishing | - |
| | 58.4.2 | 51-03 | 452 000 | No fishing | - |

a Reported in fine-scale data to July 2015.
b Whole EEZ.
c Including the limit and catch from the research surveys.
n/a Not specified by CCAMLR.

Table 2: *Dissostichus eleginoides* (estimated green weight) reported in Catch Documentation Scheme (CDS) fisheries operating outside the Convention Area in the calendar years 2013 to 2015 (to September 2015, refer to the *Statistical Bulletin* for previous years).

| Ocean sector | FAO Area | Catch (tonnes) | | |
|---|---|---|---|---|
| | | 2013 | 2014 | 2015 |
| Southwest Atlantic | 41 | 8 004 | 8 757 | 5 282 |
| Southeast Atlantic | 47 | 60 | 26 | 103 |
| Western Indian | 51 | 324 | 118 | 102 |
| Eastern Indian | 57 | - | - | - |
| Southwest Pacific | 81 | 421 | 424 | 334 |
| Southeast Pacific | 87 | 4 212 | 2 785 | 2 156 |
| Total | | 13 021 | 12 110 | 7 977 |

Table 3: Notifications for exploratory fisheries for *Dissostichus* spp. in 2015/16 as of 5 October 2015 (www.ccamlr.org/en/fishery-notifications/notified).

| Vessel name | Member | Division 58.4.1 | Division 58.4.2 | Subarea 88.1 | Subarea 88.2 | Subarea 48.6 | Division 58.4.3a |
|---|---|---|---|---|---|---|---|
| *Antarctic Chieftain* | Australia | N | N | N | N | | |
| *Globalpesca II* | Chile | | | | | N | |
| *Saint André* | France | N | N | | | | N |
| *Shinsei Maru No. 3* | Japan | N | N | N | | N | N |
| *Kingstar* | Korea, Republic of | N | N | | | | |
| *Sunstar* | Korea, Republic of | | | N | N | | |
| *Kostar* | Korea, Republic of | | | N | N | | |
| *Janas* | New Zealand | | | N | N | | |
| *San Aotea II* | New Zealand | | | N | N | | |
| *San Aspiring* | New Zealand | | | N | N | | |
| *Orion* | New Zealand | | | W | W | | |
| *Argos Helena* | Norway | | | W | W | | |
| *Yantar 33* | Russian Federation | | | N | N | | |
| *Mys Marii* | Russian Federation | | | W | W | | |
| *Yantar 31* | Russian Federation | | | N | N | | |
| *Palmer* | Russian Federation | | | N | N | | |
| *Mys Velikan* | Russian Federation | | | W | W | | |
| *Koryo Maru No. 11* | South Africa | | | | | N | |
| *Tronio* | Spain | N | N | N | N | | |
| *Yanque* | Spain | | | N | N | | |
| *Koreiz* | Ukraine | | | N | N | | |
| *Simeiz* | Ukraine | | | N | N | | |
| *Argos Froyanes* | United Kingdom | | | N | N | | |
| *Argos Georgia* | United Kingdom | | | N | N | | |
| Total Members | | 5 | 5 | 9 | 8 | 3 | 2 |
| Total vessels | | 5 | 5 | 20 | 19 | 3 | 2 |
| Total fished | | | | | | | |
| Total withdrawn | | | | 4 | 4 | | |

Legend: N = notified
W = withdrawn
F = fished

Table 4: Proposals for research fishing for *Dissostichus* spp. in closed areas in 2015/16.

| Vessel name | Member | Meeting document | Subarea 48.2 | Subarea 48.5 | Subarea 88.3 | Division 58.4.4b |
|---|---|---|---|---|---|---|
| *Puerto Ballena* | Chile | WG-FSA-15/10 | ✓ | | | |
| *Saint André* | France | WG-FSA-15/67 | | | | ✓ |
| *Shinsei Maru No. 3* | Japan | WG-FSA-15/20 | | | | ✓ |
| *Greenstar* | Korea, Republic of | WG-FSA-15/65 | | | ✓ | |
| *Yantar 31* | Russia | WG-FSA-15/29 | | ✓ | | |
| *Simeiz* | Ukraine | WG-FSA-15/45 | ✓ | | | |

Table 5: Sequence of steps and skills required to develop stock assessments through targeted research fishing.

| Step | Type of work | Skills required |
|---|---|---|
| Develop stock structure hypothesis | Desktop | Biologist and ecologist |
| Design survey proposal | Desktop | Statistician |
| Collect biological data (e.g. age, growth, maturity, density) | At-sea | Observer/biologist |
| Collect data on dependant and related species | At-sea | Skipper/observer |
| Acquire tagging data for abundance index | At-sea | Skipper/observer |
| Describe fishery (spatial and temporal patterns, tag data) | Desktop | Analyst |
| Develop indicative estimates of local biomass | Desktop | Modeller |
| Develop draft stock assessment | Desktop | Modeller |
| Collect more data | At-sea | Observer/skipper |
| Iterate to improve assessment, review | Desktop | Modeller |
| Identify sources of bias, uncertainty | Desktop | Modeller/ecologist |
| Develop medium-term research plan | Desktop | Biologist/statistician/modeller |

Table 6: Adjusted proposed catch limit (in tonnes) allocations among Members after scaling for the change in seabed area using the IBCSO data (based on WG-SAM-15/64). AUS – Australia; FRA – France; JPN – Japan; KOR – Republic of Korea; ESP – Spain.

| Division | SSRU | 2014 catch limits | AUS | FRA | JPN | KOR | ESP | Total |
|---|---|---|---|---|---|---|---|---|
| 58.4.1 | C | 180 | 34 | 34 | 34 | 34 | 42 | 178 |
| | D | 42 | | | | | 42 | 42 |
| | E | 260 | 65 | 65 | 65 | 65 | - | 260 |
| | G | 51 | 0 | 0 | 0 | 9 | 42 | 51 |
| | H | 42 | | | | | 42 | 42 |
| 58.4.2 | E | 32 | 32 | 0 | 0 | 0 | - | 32 |
| Total | | 607 | 131 | 99 | 99 | 108 | 168 | 605 |

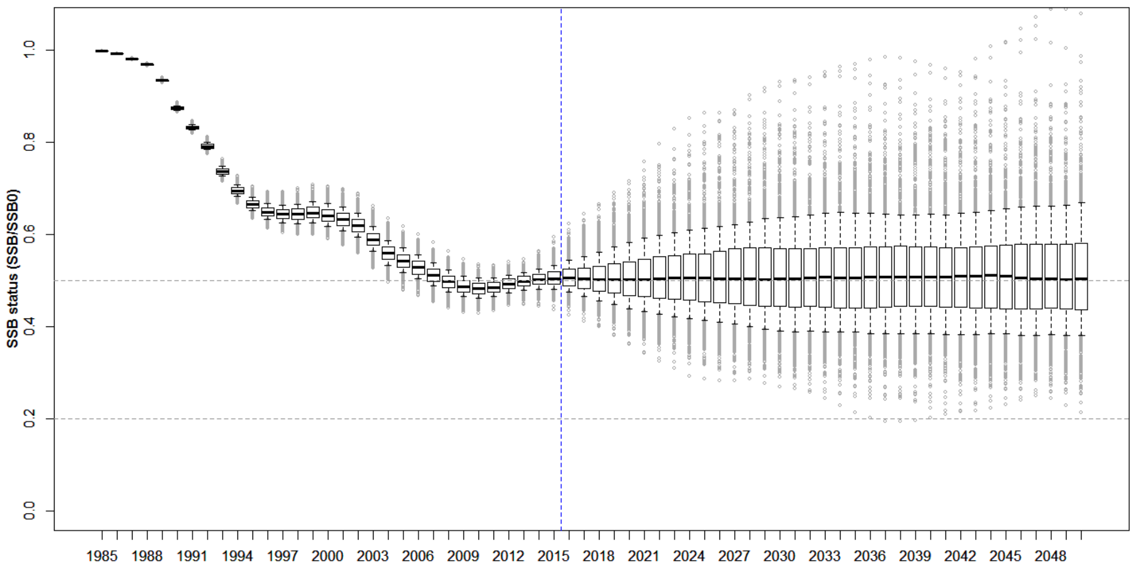



Figure 1: *Dissostichus eleginoides* in Subarea 48.3 SSB status estimated by the model described in WG-FSA-15/59. Dashed horizontal lines show a status of 0.5 and 0.2.

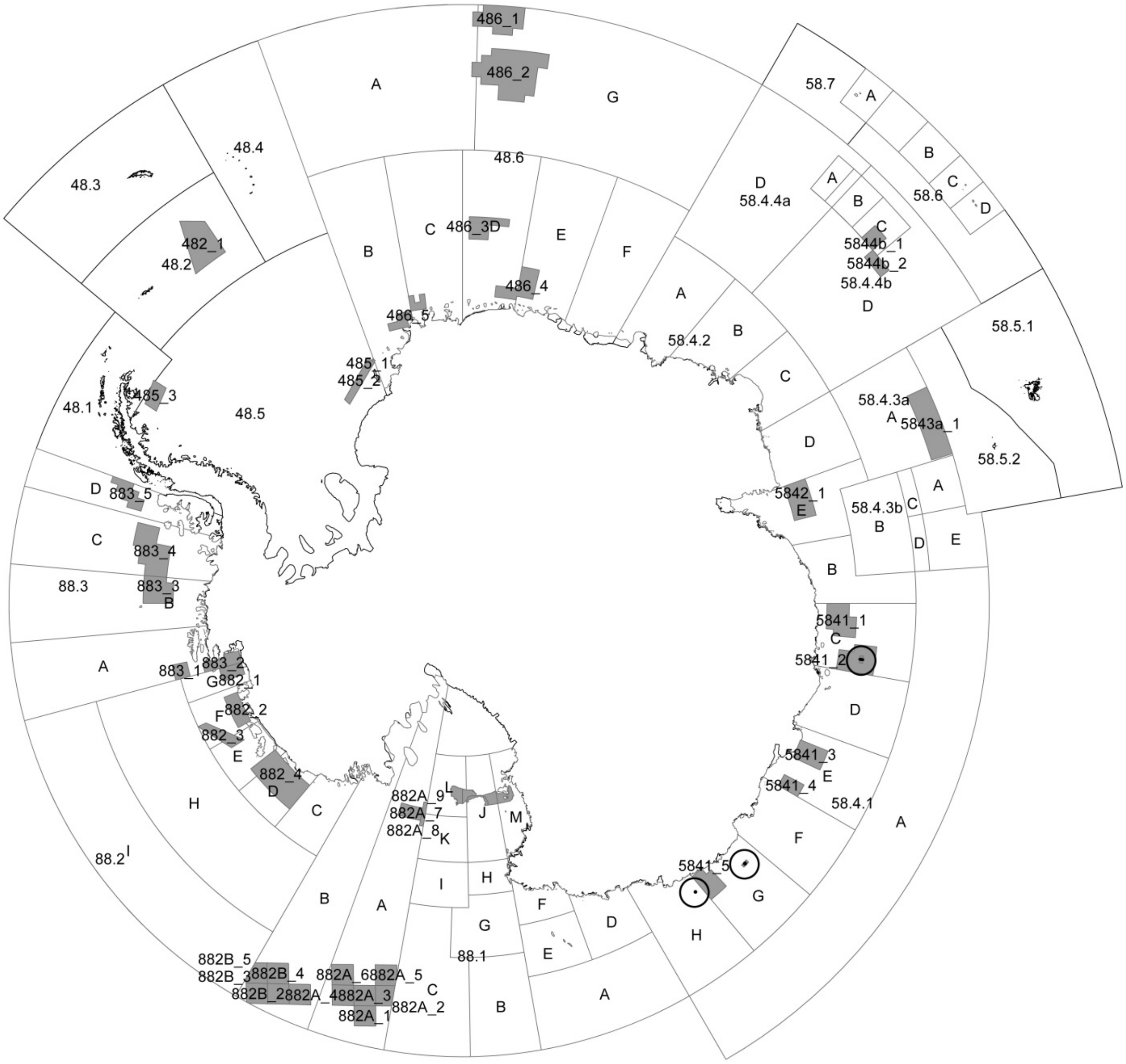



Figure 2: Location of research blocks where research fishing is proposed in exploratory fisheries for *Dissostichus* spp. and closed areas in 2015/16. The circles in Division 58.4.1 indicate the locations of the depletion experiments and stratified grids in SSRUs C and D, and the depletion experiment in SSRU H. The exploratory fisheries are located in Subareas 48.6, 88.1 and 88.2 and Divisions 58.4.1, 58.4.2 and 58.4.3a. The boundaries of small-scale research units (SSRUs) are also shown.

(a)

(b)

(c)

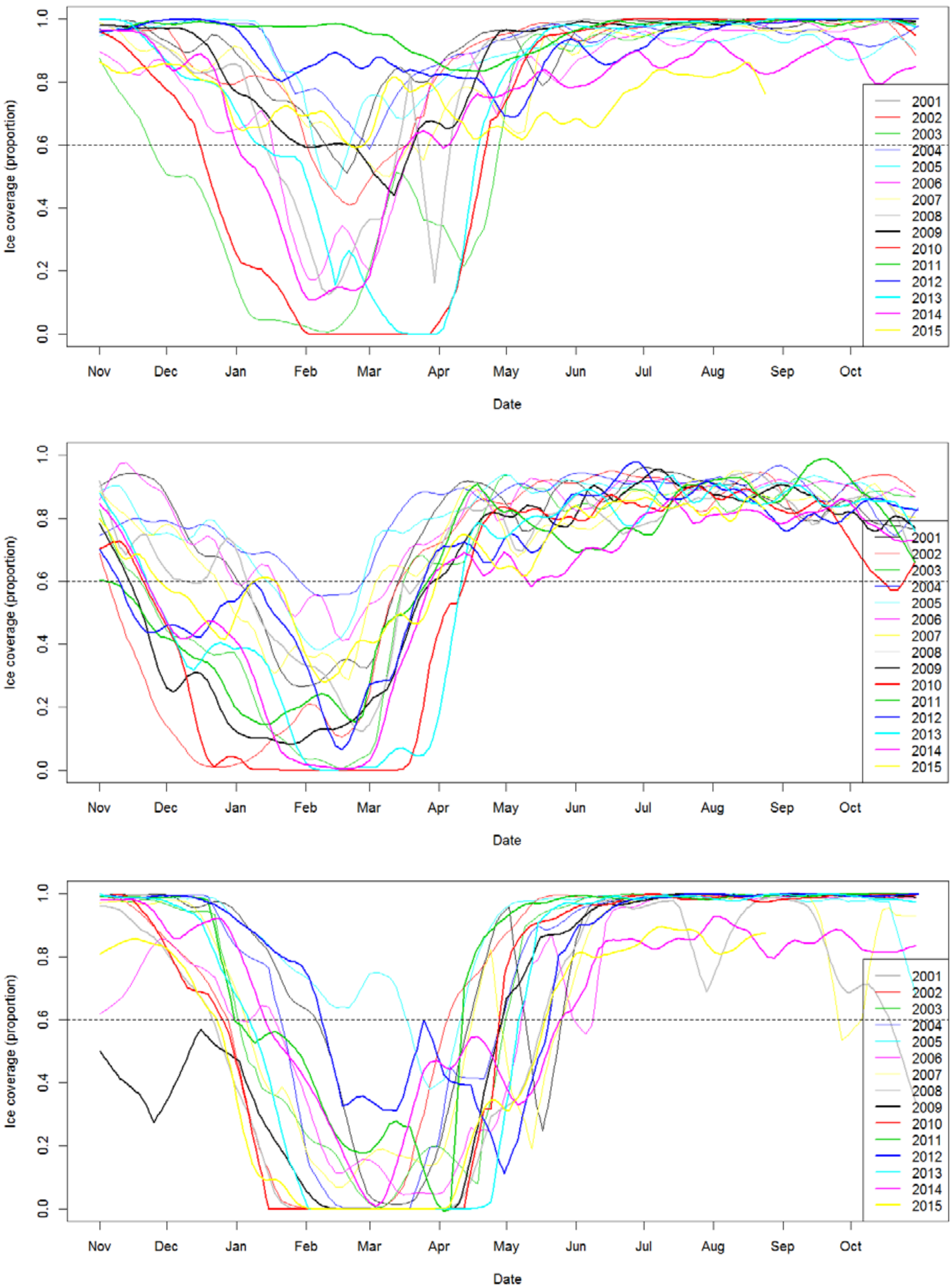
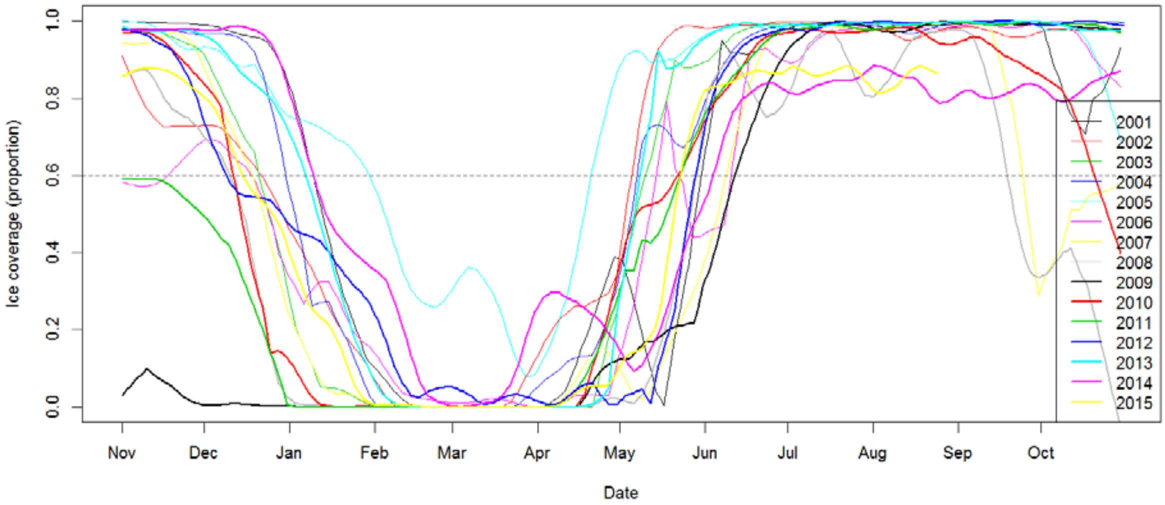



Figure 3: Daily mean sea-ice concentration within research blocks (a) 883_1, (b) 883_2 and (c) 883_3 in Subarea 88.3 (see Figure 2) for fishing years from 2001 to 2015. A threshold of 60% sea-ice concentration was considered to be the maximum level of navigable sea-ice observed for fishing vessels in the Ross Sea, although fishing typically occurs in areas with less than 15% ice coverage (WG-FSA-14/54).

(continued)

(d)




(e)

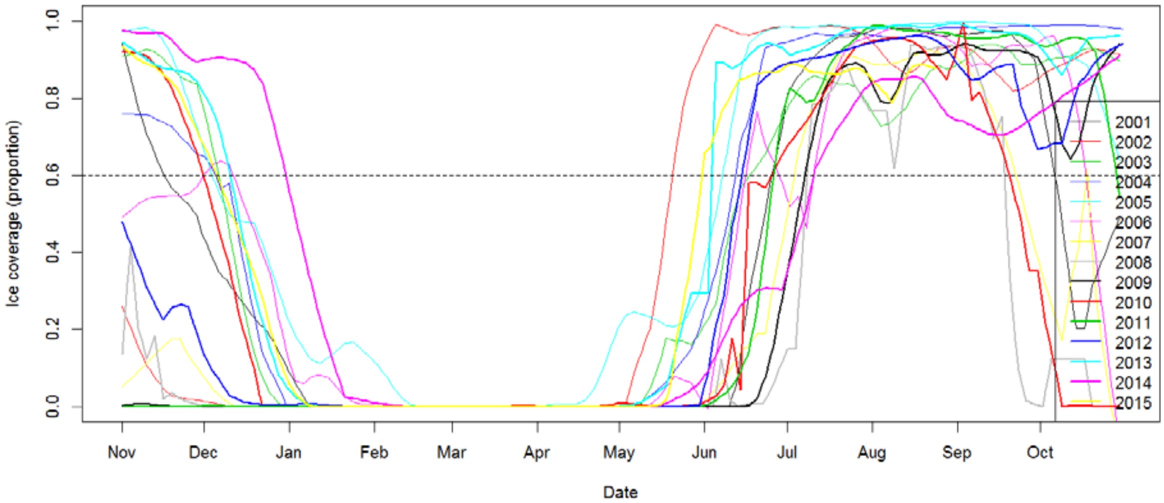



Figure 3 (continued): Daily mean sea-ice concentration within research blocks (d) 883_4 and (e) 883_5 in Subarea 88.3 (see Figure 2) for fishing years from 2001 to 2015. A threshold of 60% sea-ice concentration was considered to be the maximum level of navigable sea-ice observed for fishing vessels in the Ross Sea, although fishing typically occurs in areas with less than 15% ice coverage (WG-FSA-14/54).

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(Hobart, Australia, 5 to 16 October 2015)


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Appendix B

## Agenda

Working Group on Fish Stock Assessment
(Hobart, Australia, 5 to 16 October 2015)

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)

4. Stock assessments for fisheries for *Dissostichus eleginoides* in Subareas 48.3 and 48.4 and Division 58.5.2, for *D. mawsoni* in Subarea 48.4, for *Dissostichus* spp. in Subareas 88.1 and 88.2 and for *Champsocephalus gunnari* in Subarea 48.3 and Division 58.5.2

   4.1 Assessment by management area
      4.1.1 *Champsocephalus gunnari* Subarea 48.3
      4.1.2 *Champsocephalus gunnari* Division 58.5.2
      4.1.3 *Dissostichus eleginoides* Subarea 48.4
      4.1.4 *Dissostichus mawsoni* Subarea 48.4
      4.1.5 *Dissostichus eleginoides* Subarea 48.3
      4.1.6 *Dissostichus eleginoides* Division 58.5.1
      4.1.7 *Dissostichus eleginoides* Subarea 58.6 (French EEZ)
      4.1.8 *Dissostichus eleginoides* Division 58.5.2
      4.1.9 *Dissostichus* spp. Subarea 88.1
      4.1.10 *Dissostichus* spp. Subarea 88.2

   4.2 Model diagnostics
   4.3 Fishery Reports

5. 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

   5.1 Generic issues
   5.2 Management area research reviews
      5.2.1 *Dissostichus* spp. Subarea 48.2
      5.2.2 *Dissostichus eleginoides* Subarea 48.5
      5.2.3 *Dissostichus* spp. Subarea 48.6
      5.2.4 *Dissostichus* spp. Division 58.4.1
      5.2.5 *Dissostichus* spp. Division 58.4.2
      5.2.6 *Dissostichus* spp. Division 58.4.3
      5.2.7 *Dissostichus* spp. Division 58.4.4
      5.2.8 *Dissostichus* spp. Subarea 88.3

5.3 Fishery Reports
    5.3.1 *Dissostichus* spp. Division 58.4.3b

6. Bottom fishing activities and vulnerable marine ecosystems (VMEs)

7. Scheme of International Scientific Observation

8. Non-target catch in CCAMLR fisheries

    8.1 Fish and invertebrate by-catch
    8.2 Marine mammal and seabird by-catch

9. Biology, ecology and interactions in fish-based ecosystems

10. Future work

    10.1 Organisation of intersessional activities in subgroups
    10.2 Intersessional meetings
    10.3 Notification of Scientific Research

11. Other business

12. Advice to Scientific Committee

13. Adoption of the report and close of the meeting.

## List of Documents

Working Group on Fish Stock Assessment
(Hobart, Australia, 5 to 16 October 2015)

| | |
|---|---|
| WG-FSA-15/01 Rev. 1 | Summary of scientific observer data collected in the CAMLR Convention Area during 2015<br>Secretariat |
| WG-FSA-15/02 | A review of conversion factors used in CCAMLR toothfish fisheries<br>Secretariat |
| WG-FSA-15/03 | Update on the redevelopment of the CCAMLR database<br>Secretariat |
| WG-FSA-15/04 Rev. 1 | A meta-analysis of by-catch in the Ross Sea toothfish fishery<br>Secretariat |
| WG-FSA-15/05 | Continuation in the 2015/16 season of the research plan initiated in 2012/13 for stocks of *Dissostichus* spp. in Divisions 58.4.1 and 58.4.2<br>R. Sarralde, L.J. López-Abellán and S. Barreiro (Spain) |
| WG-FSA-15/06 | Contribution to knowledge on age and growth of Antarctic toothfish (*Dissostichus mawsoni*) from Division 58.4.1<br>L.J. López-Abellán, M.T.G. Santamaría, R. Sarralde and S. Barreiro (Spain) |
| WG-FSA-15/07 | A short guide to the identification of fish, cephalopod and marine mammal depredation marks on Patagonian and Antarctic toothfish in the Southern Ocean longline fisheries<br>V. Laptikhovsky (United Kingdom), A. Remeslo (Russia), J. Brown (United Kingdom), O. Kasnoborod'ko (Russia), N. Gasco (France) and M. Söffker (United Kingdom) |
| WG-FSA-15/08 | Initiative to monitor Antarctic toothfish movement and habitat preferences using satellite pop-up tags<br>C. Jones (USA) |
| WG-FSA-15/09 | Measurement of capacity in CCAMLR exploratory fisheries in Subareas 88.1 and 88.2: Secretariat update 2015<br>Secretariat |

| | |
|---|---|
| WG-FSA-15/10 | Revised research longline fishing proposal for *Dissostichus* spp. in Subarea 48.2<br>Delegation of Chile |
| WG-FSA-15/11 | The annual random stratified trawl survey in the waters of Heard Island (Division 58.5.2) to estimate the abundance of *Dissostichus eleginoides* and *Champsocephalus gunnari* for 2015<br>G.B. Nowara, T.D. Lamb and D.C. Welsford (Australia) |
| WG-FSA-15/12 Rev. 1 | A preliminary assessment of mackerel icefish (*Champsocephalus gunnari*) in Division 58.5.2, based on results from the 2015 random stratified trawl survey<br>D.C. Welsford (Australia) |
| WG-FSA-15/13 | Considerations for the hosting of by-catch identification guides for scientific observers<br>Secretariat |
| WG-FSA-15/14 | Status of WG-SAM reviews of research plans and research proposals and recommendations for streamlining<br>Convener of WG-SAM and Chair of the Scientific Committee |
| WG-FSA-15/15 | Report on the CCAMLR marine debris monitoring program<br>Secretariat |
| WG-FSA-15/16 Rev. 1 | Revised research plan for the 2015/16 exploratory longline fishery of *Dissostichus* spp. in Subarea 48.6<br>Delegation of Japan |
| WG-FSA-15/17 | Revised research plan for the 2015/16 exploratory longline fishery of *Dissostichus* spp. in Division 58.4.1<br>Delegation of Japan |
| WG-FSA-15/18 | Revised research plan for the 2015/16 exploratory longline fishery of *Dissostichus* spp. in Division 58.4.2<br>Delegation of Japan |
| WG-FSA-15/19 | Revised research plan for the 2015/16 exploratory longline fishery of *Dissostichus* spp. with special reference to the information on spawning dynamics in Division 58.4.3a<br>Delegation of Japan |
| WG-FSA-15/20 | Revised research plan for toothfish in Division 58.4.4b by *Shinsei Maru No. 3* in 2015/16<br>Delegation of Japan |

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| WG-FSA-15/21 | Reports on biological information of toothfish with special reference to bycatch, depredation and spawning dynamics in Division 58.4.4 a & b by *Shinsei maru No. 3* during 2008–14 seasons<br>K. Taki and T. Ichii (Japan) |
| WG-FSA-15/22 | Revised assessment models for Patagonian toothfish in research block 58.4.3a_1 of Division 58.4.3a, Elan Bank for the years 2005–2014<br>K. Taki (Japan), S. Mormede (New Zealand) and T. Ichii (Japan) |
| WG-FSA-15/23 | Revised assessment models for Patagonian toothfish in research block 58.4.4b_1 (SSRU 58.4.4bC) for the years 1990–2014<br>K. Taki (Japan), S. Mormede (New Zealand) and T. Ichii (Japan) |
| WG-FSA-15/24 | Proposed expansion of research block 48.6_4 for more reliable stock assessment<br>T. Ichii, T. Namba (Japan), D.C. Welsford (Australia) and K. Taki (Japan) |
| WG-FSA-15/25 | Assessment of mackerel icefish *Champsocephalus gunnari* in CCAMLR Statistical Subarea 48.3 based on the 2015 demersal fish survey<br>T. Earl and C. Darby (United Kingdom) |
| WG-FSA-15/26 | Configuration of the FP-120 net used on UK groundfish surveys in CCAMLR Subarea 48.3 (South Georgia)<br>M. Belchier, L. Featherstone and J. Oliver (United Kingdom) |
| WG-FSA-15/27 | Research program on resource potential and life cycle of *Dissostichus* species from the Subarea 88.2 A in 2015–2018<br>Delegation of the Russian Federation |
| WG-FSA-15/28 | An integrated stock assessment of Patagonian toothfish (*Dissostichus eleginoides*) in CCAMLR Subarea 48.4<br>M. Söffker, V. Laptikhovsky, T. Earl and C. Darby (United Kingdom) |
| WG-FSA-15/29 | Plan of research program of the Russian Federation in Subarea 48.5<br>Delegation of the Russian Federation |
| WG-FSA-15/30 | Report of the UK groundfish survey at South Georgia (CCAMLR Subarea 48.3) in January 2015<br>M. Belchier, S. Gregory, N. Fallon, J. McKenna, S. Hill, M. Söffker (United Kingdom), P. Lafite (South Africa) and L. Featherstone (United Kingdom) |

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| WG-FSA-15/31 | Preliminary tag-recapture based population assessment of Antarctic toothfish in Subarea 48.4<br>N.D. Walker, V. Laptikhovsky, T. Earl and C. Darby (United Kingdom) |
| WG-FSA-15/32 | Results of the 2015 multi-Member longline survey for toothfish in the northern Ross Sea region (Subarea 88.2 SSRUs A–B) and proposal for 2016 operations<br>S.J. Parker, R.J.C. Currey (New Zealand), M. Söffker, C. Darby (United Kingdom), O. Godø (Norway) and A. Petrov (Russia) |
| WG-FSA-15/33 | A proposal for a standardised survey for Antarctic toothfish in McMurdo Sound<br>S.J. Parker, S.M. Hanchet and S. Mormede (New Zealand) |
| WG-FSA-15/34 | Revised proposal to continue the time series of research surveys to monitor abundance of Antarctic toothfish in the southern Ross Sea, 2016 and 2017<br>S.M. Hanchet, S.J. Parker, S. Mormede and R.J.C. Currey (New Zealand) |
| WG-FSA-15/35 | Quantifying the impacts of ice on demersal longlining in CCAMLR Subarea 88.1 with updated information on the 2014/15 season<br>J.M. Fenaughty and S.J. Parker (New Zealand) |
| WG-FSA-15/36 | A characterisation of the toothfish fishery in Subareas 88.1 and 88.2 from 1997–98 to 2014–15<br>K. Large, S.M. Hanchet and S. Mormede (New Zealand) |
| WG-FSA-15/37 | Descriptive analysis of the toothfish (*Dissostichus* spp.) tagging programme in Subareas 88.1 & 88.2 for the years 2000–01 to 2014–15<br>S.J. Parker and S. Mormede (New Zealand) |
| WG-FSA-15/38 | Assessment models for Antarctic toothfish (*Dissostichus mawsoni*) in the Ross Sea region for the years 1997–98 to 2014−15<br>S. Mormede, A. Dunn and S.M. Hanchet (New Zealand) |
| WG-FSA-15/39 | Diagnostic plots of stock assessment models for Antarctic toothfish (*Dissostichus mawsoni*) in the Ross Sea region for the years 1997–98 to 2014–15<br>S. Mormede, A. Dunn and S.M. Hanchet (New Zealand) |
| WG-FSA-15/40 | Draft updated data collection plan for the Ross Sea toothfish fishery<br>S.M. Hanchet, S.J. Parker and S. Mormede (New Zealand) |

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| WG-FSA-15/41 | Predation release of Antarctic silverfish in the Ross Sea: how sensitive is the conclusion to uncertainties in the diet of Antarctic toothfish over the shelf?<br>M.H. Pinkerton, P. O'B. Lyver, D.W. Stevens, J. Forman, R. Eisert and S. Mormede (New Zealand) |
| WG-FSA-15/42 | Using spatial population models to investigate the effects of a proposed Marine Protected Area on Antarctic toothfish in the Ross Sea region<br>S. Mormede, A. Dunn, S.J. Parker and S.M. Hanchet (New Zealand) |
| WG-FSA-15/43 Rev. 1 | Report on the survey in Subarea 48.2 in 2015 (the first year of the planned 3-year-old investigations)<br>Delegation of Ukraine |
| WG-FSA-15/44 | A review of tag-based stock assessments of the Antarctic toothfish *Dissostichus mawsoni* in Subarea 48.4<br>N. Walker, M. Söffker, V. Laptikhovsky and T. Earl (United Kingdom) |
| WG-FSA-15/45 | Plan of research program of the Ukraine in Subarea 48.2 in 2016 (second season)<br>Delegation of Ukraine |
| WG-FSA-15/46 | Preliminary results of age determination of the *Dissostichus* spp. from the longline catches in 48.2 Subarea (2015, SIMIIZ)<br>Delegation of Ukraine |
| WG-FSA-15/47 Rev. 1 | Research plan for exploratory fishing for toothfish (*Dissostichus* spp.) in East Antarctica (Divisions 58.4.1 and 58.4.2) by Australia<br>Delegation of Australia |
| WG-FSA-15/48 | Season extensions in the longline fishery for *Dissostichus eleginoides* in Statistical Division 58.5.2<br>J. Barrington and T. Lamb (Australia) |
| WG-FSA-15/49 | Quantifying uncertainty in the Chapman mark-recapture estimate of abundance<br>P. Burch (Australia), S. Parker (New Zealand) and D. Welsford (Australia) |
| WG-FSA-15/50 | An updated assessment of unicorn icefish (*Channichthys rhinoceratus*) in Division 58.5.2, based on results from the 2015 random stratified trawl survey<br>D. Maschette and J. Dell (Australia) |

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| WG-FSA-15/51 | Exploring age and growth dynamics of a historically overfished Sub-Antarctic fish species: The grey rockcod (*Lepidonotothen squamifrons*) in the vicinity of Heard Island and McDonald Island<br>D. Maschette, D.C. Welsford and C. Gardner (Australia) |
| WG-FSA-15/52 | An integrated stock assessment for the Heard Island and the McDonald Islands Patagonian toothfish (*Dissostichus eleginoides*) fishery in Division 58.5.2<br>P. Ziegler and D. Welsford (Australia) |
| WG-FSA-15/53 | Spatial and temporal patterns of sperm whale (*Physeter macrocephalus*) depredation on Australian longline vessels in the Patagonian toothfish (*Dissostichus eleginoides*) fishery at Heard Island and McDonald Islands (CCAMLR Division 58.5.2)<br>D.C. Welsford and R. Arangio (Australia) |
| WG-FSA-15/54 | Proposed allocation of research catches in Divisions 58.4.1 and 58.4.2<br>D.C. Welsford (Australia), R. Sarralde Vizuete (Spain) and T. Ichii (Japan) |
| WG-FSA-15/55 | Updated description of Patagonian toothfish (*Dissostichus eleginoides*) tagging and ageing programs in Division 58.5.2, 1997–2015<br>D.C. Welsford, B. Farmer, T.D. Lamb, C. Péron, E. Woodcock and P.E. Ziegler (Australia) |
| WG-FSA-15/56 | Revised research plan for the exploratory longline fishery for *Dissostichus* spp. in Divisions 58.4.1 and 58.4.2 in 2015/16<br>Delegation of the Republic of Korea |
| WG-FSA-15/57 | Diet composition and feeding strategy of Antarctic toothfish, *Dissostichus mawsoni* in the research blocks 58.4.2-1, 58.4.1-2, 58.4.1-3, 58.4.1-4, and 58.4.1-5 for the exploratory longline fishery in 2014/2015 of Korea<br>Delegation of the Republic of Korea |
| WG-FSA-15/58 | Towards an all year round monitoring the Antarctic silverfish nursery area in the Ross Sea<br>L. Ghigliotti, E. Pisano, E. Carlig (Italy), J.H. Kim, T. Choi (Republic of Korea) and M. Vacchi (Italy) |
| WG-FSA-15/59 | Assessment of the Patagonian Toothfish (*D. eleginoides*) in Subarea 48.3<br>T. Earl, M. Söffker and C. Darby (United Kingdom) |

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| WG-FSA-15/60 | Model diagnostics for the Antarctic krill assessment for Subarea 48.1<br>D. Kinzey, G.M. Watters and C.S. Reiss (USA) |
| WG-FSA-15/61 | Identification of *Pleuragramma antarctica* larvae in the Ross Sea via mitochondrial DNA<br>J.A. Caccavo (Italy), C. Brooks (USA), L. Zane (Italy) and J.R. Ashford (USA) |
| WG-FSA-15/62 Rev. 1 | Method for rapidly assessing spatial scale of interactions of fishing gear with habitats and Antarctic marine living resources<br>A. Constable, M. Sumner, J. Melbourne-Thomas and D. Welsford (Australia) |
| WG-FSA-15/63 | Biology, population dynamics and preliminary assessment of the long-term yield of *Macrourus caml* by-caught by the Australian fishery at Heard Island and the McDonald Islands (CCAMLR Division 58.5.2)<br>J. Dell, D. Maschette, E. Woodcock and D. Welsford (Australia) |
| WG-FSA-15/64 | Modelling the circumpolar distribution of Antarctic toothfish (*Dissostichus mawsoni*) habitat suitability using correlative species distribution modelling methods<br>Secretariat |
| WG-FSA-15/65 | Revised research plan for the exploratory longline fishery for *Dissostichus* spp. in Statistical Subarea 88.3 in 2015/16<br>Delegation of the Republic of Korea |
| WG-FSA-15/66 | Summary of data collected by Japan and South Africa in Subarea 48.6 between 2013 and 2015, and other statistics available for assessment of *Dissostichus* spp. in Subarea 48.6.<br>R.W. Leslie (South Africa), K. Taki, T. Ichii (Japan) and S. Somhlaba (South Africa) |
| WG-FSA-15/67 | Research plan for the exploratory longline fishery for *Dissostichus* spp. in 2015/16 in Division 58.4.4<br>A. Rélot-Stirnemann (France) |
| WG-FSA-15/68 | Updated stock assessment of Patagonian toothfish (*Dissostichus eleginoides*) in the vicinity of Kerguelen Islands (Division 58.5.1)<br>R. Sinegre and G. Duhamel (France) |
| WG-FSA-15/69 | Updated assessment of Patagonian toothfish (*Dissostichus eleginoides*) in the vicinity of Crozet Islands (Subarea 58.6)<br>R. Sinegre and G. Duhamel (France) |

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| WG-FSA-15/70 | New bird guide for observers at sea in southern Indian Ocean<br>N. Gasco, K. Delord and C. Barbraud (France) |
| WG-FSA-15/71 | New photo-identification catalogues from Crozet and Kerguelen Islands<br>P. Tixier, N. Gasco and C. Guinet (France) |
| WG-FSA-15/72 | Technical guide to collect data related to depredation on board longline vessels<br>N. Gasco, P. Tixier and C. Guinet (France) |
| WG-FSA-15/73 | Revised research plan for the exploratory longline fishery for *Dissostichus* spp. in 2015/16 in Division 58.4.1<br>A. Rélot-Stirnemann (France) |
| WG-FSA-15/74 | Revised research plan for the exploratory longline fishery for *Dissostichus* spp. in 2015/16 in Division 58.4.2<br>A. Rélot-Stirnemann (France) |
| WG-FSA-15/75 | Identification self training for observers<br>N. Gasco and A. Martin (France) |
| WG-FSA-15/76 | PiNT – a tool for renaming observer photographs at sea<br>N. Gasco, C. Chazeau, P. Tixier (France), C. Heinecken (South Africa), J. Clark and M. Söffker (United Kingdom) |
| WG-FSA-15/77 | Conversion Factors used for Patagonian toothfish in Division 58.5.1. and Subarea 58.6<br>N. Gasco (France) |
| WG-FSA-15/78 | Revised research plan for the exploratory longline fishery for *Dissostichus* spp. in 2015/16 in Division 58.4.3a<br>A. Rélot-Stirnemann (France) |

Other Documents

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| WG-FSA-15/P01 | Have Antarctic toothfish returned to McMurdo Sound?<br>S.J. Parker, S. Mormede, A.L. DeVries, S.M. Hanchet and R. Eisert<br>*Ant. Sci.* (2015), doi: 10.1017/S0954102015000450 |
| CCAMLR-XXXIV/07 | Analysis of live untagged toothfish release<br>Secretariat |
| CCAMLR-XXXIV/17 Rev. 1 | Review of the CCAMLR regulatory framework and recommendations for streamlining fishery status<br>Chair of the Scientific Committee |

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| CCAMLR-XXXIV/32 | Combatting IUU fishing in the Southern Ocean: international cooperation and information sharing<br>Delegation of New Zealand |
| CCAMLR-XXXIV/37 | IUU fishing activity and trends in 2014/15 and IUU Vessel Lists<br>Secretariat |
| CCAMLR-XXXIV/BG/02 | Implementation of conservation measures in 2014/15: fishing and related activities<br>Secretariat |
| CCAMLR-XXXIV/BG/03 | Fishery notifications 2015/16<br>Secretariat |
| CCAMLR-XXXIV/BG/10 | Discharge of offal in the Ross Sea – follow up to COMM CIRC 15/15–SC CIRC 15/06<br>Secretariat |
| CCAMLR-XXXIV/BG/18 | Analysis of catch and effort data from the IUU fishing vessel *Kunlun*<br>Delegation of Australia |
| CCAMLR-XXXIV/BG/19 | Status Report – Macquarie Island Toothfish Fishery<br>Delegation of Australia |

Annex 8

**Glossary of acronyms and abbreviations used in SC-CAMLR reports**

**Glossary of acronyms and abbreviations used in SC-CAMLR reports**

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| 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 |

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| 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 |

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| 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 |

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| 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 |

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| DPOI | Drake Passage Oscillation Index |
| 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 |

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| 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) |

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| 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 |

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| 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 |

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| 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 |

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| 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 |

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|---|---|
| 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 |

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|---|---|
| PIT | Passive Integrated Transponder |
| PRP | CCAMLR Performance Review Panel |
| PS | Paired Streamer Line |
| 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) |

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| 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 |

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|---|---|
| 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 |
| 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 |

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|---|---|
| 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 |

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|---|---|
| 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 |

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|---|---|
| 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) |