

SC-CAMLR-XXXIII

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

**REPORT OF THE THIRTY-THIRD MEETING  
OF THE SCIENTIFIC COMMITTEE**

HOBART, AUSTRALIA  
20–24 OCTOBER 2014

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Chair of the Scientific Committee  
November 2014

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### **Abstract**

This document presents the adopted report of the Thirty-third Meeting of the Scientific Committee for the Conservation of Antarctic Marine Living Resources held in Hobart, Australia, from 20 to 24 October 2014. 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.

## Contents

	Page
<b>Opening of the meeting</b> .....	1
Adoption of the agenda .....	2
Chair's report .....	2
<b>Advances in statistics, assessments, modelling, acoustics and survey methods</b> .....	2
Statistics, assessments and modelling .....	2
Acoustic survey and analysis methods .....	5
<b>Harvested species</b> .....	7
Krill resources .....	7
Catch in the current fishing season, 2013/14 .....	7
Notifications for the next fishing season, 2014/15 and krill catch reports .....	7
Catch and effort reporting system in the krill fishery .....	8
ARK workshop .....	9
Krill biology, ecology and management .....	9
Current ecosystem monitoring and estimates of penguin populations .....	9
Feedback management strategy – overlap between the krill fishery and land-breeding predators .....	10
Feedback management strategy – simple feedback .....	10
Feedback management strategy – advancement to stage 2 .....	12
Conservation Measure 51-07 .....	13
CEMP fund .....	14
Oceanographic models .....	15
Integrated assessment .....	15
2015/16 multinational investigation of the krill-based ecosystem .....	15
Ecosystem modelling .....	16
Finfish .....	16
Fish resources .....	17
Status and trends .....	17
CCAMLR GIS .....	18
Data quarantine .....	18
Toothfish trade .....	19
Fishery surveys .....	19
Data on sea-ice .....	19
Tag-overlap statistic .....	20
Depredation .....	20
Icelfish assessments .....	21
<i>Chamsocephalus gunnari</i> South Georgia (Subarea 48.3) .....	21
Management advice .....	22
<i>Chamsocephalus gunnari</i> Kerguelen Island (Division 58.5.1) .....	22
Management advice .....	22
<i>Chamsocephalus gunnari</i> Heard Island (Division 58.5.2) .....	22
Management advice .....	23

Toothfish assessments .....	23
<i>Dissostichus eleginoides</i> South Georgia (Subarea 48.3) .....	23
Management advice .....	23
<i>Dissostichus eleginoides</i> South Sandwich Islands (Subarea 48.4) .....	23
Management advice .....	24
<i>Dissostichus mawsoni</i> South Sandwich Islands (Subarea 48.4) .....	24
Management advice .....	24
By-catch limits for Subarea 48.4 .....	24
<i>Dissostichus eleginoides</i> Kerguelen Islands (Division 58.5.1) .....	25
Management advice .....	25
<i>Dissostichus eleginoides</i> Heard Island (Division 58.5.2) .....	25
Management advice .....	27
<i>Dissostichus eleginoides</i> Crozet Islands (Subarea 58.6) .....	27
Management advice .....	27
<i>Dissostichus eleginoides</i> Prince Edward and Marion Islands (Subareas 58.6 and 58.7) and Area 51 inside the South African EEZ .....	28
Management advice for <i>D. eleginoides</i> at Prince Edward and Marion Islands (Subareas 58.6 and 58.7) inside the EEZ .....	28
Management advice for <i>D. eleginoides</i> at Prince Edward Islands (Subareas 58.6 and 58.7 and Division 58.4.4) outside the EEZ .....	28
Fish and invertebrate by-catch .....	28
Exploratory fisheries .....	30
<i>Dissostichus</i> spp. Subarea 88.1 .....	31
Management advice .....	31
<i>Dissostichus</i> spp. Subarea 88.2 .....	31
Research to inform current or future assessments in exploratory fisheries and other fisheries .....	34
<i>Dissostichus</i> spp. Subarea 48.6 .....	35
<i>Dissostichus</i> spp. Division 58.4.3a (Elan Bank) .....	37
<i>Dissostichus</i> spp. Divisions 58.4.1 and 58.4.2 .....	37
<i>Dissostichus</i> spp. Subarea 48.2 .....	39
<i>Dissostichus</i> spp. Division 58.4.4a and 58.4.4b (Ob and Lena Banks) .....	39
<i>Dissostichus</i> spp. in Subarea 88.1 and SSRUs 882A–B .....	39
Multiyear research plan for the Ross Sea .....	39
Catch limits for research surveys .....	39
Ross Sea sub-adult survey .....	40
SSRUs 882A–B .....	41
<i>Dissostichus</i> spp. Subarea 48.5 Weddell Sea .....	43
<b>Incidental mortality arising from fishing operations</b> .....	44
Incidental mortality associated with fisheries .....	44
Marine debris .....	45
<b>Spatial management of impacts on the Antarctic ecosystem</b> .....	45
Bottom fishing and vulnerable marine ecosystems .....	45
Marine Protected Areas .....	48
Domain 1 – Western Antarctic Peninsula and South Scotia Sea .....	48
Domains 3 and 4 – Weddell Sea .....	49
Domain 7 – East Antarctica .....	51

Domain 8 – Ross Sea .....	54
MPA Reports .....	54
General MPA issues .....	55
South Orkney Islands southern shelf MPA (Domain 1) .....	55
<b>IUU fishing activity</b> .....	59
<b>CCAMLR Scheme of International Scientific Observation</b> .....	60
<b>Climate change</b> .....	62
<b>Scientific research under CM 24-01</b> .....	63
<b>Cooperation with other organisations</b> .....	63
Cooperation with the Antarctic Treaty System .....	63
Committee for Environmental Protection (CEP) .....	63
Scientific Committee for Antarctic Research .....	64
Reports of observers from other international organisations .....	65
FAO .....	65
ARK .....	66
COLTO .....	66
ASOC .....	67
Reports from observers at meetings of other international organisations .....	67
IWC .....	67
Krill stakeholder workshop .....	68
Future cooperation .....	69
<b>Forecast Budget for 2015</b> .....	69
<b>Advice to SCIC and SCAF</b> .....	69
<b>Scientific Committee activities</b> .....	69
Priorities for the work of the Scientific Committee and its working groups .....	69
Intersessional activities .....	70
CCAMLR Scientific Scholarship Scheme .....	70
Invitation of experts and observers .....	72
Invitation of experts to the meetings of working groups .....	72
Next meeting .....	72
<b>Secretariat-supported activities</b> .....	73
External review of assessments .....	73
<b>Election of Vice-Chair</b> .....	73
<b>Other business</b> .....	73
ICES Symposium on acoustics .....	73
<b>Adoption of the report</b> .....	73
<b>Close of the meeting</b> .....	74

<b>References</b> .....	74
<b>Table</b> .....	75
<b>Figures</b> .....	76
<b>Annex 1:</b> List of Participants .....	81
<b>Annex 2:</b> List of Documents .....	99
<b>Annex 3:</b> Agenda .....	113
<b>Annex 4:</b> Report of the Meeting of the Subgroup on Acoustic Survey and Analysis Methods (SG-ASAM) .....	117
<b>Annex 5:</b> Report of the Working Group on Statistics, Assessments and Modelling (WG-SAM) .....	149
<b>Annex 6:</b> Report of the Working Group on Ecosystem Monitoring and Management (WG-EMM) .....	187
<b>Annex 7:</b> Report of the Working Group on Fish Stock Assessment (WG-FSA) ....	275
<b>Annex 8:</b> Feedback management pro forma .....	369
<b>Annex 9:</b> Glossary of acronyms and abbreviations used in SC-CAMLR reports ....	373

**Report of the Thirty-third  
Meeting of the Scientific Committee  
(Hobart, Australia, 20 to 24 October 2014)**

**Opening of the meeting**

1.1 The Scientific Committee for the Conservation of Antarctic Marine Living Resources met from 20 to 24 October 2014 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, Brazil, Chile, People's Republic of China, European Union, France, Germany, Italy, Japan, Republic of Korea, Namibia, New Zealand, Norway, Poland, Russian Federation, South Africa, Spain, Sweden, Ukraine, United Kingdom of Great Britain and Northern Ireland, United States of America and Uruguay.

1.3 The Chair also welcomed to the meeting Observers from Mauritius, the Netherlands, Peru (Acceding States) and Singapore, along with Observers from ACAP, ARK, ASOC, CCSBT, CEP, COLTO, IWC, SCAR (including SCOR) and SEAFO, and encouraged them to participate in the meeting to the extent possible.

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 new, web-based system which had been developed by the Secretariat and trialled during WG-FSA-14. The system allows rapporteurs and other meeting participants to develop and edit report text, post comments and contribute text, as well as track versions. The system may be accessed remotely by meeting participants and integrates the Secretariat's workflow associated with the production of the meeting report.

1.6 The report of the Scientific Committee was prepared by Drs A. Constable (Australia), R. Currey (New Zealand), C. Darby (UK), Mr I. Forster (Secretariat), Drs O.R. Godø (Norway), S. Grant (UK), S. Hain (Germany), S. Hanchet (New Zealand), K.-H. Kock (Germany), J. Melbourne-Thomas (Australia), Mr A. Miller (Secretariat), Drs S. Parker (New Zealand), P. Penhale (USA), D. Ramm, K. Reid (Secretariat), C. Reiss (USA), L. Robinson (Secretariat), M. Soffker (UK), Mr S. Somhlaba (South Africa), Drs 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.

## Adoption of the agenda

1.8 The Scientific Committee discussed the Provisional Agenda which had been circulated prior to the meeting (11 July 2014). The agenda was adopted (Annex 3) with two minor changes (inclusion of Subitem 3.3.3 'Advice to Commission' and renaming of Subitem 5.2.1 to 'Scientific considerations').

## Chair's report

1.9 Dr Jones reflected on the Scientific Committee's work in the 2013/14 intersessional period. The following meetings had taken place:

- (i) the Subgroup on Acoustic Survey and Analysis Methods (SG-ASAM) met in Qingdao, People's Republic of China, from 8 to 11 April 2014 (Annex 4) and was co-convened by Drs J. Watkins (UK) and X. Zhao (China); 12 participants from 6 Members participated
- (ii) the Working Group on Statistics, Assessments and Modelling (WG-SAM) met in Punta Arenas, Chile, from 30 June to 4 July 2014 (Annex 5) and was convened by Dr Hanchet; 37 participants from 12 Members participated
- (iii) the Working Group on Ecosystem Monitoring and Management (WG-EMM) met in Punta Arenas, Chile, from 7 to 18 July 2014 (Annex 6) and was convened by Dr S. Kawaguchi (Australia); 49 participants from 16 Members, Peru (Acceding State) and an Observer from the IWC participated
- (iv) the Working Group on Fish Stock Assessment (WG-FSA) met at the CCAMLR Headquarters, Hobart, from 6 to 17 October 2014 (Annex 7) and was convened by Dr M. Belchier (UK); 44 participants from 13 Members participated.

1.10 Dr Jones, on behalf of the Scientific Committee, thanked all chairs, conveners and coordinators of intersessional meetings, and Chile and China for hosting the meetings of WG-EMM, WG-SAM and SG-ASAM in 2014. He also thanked participants for developing the Scientific Committee's work in 2013/14 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) an evaluation of research plans for notifications to fish in exploratory fisheries in Subareas 48.6 and 58.4 under Conservation Measure (CM) 21-02
- (iii) a review of research proposals submitted under CM 24-01.

2.2 The Scientific Committee noted that many issues discussed by WG-SAM that had been taken up by WG-FSA are further considered within the WG-FSA report (Annex 7).

2.3 The Scientific Committee noted advice from WG-SAM regarding progress toward integrated assessments in Divisions 58.5.2 and 58.4.4 and Subarea 88.2 and that WG-SAM:

- (i) reviewed progress on developing an updated stock assessment for toothfish (*Dissostichus* spp.) in Division 58.5.2 and discussed incorporating tag-recapture data from trawl and longline fisheries (Annex 5, paragraphs 2.3 to 2.6)
- (ii) made recommendations for further work on the assessment in Division 58.4.4 (Annex 5, paragraphs 2.18 to 2.25)
- (iii) considered several papers about toothfish in Subarea 88.2, covering stock structure, tag-based biomass estimates and an integrated stock assessment in CASAL, and proposed methods to develop an abundance index for the slope small-scale research units (SSRUs) 882C–G. It advised that estimates of abundance should be presented to WG-FSA using information from recaptured tagged fish with up to one, two and three years at liberty (Annex 5, paragraphs 2.10 and 2.13)
- (iv) considered several other generic aspects of stock assessments, including:
  - (a) advice on software version control (Annex 5, paragraph 2.29)
  - (b) advice on a process for external review of stock assessments (paragraph 14.2; Annex 5, paragraph 2.33)
  - (c) identification of high-priority assessment methodology issues (Annex 5, paragraphs 2.40 and 2.41)
  - (d) noted that intersessional e-groups<sup>1</sup> had been set up to consider further paragraphs 2.3(i) and (iii).

2.4 The Scientific Committee noted that WG-SAM reviewed research plans submitted by France, Japan, the 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. Under this topic, WG-SAM:

- (i) recommended updating Table 13 from WG-FSA-13 (SC-CAMLR-XXXII, Annex 6) to include local biomass estimates, catch levels and predicted tag recaptures as part of the research plan review process (Annex 5, paragraph 3.2) and recommended that an in-depth review of research plans be undertaken after an appropriate period (Annex 5, paragraph 3.3)
- (ii) noted practical difficulties in developing multi-Member research proposals and requested the Scientific Committee consider mechanisms to aid in effective collaboration (Annex 5, paragraph 3.5)

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<sup>1</sup> CCAMLR e-groups can be accessed from the [CCAMLR homepage](#) and are available to authorised users.

- (iii) discussed the individual plans (Annex 5, paragraphs 3.6 to 3.38), with specific advice for Subarea 48.6 and Divisions 58.4.1, 58.4.2 and 58.4.3a.

2.5 The third area of work reported by WG-SAM was the review of scientific research proposals notified under CM 24-01. The Scientific Committee noted that WG-SAM:

- (i) reviewed research proposals submitted by Chile, Japan, New Zealand, Russia and Ukraine notified under CM 24-01 and recommended that all the research proposals be updated and submitted to WG-FSA for discussion; the specific advice for each of the research proposals can be found in Annex 5, paragraphs 4.1 to 4.28
- (ii) noted some unusual patterns in the by-catch rates and species between the two surveys carried out by Russia in Subarea 48.5 (Annex 5, paragraphs 4.6 to 4.10)
- (iii) requested that the Scientific Committee consider, consistent with the CCAMLR regulatory framework, whether fishing for *Dissostichus* spp. in Subarea 48.5 be considered an exploratory fishery under CM 21-02 (Annex 5, paragraph 4.12)
- (iv) recalled previous Scientific Committee advice that SSRU 882A could potentially be opened and managed as part of the Ross Sea fishery (SC-CAMLR-XXXI, paragraph 9.30) and that the boundaries of CM 41-09 should be revised so that catches in Subarea 88.1 and SSRUs 882A–B are managed under a single conservation measure commensurate with the Ross Sea fishery stock assessment (SC-CAMLR-XXXII, paragraph 3.160). On this basis, WG-SAM requested that WG-FSA consider an appropriate mechanism to account for the catches required in these research plans.

2.6 The Scientific Committee noted that under Other Business, WG-SAM also discussed the issues of:

- (i) fishery capacity (Annex 5, paragraph 5.2)
- (ii) Fishery Reports, translation, executive summary and dashboard (Annex 5, paragraphs 5.5 to 5.7)
- (iii) offering of a CASAL stock assessment course (Annex 5, paragraphs 5.8).

2.7 On the topic of software version control, the Scientific Committee recommended that CASAL version v. 2.30-2012-03-21 rev. 4648 be used for stock assessment.

2.8 The Scientific Committee noted that this version needs to be manually installed. More recent versions are available and can be auto-installed. The Scientific Committee requested the Secretariat develop support for the currently approved version in order to assist Members in the installation. It further noted that an e-group to discuss software validation procedures had been established to further discuss and progress this issue.

2.9 The Scientific Committee considered the issue of coordination and collaboration among Members working on research plans. Japan noted that although difficulties exist, it will be collaborating with other Members on research plans this year. The Republic of Korea also indicated that with multiple research plans operating in the same area, collaboration was

necessary. The Scientific Committee noted that collaboration can also extend to more than just fishing activities to include data analysis and comparative work. Standardising data collection procedures and data analysis among research plans may create synergies, provide more robust conclusions and make larger datasets available for analyses such as habitat modelling. The Scientific Committee recalled that standardisation of research plan data was considered by WG-SAM in 2011 (SC-CAMLR-XXXI, Annex 5, paragraphs 2.40 to 2.50) and that experience derived from recent collaboration may further inform new discussions by WG-SAM.

2.10 The Scientific Committee noted that while there was no evidence for overcapacity in the current metrics provided, the overshoots of the catch limit in Subarea 88.2 and the resulting impacts on tag-overlap statistics in the subarea could both be related to overcapacity. The Scientific Committee recommended that the Secretariat continue to monitor CCAMLR fisheries for evidence of overcapacity using the metrics outlined by WG-SAM (Annex 5, paragraph 5.2).

2.11 The Scientific Committee noted that Dr Hanchet would step down as Convener of WG-SAM and thanked him for his excellent work and guidance for the past three years. The Scientific Committee endorsed the nomination of Dr Parker as Convener of WG-SAM-15.

#### Acoustic survey and analysis methods

2.12 The Scientific Committee thanked the Co-conveners (Drs Zhao and Watkins) and the participants of SG-ASAM and welcomed their progress in establishing protocols that will lead to the scientific use of acoustic data from fishing vessels. The proof of concept that was achieved using fishing vessels for collecting acoustic data greatly enhanced the possibility for collecting krill density distribution information on extended temporal and spatial scales (Annex 4, paragraphs 2.1 to 2.8).

2.13 Based on the work on stage 1 of the proof of concept, the Scientific Committee advised that acoustic data from fishing vessels can now be used for collecting time- and space-referenced data on krill densities.

2.14 The Scientific Committee endorsed the ambitious timeline for further development of these methods, suggesting that data should become available for management purposes during the 2016/17 fishing season. This implied that development of the required protocols for collection and analysis of the acoustic data be in place. The Scientific Committee encouraged the plans for further development of the methodology, including calibration protocols using suitable seabed as external reference targets.

2.15 The Scientific Committee underlined that the potential for using these data is much wider than those outlined by SG-ASAM, but simultaneously supported the Subgroup in taking the development step-by-step to secure the quality and integrity of the information that will be collected.

2.16 The Scientific Committee emphasised the importance of this work in the context of establishing a data collection regime for an operational feedback management system. It requested SG-ASAM consider how acoustic data may be routinely analysed to support such a system.

2.17 The Republic of Korea welcomed the progress of the Subgroup and confirmed that it has stimulated instrument improvements on Korean vessels to make them suitable for collecting acoustic data.

2.18 It was underlined by the Scientific Committee that there is a need to discuss how uncertainty in the data collected by fishing vessels can be handled and this should be part of the further development of the methodology. WG-SAM should become involved in such work.

2.19 To promote the further development, the Scientific Committee recommended that the Subgroup meet during the intersessional period, co-convened by Drs Zhao and Watkins, to work on protocols for collecting and analysing acoustic data from fishing vessels according to the agreed plans.

2.20 The Scientific Committee agreed on the following provisional terms of reference for SG-ASAM-15:

To continue the work on protocols for collection and analysis of acoustic data collected on board fishing vessels:

1. Proof of Concept: 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 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 (standardised 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 multinational effort as well as in FBM in general.

## Harvested species

### Krill resources

Catch in the current fishing season, 2013/14

3.1 The Scientific Committee noted that 12 vessels from five Members have fished for krill in three subareas in 2013/14 and the total reported catch to date is approximately 285 000 tonnes. This is the highest reported catch since 1991. Most of this catch was taken from Subarea 48.1, which reached 94% of its allocated trigger level (155 000 tonnes) and was closed on 17 May 2014. This closure was earlier than the previous two closures under similar circumstances (June 2013 and October 2010). Approximately 72 000 tonnes have been taken from Subarea 48.2 and 66 000 tonnes from Subarea 48.3 (SC-CAMLR-XXXIII/BG/01).

3.2 Dr E. Barrera-Oro (Argentina) highlighted that the interim allocated trigger level has been reached for the third time in Subarea 48.1 and that this is likely to continue to occur in the future. Conditions of reduced ice extent due to climate change are more frequent and vessels are able to get closer to seal and seabird populations. He reminded the Committee of similar conditions in 2009 in Admiralty Bay, when vessels fished in zones immediate to predator populations. The high number of inshore areas in Subarea 48.1 in particular means that vessels can fish in close proximity to colonies.

3.3 The Scientific Committee agreed that work to update the CCAMLR website with a synthesis of knowledge on key questions often discussed by the Scientific Committee and the Commission on the krill fishery, summarised by WG-EMM (Annex 6, paragraph 2.6), should be progressed and thanked the Secretariat for progress it had made on the CCAMLR website providing general descriptions of many elements of its work. It was agreed that this summary should include an update of CCAMLR's approach to management, coordinated by Dr Kock in the early 1990s (Annex 6, paragraph 2.7), and that progress could be made by means of an intersessional correspondence group in advance of WG-EMM-15.

Notifications for the next fishing season, 2014/15 and krill catch reports

3.4 The notified catch for 2014/15 is 611 000 tonnes and all notifications provided the information required by CM 21-03. The Scientific Committee welcomed progress in regards to methods for estimating green weight but noted that there were still some outstanding issues that require further work in the coming season. In relation to notification requirements for green-weight estimation, the Scientific Committee endorsed the recommendations from WG-EMM that the parameter defined as 'density of the sample' in CM 21-03, Annex 21-03/B, be renamed to 'volume-to-mass conversion factor' and

- (i) the frequency requirement for estimating this parameter be increased to improve the estimate of variability in this measurement
- (ii) the alternative version of the flow-meter method for estimating green weight used by the vessel *Betanzos* be added to CM 21-03, Annex B, and that the operator be encouraged to compare this method with another method for estimating green weight (e.g. the codend method) and to present the results of such comparison at WG-EMM.

3.5 The Scientific Committee also agreed:

- (i) that scientific observers may provide guidance to assist crew in obtaining parameter measurements required for green-weight estimation
- (ii) it was the responsibility of Flag States to provide these data in the C1 form and that at the moment there is not 100% observer coverage on all vessels
- (iii) observers could provide a clear description of green-weight estimation methods used by the vessels and provide independent estimates of green-weight parameters.

Catch and effort reporting system in the krill fishery

3.6 The Scientific Committee considered the advice from WG-EMM regarding the catch and effort reporting system currently in use in the krill fishery (Annex 6, paragraphs 2.21 and 2.22). The reporting system (CM 23-06, paragraphs 3 to 5) is a dual system which requires monthly reporting of catch and effort while the total catch is less than 50–80% of the trigger level, and five-day reporting when catches exceed 50–80%.

3.7 The Scientific Committee noted that in recent seasons Members had successfully applied this dual reporting system, switching from monthly to five-day reporting in Subarea 48.1 according to CM 23-06, and the Secretariat had successfully implemented closures in that subarea.

3.8 However, the Scientific Committee also noted the Secretariat's concern that the dual reporting system may not provide timely information on catch and effort while monthly reporting applies, because catch and effort is only reported month by month and the deadline for submitting these reports is the end of following month (Annex 6, paragraph 2.22). The Scientific Committee also noted that the switch from monthly to five-day reporting may require up to two five-day reporting periods (i.e. up to 10 days) in order to fully implement this switch across all fishing vessels and that this season's closure in Subarea 48.1 was implemented 17 days after the switch in reporting period.

3.9 The Scientific Committee considered various reporting options which may improve the timeliness of reporting, including the use of a single five-day reporting system for the entire season and bringing forward the deadline for the submission of monthly reports (CM 23-03). The Scientific Committee noted that these options may incur additional administrative costs. It also noted that some Members had already implemented the five-day reporting system on their flagged vessels for the entire season on a voluntary basis.

3.10 Mr S. Nordrum (ARK) advised that ARK supports five-day reporting of catch and effort in the krill fishery for the entire season and that frequent reporting was technically feasible on board fishing vessels.

3.11 The Scientific Committee agreed to maintain the current reporting system in CM 23-06; however, it also agreed that the five-day reporting system may be implemented before the 50% threshold in Subarea 48.1 is reached, on a case-by-case basis. This early

application of five-day reporting would be implemented by all fishing vessels in Subarea 48.1 once the monthly catch of krill exceeded 10% of the trigger level allocated in that subarea. The Secretariat would notify Members when such a situation occurred.

3.12 The Scientific Committee agreed to keep this arrangement under review.

#### ARK workshop

3.13 ARK introduced SC-CAMLR-XXXIII/BG/21 that reports on a workshop for krill fishery representatives and the scientific community to share information on krill in Punta Arenas, Chile, in July 2014, and thanked the scientists who participated and the local organisers.

3.14 The Scientific Committee acknowledged the value of the ARK workshop and agreed that it would be useful to explore the potential for another similar meeting in the future.

#### Krill biology, ecology and management

3.15 The Scientific Committee noted that changes in  $p\text{CO}_2$  in the Southern Ocean and associated physiological costs to krill will increase the vulnerability of krill to stress. It agreed that such changes highlight the need to think about future decision rules and alternative reference points to inform the management of the fishery under environmental change (paragraphs 8.4 and 8.5).

3.16 Dr Barrera-Oro presented a paper on a long-term study of krill larvae in the Scotia Sea and noted the apparent decline in krill larval production and changes in community composition since the 1980s (SC-CAMLR-XXXIII/BG/20). A new research cruise on this issue is planned for the same region in the upcoming 2014/15 season. The Scientific Committee welcomed this study and encouraged further work to complete the analysis of the remaining years of data and to continue their study in light of changes in the Southern Ocean ecosystem.

#### Current ecosystem monitoring and estimates of penguin populations

3.17 The Scientific Committee welcomed new work reported to WG-EMM using satellite technology to contribute to estimates of penguin population status and trends. The Convener of WG-EMM-STAPP, Dr C. Southwell (Australia), noted the promising prospects of these technologies for making observations in a cost-effective way and echoed WG-EMM's encouragement for ongoing efforts to ground truth population estimates from satellite observations.

3.18 The Scientific Committee thanked Argentina for an update regarding the population count of emperor penguins on the south coast of Snow Hill Island which confirmed an increase in the number of pairs since 2013 (using in situ and aerial methods). These new data will be presented to WG-EMM.

3.19 The SCAR Observer to SC-CAMLR (Prof. M. Hindell), presented SC-CAMLR-XXXIII/BG/15 that described a proposal for a new program of research to use high-resolution satellite images for a global census of pack-ice seals. He noted that there has only been one comprehensive assessment of pack-ice seal status, the first Antarctic pack-ice seal survey (APIS), coordinated by SCAR more than a decade ago and that such an expensive and demanding program of research is unlikely to ever be repeated. SCAR proposed the establishment of a SOOS working group to provide an international coordination team with membership from CCAMLR SCAR and leading researchers in the field.

3.20 The Scientific Committee agreed that the status and trends of Antarctic pack-ice seals represent an important knowledge gap for CCAMLR, in particular crabeater seals, which are one of the most abundant of the krill-dependent predators. The Scientific Committee endorsed the proposal for a global census of pack-ice seals and encouraged Members to engage with relevant national research programs and the SOOS working group.

Feedback management strategy – overlap between  
the krill fishery and land-breeding predators

3.21 The Scientific Committee agreed that the concept of ongoing ‘ecosystem checks’ (Annex 6, paragraph 2.117) based on indicators of possible competition between the krill fishery and krill-dependent predators was a useful basis for management advice during the staged development of feedback management. For example, it was noted that proximity to the coast was a major potential influence on the fishery impact on pinnipeds, seabirds and fish (paragraphs 3.147 and 3.148).

Feedback management strategy – simple feedback

3.22 Dr S. Kasatkina (Russia) highlighted the following key points in relation to uncertainty in the development of a feedback management strategy including simple feedback (SC-CAMLR-XXXIII/07):

- (i) the existing lack of information on spatial and temporal variability of krill biomass and distribution
  - (a) the existing estimates of krill biomass  $B_0$ , allowable catch and krill distribution by subareas and SSMUs in Area 48 are based on the CCAMLR 2000 survey and used for developing feedback management for future years
  - (b) the lack of sufficient information for understanding the fishery strategy and estimating risks to fishery performance associated with developing feedback management (for example, information on the variability of fishable and total krill biomass concentrated in SSMUs during fishing seasons, efficiency of commercial trawls in relation to characteristics of fishing krill aggregations)
  - (c) characteristics of fishable biomass in coastal and oceanic areas, etc.

- (ii) understanding of krill flux and its influence on the variability of krill biomass concentrated in SSMUs during fishing seasons
- (iii) issues for competitive relationships between the krill fishery and krill-dependent predators
  - (a) the lack of criteria for determining impacts of the fishery on krill stocks and krill-dependent predators
  - (b) the need to consider alternative sources of prey for predators in relation to krill
  - (c) the need to consider both spatial and functional overlap in evaluating the competitive relationship between predators and the krill fishery
  - (d) how do we separate impacts of the fishery on the state of predators from natural population fluctuations and climate change effects?

3.23 Dr Kasatkina noted that the above-mentioned information on krill distribution may be provided from combined data of large-scale international acoustic surveys and multinational acoustic surveys and acoustic surveys on board commercial vessels planned by CCAMLR. It would be important to orient acoustic surveys aboard commercial vessels on data collection in relation to options (paragraph 3.22(i)b).

3.24 Dr Kasatkina noted that local harvest rates as indicators for feedback management should be calculated using the catch data and estimates of krill biomass obtained in the same period of the fishing season. In view of this, the local harvest rates cannot be calculated using krill biomass estimates from research surveys like those provided by the US AMLR Program (in Subarea 48.1) and the British Antarctic Survey (BAS) (in Subarea 48.3) because these surveys have short durations and do not coincide with the period of the fishery. There are prospects for using acoustic estimates of krill biomass provided aboard commercial vessel during the fishing period.

3.25 The Scientific Committee agreed that these sources of uncertainty may need to be considered in developing stage 3, but resolving these issues or including them within feedback management will require a commitment to collect data. In the absence of such data, the management strategy will need to take account of these uncertainties to ensure the objectives of Article II will be met. It also acknowledged that increases in populations of cetaceans and Antarctic fur seals need to be accounted for in drawing conclusions on changes in local populations of predators and krill.

3.26 The Scientific Committee agreed that different krill predators feed in different ways and use prey fields differently. It is therefore likely that a series of metrics will need to be developed to monitor the effects of fishing. The Scientific Committee recognised that the current set of CCAMLR Ecosystem Monitoring Program (CEMP) parameters are providing indices at different time and space scales and that this will benefit further development of feedback management approaches.

3.27 Dr Constable noted the difference between local and regional impacts and recalled Figure 4 from the report of WG-EMM-11 (SC-CAMLR-XXX, Annex 4) which illustrates the expectation of managing risk locally in the early phases of the fishery and then, as data is

acquired, management of regional impacts will be possible and the fishery can expand while maintaining the same level of risk. In stage 2, confidence is needed that there are no local impacts as the fishery expands towards the trigger level. For later stages, how regional impacts might be managed beyond the trigger level needs to be determined. For stage 2, local harvest rates may provide some guidance on whether local impacts might be occurring, for example, the concentration of effort in Bransfield Strait.

3.28 The Scientific Committee sought advice from SG-ASAM and/or WG-SAM on how to estimate the one-sided lower 95% confidence bound for krill (similar to the assessment of icefish), which might also assist in local and regional management of krill resources. This is because it would provide the level of biomass for which there is 95% confidence that the abundance is at or greater than that level.

3.29 The Scientific Committee agreed that work to use local harvest rates as indicators in support of feedback management should proceed but in the context of the sources of uncertainty, including those illustrated in the previous paragraphs. It also recognised that other indicators will need to be considered in the development of feedback management approaches. The Scientific Committee and WG-EMM will need to provide advice that is robust to uncertainty in krill flux.

#### Feedback management strategy – advancement to stage 2

3.30 The Scientific Committee thanked WG-EMM for its work in developing a pro forma for Members to submit ideas regarding stage 2 feedback management for consideration by WG-EMM-15. The pro forma is intended to ease comparisons of ideas for stage 2 and Members are asked to identify available data to be used to implement their ideas, how those data would be analysed and how management advice would be developed. The pro forma developed at WG-EMM-14 is provided in Annex 6, Appendix D.

3.31 The Scientific Committee considered what has been developed since WG-EMM-14 using the pro forma and issues that have arisen. It recommended that broader headings with a list of specific points that might be considered under each heading would provide greater flexibility in developing proposals for stage 2 feedback management. It further recommended that the temporal sequencing of requirements and the time scale over which the work would be implemented should be included in proposals. The updated format is provided in Annex 8.

3.32 The Scientific Committee encouraged Members to fill out the updated pro forma in Annex 8 and to exchange ideas on options for stage 2 feedback management by means of the Developing Practical Approaches to Feedback Management for Krill e-group in advance of WG-EMM-15.

3.33 The Scientific Committee further recommended that, in progressing the work program towards stage 2 of feedback management in advance of WG-EMM-15, Members are encouraged to collaborate through two e-groups (Developing Practical Approaches to Feedback Management for Krill and 2016 Multi-nation Research Group) to develop:

- (i) questions for SG-ASAM to consider regarding design and data-collection requirements for acoustic work in the intensive studies of 2015/16

(ii) possible approaches to collecting and using acoustic data in feedback management

(iii) plans for the 2015/16 field program.

3.34 The Scientific Committee recognised the importance of working with the fishing industry in moving to stage 2 of feedback management and of developing a strategy for collaborating with the industry to access data. It recommended the development of such a strategy in tandem with use of the pro forma and, where possible, details could be included in proposals described using the pro forma.

3.35 The Scientific Committee discussed the length of time necessary to develop feedback management approaches and recalled the staged approach that was agreed on in 2013 (SC-CAMLR-XXXII, paragraphs 3.14 and 3.15), including the agreement to move to stage 2 using currently available data by 2015. The Convener of WG-EMM, Dr Kawaguchi, encouraged Members to work together to meet this goal.

3.36 Dr T. Ichii (Japan) requested clarification on terminology, specifically the difference between the terms ‘adaptive management’ and ‘feedback management’. The Scientific Committee agreed that these terms have very similar meanings and that summary definitions for these terms are:

- (i) feedback management: catch is adjusted on the basis of a feedback signal from data collection/monitoring; decisions on catches rely on decision rules
- (ii) adaptive management: catch is arranged spatially to test hypotheses on stock and/or ecosystem dynamics, while not violating the objectives of Article II.

3.37 The Scientific Committee agreed that proposals for structured fishing in a feedback management procedure would be consistent with incorporating adaptive management concepts into feedback management. It agreed that adaptive management could be a strategy for stage 2 of developing feedback management, while a full feedback management procedure would be as defined above (paragraph 3.36).

3.38 The Scientific Committee recommended that the term feedback management continue to be used by CCAMLR with respect to the krill fishery.

#### Conservation Measure 51-07

3.39 The Scientific Committee noted advice from WG-EMM that absolute estimates of krill biomass and predator biomass/performance for the whole of Area 48 are unlikely to be available on a regular basis and this will be an important consideration for the Scientific Committee in developing approaches to the management of the krill fishery. In particular, 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.

3.40 The Scientific Committee therefore endorsed recommendations from WG-EMM-14 (Annex 6, paragraphs 2.155 to 2.157) and advised that:

- (i) based on our current knowledge, a continuation of CM 51-07 in its current form would be consistent with the objectives of Article II
- (ii) the current interim distribution of the trigger level in the krill fishery in Subareas 48.1 to 48.4 be carried forward while the science needed to move to stage 2 of feedback management is progressed.

3.41 The Scientific Committee noted its intention to develop stage 2 of feedback management in 2015 by WG-EMM.

3.42 Dr Kasatkina stated that the current trigger level corresponds to the value of the maximum historical catch achieved in the 1980s and has nothing to do with the status of krill stock and predators in the 1980s as well as with the current status of krill stock and predators. Moreover, there is no science-based evidence of fishery impacts on the status of the krill stock and dependent predators in years of maximum pressure from commercial fishing. The trigger level has remained the same despite significant increased estimates for krill biomass  $B_0$  and allowable catch in Area 48 during recent years (increasing allowable catch from 4 million tonnes to 5.61 million tonnes). It is unclear how this value can be used to manage the current fishery. The trigger level needs scientific justification. There is a need for more substantiated reference points for krill fishery management. There is no scientifically based evidence for limiting the krill fishery to the current trigger level (620 000 tonnes) neither in respect of the status of the krill stock nor in terms of the impact of the fishery on dependent predators.

3.43 The Scientific Committee recognised that the endeavour to develop feedback management is exactly an attempt to address the issues raised by Dr Kasatkina.

3.44 Dr Barrera-Oro noted that there are many uncertainties associated with krill stock status and potential impacts on predators. Because of these uncertainties he called for the Scientific Committee and Commission to follow the precautionary approach that differentiates CCAMLR from other forums and to maintain the trigger level. He also suggested that the saturation of the fishery in Subarea 48.1 highlights the need for the precautionary approach.

3.45 Some Members believed that there is a need to review the trigger level.

3.46 Dr R. Werner (ASOC) introduced CCAMLR-XXXIII/BG/25 'Krill: the power lunch of Antarctica' and provided comments with regard to the revision of CM 51-07. He noted that as the krill fishery has become more concentrated in Subarea 48.1, this has resulted in its closure before the end of the fishing season, in several of the last years. This concentration of fishing is occurring close to threatened species of penguins in the area, potentially increasing risks to these populations. ASOC supported the extension of CM 51-07 in its current form.

#### CEMP fund

3.47 The Scientific Committee recalled that during its 2013 meeting, a CEMP Special Fund Management Group was established with Dr Godø appointed as Convener, Dr J. Arata (Chile) as Junior Vice-Chair, and Dr Ichii was appointed as Senior Vice-Chair during WG-EMM-14. The Scientific Committee thanked the Management Group for its work during the

intersessional period, including its assessment of two proposals submitted by a group led by Dr Watters on penguin tracking and on the use of cameras for penguin population monitoring.

3.48 Dr Watters thanked collaborators for their work on the two proposals and the Management Group for its favourable reviews of the proposals. He indicated that, to date, it has not been possible to find matching funding for the more expensive of the two proposals (penguin tracking). Dr Watters proposed that the tracking proposal not be funded at this time until matching funds can be secured, but that it would be possible to move forward with the camera proposal through the CEMP Special Fund.

3.49 On behalf of the Management Group, Dr Arata thanked Dr Watters and the group that had submitted the proposals. He suggested that the camera proposal, aimed at detecting changes in penguin populations in different areas, be funded. He further suggested that this proposal be open to discussion at WG-EMM and that the project follow its proposed schedule but with certain adjustments depending on discussions at WG-EMM.

3.50 The Scientific Committee endorsed the advice from the Management Group with respect to use of the CEMP Special Fund and welcomed the opportunity for enhanced collaboration between Members. It encouraged Members to pursue ideas for securing funds for the second proposal introduced by Dr Watters.

#### Oceanographic models

3.51 The Scientific Committee welcomed the variety of oceanographic modelling studies being proposed by Members. The Scientific Committee recognised the importance of the understanding of hydrographic processes in the Scotia Sea that can influence aggregations of krill and predators and contribute to the flux of krill between SSMUs to the development of feedback management schemes. The Scientific Committee noted the importance of oceanographic modelling to these goals.

#### Integrated assessment

3.52 The Scientific Committee recognised the continued development and recent results of the integrated assessment model being developed for krill. The Scientific Committee noted the model provides a credible index of krill biomass. However it does not currently produce a robust estimate of absolute biomass. The Scientific Committee looked forward to future developments in this model and noted that there may be an eventual need to develop the model beyond its current subarea scale to consider subdivision at a finer scale (e.g. SSMUs).

#### 2015/16 multinational investigation of the krill-based ecosystem

3.53 The Scientific Committee was provided an update on the upcoming multinational investigation planned for 2015/16. Proponents of the study indicated that a number of other nations had expressed interest in contributing to this effort and this was encouraged by the Scientific Committee and Members.

3.54 The aims of the 2015/16 international study presently include:

- (i) exploration of the spatial variability in krill abundance
- (ii) determination of krill responses to varying oceanographic conditions, school dynamics and fisheries interactions
- (iii) krill–predator interactions at various scales.

3.55 The Scientific Committee noted the timeliness of this proposed research given the stated goal to develop feedback management. Details of the planning for this effort are reported in SC-CAMLR-XXXIII/BG/33 Rev. 1.

3.56 The Scientific Committee agreed that this was an important initiative for progressing its work on the development of the feedback management for the krill fishery and suggested that a special focus topic during WG-EMM could be useful to more fully integrate research plans among Members.

3.57 The Scientific Committee noted that the workload of SG-ASAM was full but agreed that inclusion of this effort into their meeting was necessary as a matter of priority in the coming intersessional period.

3.58 The Scientific Committee was informed of updates to the status of participants and ship time for the 2015/16 multinational study. Although challenges were noted by many participants, there was still substantial support to enable this study to continue. The Scientific Committee suggested that further updates be made a focus topic at WG-EMM to ensure the highest level of integration could be reached given the need for progressing the staged approach of the feedback management strategy.

#### Ecosystem modelling

3.59 The Scientific Committee has noted the need for modelling ecosystem processes at scales relevant for management and for understanding the potential ecosystem effects of the krill fishery. The Scientific Committee agreed that priority needs to be given to the development of multispecies models to support work in developing krill feedback management, the desire to hold a symposium to further this work, but noted that the workloads of WG-EMM and WG-SAM are rather full.

#### Finfish

3.60 The Scientific Committee noted the number and diversity of papers regarding the biology and ecology of fish submitted to WG-EMM during 2014. The Scientific Committee thanked the authors for their work. The Scientific Committee recalled its previous discussions on this topic and noted the need to better integrate the finfish component of the ecosystem into its work (paragraphs 3.154 to 3.156 and 13.1 to 13.4). In the interim, the Scientific Committee considered the best mechanism to ensure that appropriate information and expertise is brought together to provide advice on the ecological impacts of finfish fishing on finfish predators and krill could be to provide such reports to each working group.

## Fish resources

### Status and trends

3.61 The Scientific Committee noted that the following finfish fisheries operated in the Convention Area in 2013/14:

- (i) fisheries for *Champsoccephalus gunnari* (icefish)
  - (a) Subarea 48.3 (CM 42-01)
  - (b) Division 58.5.2 (CM 42-02)
  
- (ii) fisheries for *Dissostichus eleginoides* and/or *D. mawsoni* (toothfish)
  - (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, no fishing reported)
  - (f) Division 58.4.3a (exploratory fishery, CM 41-06)
  - (g) Division 58.5.1 (waters adjacent to the Kerguelen Islands, French exclusive economic zone (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).

3.62 Catches of *C. gunnari* and *Dissostichus* spp. taken in the Convention Area in 2013/14 to 20 September 2014 are summarised in Table 1 of SC-CAMLR-XXXIII/BG/01, catches taken in 2012/13 are summarised in Table 2 of SC-CAMLR-XXXIII/BG/01. These catches include by-catch and catches taken during research fishing in areas closed to fishing (Subarea 48.5 and Divisions 58.4.4a and 58.4.4b).

3.63 For *Dissostichus* spp., research fishing was carried out in the closed areas, namely Subarea 48.5 (229 tonnes) and Division 58.4.4b (16 tonnes). The Secretariat also closed the following fisheries this season for *Dissostichus* spp.: Subarea 48.4 on 1 April (at 98% of catch limit for *D. eleginoides* and at 100% for *D. mawsoni*), Subarea 48.6 on 10 February (at 100% of catch limit), Division 58.4.3a on 31 August (at 100% of catch limit), Subarea 88.1 on 17 January (at 97% of catch limit) and Subarea 88.2 on 26 January (at 109% of catch limit). There were also closures at SSRU level in Subareas 88.1 and 88.2 (see also CCAMLR-XXXIII/BG/01).

3.64 There are two main fisheries targeting *C. gunnari*, in Subarea 48.3 and Division 58.5.2. In Subareas 48.1, 48.2 and 48.3 there have been small catches of *C. gunnari* as by-catch to the krill fishery (SC-CAMLR-XXXIII/BG/01, Table 1).

## CCAMLR GIS

3.65 The Scientific Committee welcomed the creation of the CCAMLR geographic information system (GIS) which was developed by the Secretariat in collaboration with BAS ([www.ccamlr.org/node/82341](http://www.ccamlr.org/node/82341)). The GIS improves access to CCAMLR spatial data and enables a variety of data formats to be visualised along with other Antarctic datasets.

### Data quarantine

3.66 The Scientific Committee noted the outcomes of the investigation on anomalous CPUE which had been conducted by the Republic of Korea (COMM CIRC 14/93, 9 September 2014). The Scientific Committee thanked Korea for its efforts to address and resolve this issue and agreed that the process undertaken by Korea is a good template for future investigations.

3.67 The Scientific Committee noted the need for a wide-scale analysis of CPUEs, which would be useful to identify any other potential issue related to anomalous CPUE. It noted that observer reports may contain information which may inform such an analysis.

3.68 The Scientific Committee recommended that for the following vessels fishery and observer data should be quarantined and excluded from future data requests and analyses, and metadata provided with data extracts should include details of any quarantined data, which would be available on specific request:

- (i) *Insung No. 2* in Subarea 48.6 and Divisions 58.4.1 and 58.4.2 in 2009/10
- (ii) *Insung No. 7* in Subareas 48.6 and 88.1 and Divisions 58.4.1 and 58.4.2 in 2010/11
- (iii) *Insung No. 22* in Subarea 48.6 and Divisions 58.4.1 and 58.4.2 in 2008/09
- (iv) *Paloma V* in Divisions 58.4.1 and 58.4.3b in 2006/07.

3.69 The Scientific Committee requested that WG-SAM develop methods and approaches that could be used for validation of fishery and observer data, and recommended that the Secretariat then develop routine procedures for validation of data that are being used in stock assessments. It was noted that the quarantined data provides case studies of investigated illegal, unreported and unregulated (IUU) activities that can be used for evaluating and testing such diagnostic techniques.

3.70 In particular, the Scientific Committee noted that during the reviews by WG-SAM-13, WG-FSA-13 and the Scientific Committee of the observer data collected on the *Insung* vessels, WG-SAM and WG-FSA had not evaluated if the fishing that had occurred violated CCAMLR conservation measures. Therefore, the Scientific Committee sought advice and guidance from the Standing Committee on Implementation and Compliance (SCIC) on how to deal with such inconsistencies. The Scientific Committee also requested WG-FSA to report any anomalous fishery or observer data to the Scientific Committee and SCIC.

3.71 The Scientific Committee recommended that if vessel monitoring system (VMS) data were made available consistent with the Rules for Access and Use of CCAMLR Data, this may help to inform the spatial attribution of biomass removals associated with quarantined data for the purposes of stock assessment.

3.72 The Scientific Committee requested that the Secretariat develop data checking/processing algorithms to routinely compare the catch location and time reported in the catch data and the VMS data in order to develop data quality thresholds to improve overall data quality and the interpretation of maps depicting catch locations and VMS data. The Scientific Committee requests that the algorithms are applied to the data collected throughout the Convention Area.

#### Toothfish trade

3.73 The Scientific Committee noted an analysis of global patterns of trade volume and price of *Dissostichus* spp. by the Secretariat using United Nations Commodity Trade Statistics (CCAMLR-XXXIII/BG/14 Rev. 1). It noted that initial results revealed a strong relationship between supply and demand within international markets, and that identifying trends in the global market may assist in the management of fisheries for *Dissostichus* spp.

#### Fishery surveys

3.74 The Scientific Committee noted the results from the annual random stratified trawl survey in Division 58.5.2 that was conducted in June 2014. In 2014, the catches of both *D. eleginoides* and *C. gunnari* were higher than the average since 2006, although the catches of *C. gunnari* were less than half of those in 2013. Catches of *Channichthys rhinoceratus* and *Lepidonotothen squamifrons* were also higher than average.

3.75 The Scientific Committee noted that further analysis of trends in surveys, such as the POKER surveys, across the whole Kerguelen plateau for all species may help to inform the processes and time frames required for the recovery of particular species and may be informative to the Commission in meeting its objectives under Article II of the Convention.

3.76 The Scientific Committee recommended that detailed descriptions of the trawl configurations and standard survey procedures be submitted to the CCAMLR gear library, which so far only holds descriptions of longline gear used in the Convention Area.

#### Data on sea-ice

3.77 The Scientific Committee noted two methods to automatically summarise sea-ice concentration and characterise sea-ice concentration dynamics and its impact upon fishing and research fishing activities. Sea-ice concentration analyses indicated that over 86% of fishing events took place in ice conditions where the sea-ice concentration was less than 20%.

3.78 The method for indexing the effects of ice on fishing operations used the toothfish fishery in Subarea 88.1 as a case study. The Scientific Committee recommended that sea-ice analyses be broadened to encompass other areas, and may be useful to identify trends in ice coverage and access of areas available to fishing – particularly in light of the Intergovernmental Panel on Climate Change (IPCC) findings of changing sea-ice conditions in the Ross Sea. Combined analysis of sea-ice analysis and fish habitat modelling might also

provide insights that could assist the design of research and assessment programs. The Scientific Committee noted that the spatial data of sea-ice concentration could be incorporated into the CCAMLR GIS and be used to characterise areas that had research fishing proposals.

#### Tag-overlap statistic

3.79 The Scientific Committee noted an analysis that reported a false positive in the tag-overlap statistic arising from low catch volume and the resulting limited sample size. In 2013/14 in Subarea 88.2, the tagging rate by the FV *Argos Georgia* was higher than the required minimum set by the Commission but the achieved tag-overlap statistic was 52%. The Scientific Committee recalled that CM 41-01 requires a tag-overlap statistic of at least 60% for catches of at least 10 tonnes, but noted that in this case the tag-overlap statistic was sensitive to moving a single fish from one 10-centimetre size bin to the adjacent size bin when the catch was slightly above 10 tonnes.

3.80 The Scientific Committee noted that the required tag-overlap statistic was not achieved for the *Argos Georgia*, *Palmer* and *Yantar 31* in Subarea 88.2 in 2014 and agreed that these three events represented sampling artefacts, rather than compliance concerns, due to the tag-overlap statistic being calculated on a small number of fish tagged and released.

3.81 The Scientific Committee agreed that this information should be passed to SCIC in order that it be included in the consideration of the CCAMLR Compliance Evaluation Procedure (CCEP).

3.82 The Scientific Committee recommended that the fifth sentence in CM-41-01, Annex 41-01/C, paragraph 2(ii), be revised as follows:

For any vessel fishing for each species of *Dissostichus* in the Convention Area from 2014/15 onward, the minimum tag-overlap statistic of 60% shall not apply in a given fishery where the total catch is less than 10 tonnes or where the number of tagged fish released is fewer than 30 and the vessel has achieved the required tagging rate.

3.83 The Scientific Committee recalled the importance of the tag-overlap statistic (SC-CAMLR-XXIX, paragraph 3.139) and emphasised its importance for vessels with small catches. Accordingly, it requested that the Secretariat continue to calculate the tag-overlap statistics for all vessels and provide those estimates to the WG-FSA.

#### Depredation

3.84 The Scientific Committee noted the results of analyses of depredation by killer whales and sperm whales and its mitigation carried out by French scientists within the French EEZ in Subarea 58.6. Fish losses due to depredation were assessed indirectly by means of either catch rate comparisons or a novel method examining differences in the proportion of by-catch (*Macrourus* spp.). The assessment methods gave consistent results and indicated very high levels of depredation (27%–29% of the total catch from 2003 to 2013) compared with estimates for other subareas. The results highlighted the importance of accounting for

depredation when assessing and managing fish stocks. The Scientific Committee recommended that similar analyses on whale depredation using by-catch analyses be conducted in other areas.

3.85 The Scientific Committee noted that killer whales (*Orcinus orca*) can quickly become habituated to a proprietary acoustic harassment device (AHD) intended to deter depredation. In addition, it was suggested that this AHD could cause harmful hearing disturbance to killer whales. The use of alternative mitigation measures was therefore recommended.

#### Icefish assessments

##### *Champscephalus gunnari* South Georgia (Subarea 48.3)

3.86 Fishery Reports for each fishery are provided on the website ([www.ccamlr.org/node/75667](http://www.ccamlr.org/node/75667)), and discussion by WG-FSA is in Annex 7, paragraphs 4.43 to 4.45.

3.87 The fishery for *C. gunnari* at South Georgia (Subarea 48.3) operated in 2013/14 in accordance with CM 42-01 and associated measures. The fishing season started on 1 December 2013 and remains open to date. The catch of *C. gunnari* in Subarea 48.3 up to 20 September 2014 was 4 tonnes. The fishery was active at the time of the WG-FSA meeting.

3.88 Dr Barrera-Oro noted that, to date, the catches in the current season had been only 4 tonnes, well below the 4 600 tonnes catch limit. Very low catches (<10 tonnes) were also recorded in 2009/10 and 2010/11 and only less than 45% of the catch limit were reached in 2011/12 and 2012/13. He commented that, as had been noted in previous CCAMLR meetings, the difference in the catches between pelagic trawl to which the fishery was restricted, and the bottom trawl used to conduct the demersal biomass survey, may account for some of the discrepancy between potential catch and realised catch. However, more than two decades ago, using the same pelagic gear, the commercial fishery obtained substantial catches closer to the levels of the established catch limits. In comparison, the inability of the fishery to achieve the catch limit by such a substantial margin in the last five years was of concern and could be a sign of a decrease in the resource.

3.89 Dr Kock noted that it was not unusual for icefish to be unavailable to the fishery. The species exhibited large variation in its spatial distribution, local abundance, and especially its movement up into the water column in response to the density of available krill prey.

3.90 Dr Darby noted that the recent surveys had recorded an increasing stock abundance during the years with low catches and that catches were determined not only by stock abundance but also by the effort exerted by the fishery, as well as the unpredictable catchability associated with fishing for a predominantly demersal species with pelagic gear. He noted that the UK had initiated a research studentship into the dynamics of icefish within the water column and that this would hopefully provide some insight. A new survey is scheduled for January 2015.

## Management advice

3.91 The Scientific Committee recommended a catch limit for *C. gunnari* in Subarea 48.3 of 2 659 tonnes for 2014/15 based on the assessment in 2013.

### *Chamsocephalus gunnari* Kerguelen Island (Division 58.5.1)

3.92 The discussion by WG-FSA on *C. gunnari* in Division 58.5.1 is in Annex 7, paragraphs 4.46 to 4.49.

3.93 In the French EEZ of Kerguelen, trawl fisheries have been closed since 1994/95 (see *CCAMLR Statistical Bulletin*) due to the decline of stocks prior to those years. The Scientific Committee noted that a stock assessment was conducted that was based on the 2013 POKER biomass survey for *C. gunnari* in Division 58.5.1 following that agreed by CCAMLR (SC-CAMLR-XVI, paragraph 5.70). Biomass estimates and weight at length were obtained from the random trawl survey. Densities at age were estimated with CCAMLR's mixture analysis program (CMIX) and supplied to the General Yield Model (GYM). The lower one-sided 95% confidence bound of the biomass estimate was used as the estimate of the standing stock at the start of the projection period.

3.94 Only the 1+ to 3+ cohorts were projected for evaluating whether proposed catches met the CCAMLR decision rules. These projections indicated that catches of 840 tonnes in 2013/14 and 580 tonnes in 2014/15, or 0 tonnes in 2013/14 and 1 490 tonnes in 2014/15 satisfied the CCAMLR decision rules.

## Management advice

3.95 The Scientific Committee recommended that a catch limit for *C. gunnari* in 2014/15 of 1 490 tonnes would meet the CCAMLR decision rules, based on no catch being taken in the remainder of the 2013/14 season.

### *Chamsocephalus gunnari* Heard Island (Division 58.5.2)

3.96 Discussion by WG-FSA is in Annex 7, paragraphs 4.50 to 4.54.

3.97 In 2013/14, the catch limit for *C. gunnari* was 1 267 tonnes. Fishing was conducted by one vessel using a semipelagic trawl and the total reported catch up to 20 September 2014 was 1 123 tonnes.

3.98 The Scientific Committee noted that Australia had undertaken a random stratified trawl survey in Division 58.5.2 during June 2014, using a demersal trawl. It also noted a continuation in the 2014 survey of a pattern first noted in 2011 of multiple apparent cohorts of *C. gunnari* in the survey catches. This is a change from years previous to 2011 when a single cohort dominated the survey catches.

3.99 The assessment method followed that agreed by CCAMLR (SC-CAMLR-XVI, paragraph 5.70) for assessing yield in *C. gunnari* and was identical to that used to estimate yields for *C. gunnari* in Division 58.5.2 in previous years. Biomass estimates and weight at length were obtained from the random trawl survey. Densities at age were estimated with CMIX and supplied to the GYM. The lower one-sided 95% confidence bound of the biomass estimate was used as the estimate of the standing stock at the start of the projection period.

3.100 With the expectation that the current 4+ and 5+ cohorts are fully exploited, only the 1+ to 3+ cohorts were projected for evaluating whether proposed catches met the CCAMLR decision rules. These projections indicated that catches of 309 tonnes in 2014/15 and 275 tonnes in 2015/16 satisfied the CCAMLR decision rules.

#### Management advice

3.101 The Scientific Committee recommended a catch limit for *C. gunnari* in 2014/15 of 309 tonnes and 275 tonnes for 2015/16.

#### Toothfish assessments

##### *Dissostichus eleginoides* South Georgia (Subarea 48.3)

3.102 Discussion by WG-FSA is in Annex 7, paragraphs 4.1 to 4.2. In 2013/14, the catch limit for *D. eleginoides* was 2 400 tonnes. Fishing was conducted by six vessels using longlines and the total reported catch was 2 180 tonnes.

#### Management advice

3.103 The Scientific Committee recommended that its advice from 2013 with a catch limit for *D. eleginoides* in Subarea 48.3 of 2 400 tonnes be carried forward in its entirety for 2014/15.

##### *Dissostichus eleginoides* South Sandwich Islands (Subarea 48.4)

3.104 Discussion by WG-FSA is in Annex 7, paragraphs 4.3 to 4.7.

3.105 In 2013/14 the catch limit for *D. eleginoides* for Subarea 48.4 was 45 tonnes. The total reported catch up to 20 September 2014 was 44 tonnes.

3.106 The Scientific Committee noted that a preliminary CASAL population assessment of *D. eleginoides* in Subarea 48.4 was based on data for the 2009–2014 fishing seasons. The fishery is still largely based on a range of strong recruitment events that occurred around 1994–1996. The Scientific Committee noted the importance of ageing data in estimating these

recruitment events and recommended stratified sampling of length data and also noted that without future strong recruitment events, the future catch is likely to be reduced to research catch only.

#### Management advice

3.107 The Scientific Committee recommended that the catch limit for *D. eleginoides* in Subarea 48.4 should be set at 42 tonnes for 2014/15 based on the outcome of this assessment.

#### *Dissostichus mawsoni* South Sandwich Islands (Subarea 48.4)

3.108 Discussion by WG-FSA is in Annex 7, paragraphs 4.3 to 4.7.

3.109 In 2013/14 the catch limit for *D. mawsoni* for Subarea 48.4 was 24 tonnes. The total reported catch up to 20 September 2014 was 24 tonnes.

3.110 The Scientific Committee noted a tag-based Petersen estimator had previously been used to provide species-specific biomass estimates for *D. mawsoni* in Subarea 48.4. It also noted that WG-FSA recommended using a Chapman estimator for estimating biomass where the number of annual recaptures is lower than 10, instead of a Petersen estimator. Using the Chapman estimator, biomass was estimated at 725 tonnes. The catch limit for 2014/15 was estimated by applying the same harvest rate as in previous years which is based on the harvest rate of *D. eleginoides* in Subarea 48.3 ( $\gamma = 0.038$ ). Accordingly, a total catch limit of 28 tonnes was recommended for 2014/15.

3.111 The Scientific Committee recommended that  $\gamma$  be estimated using biological parameters for *D. mawsoni* from this area in the future.

#### Management advice

3.112 The Scientific Committee recommended that the catch limit for *D. mawsoni* in Subarea 48.4 be set at 28 tonnes for 2014/15 based on the outcome of this assessment.

#### By-catch limits for Subarea 48.4

3.113 The Scientific Committee recommended that the catch limits for by-catch species in Subarea 48.4 should be determined for 2014/15 using the percentages of the catch applied in its advice from previous years.

3.114 The Scientific Committee therefore recommended that the catch limits for macrourids be set at 11.2 tonnes (16% of the catch limit for *Dissostichus* spp.) and for skates at 3.5 tonnes (5% of the catch limit for *Dissostichus* spp.).

3.115 The Scientific Committee also recommended the maintenance of a move-on rule for by-catch species, with a minimum macrourid trigger of 150 kg and 16% of the catch by weight of *Dissostichus* spp. per line, and a trigger for skates set at 5% of the catch by weight of *Dissostichus* spp. per line.

#### *Dissostichus eleginoides* Kerguelen Islands (Division 58.5.1)

3.116 Discussion by WG-FSA is in Annex 7, paragraphs 4.33 to 4.37.

3.117 The fishery for *D. eleginoides* in Division 58.5.1 is conducted in the French EEZ. In 2013/14, 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 20 September 2014 was 3 017 tonnes.

3.118 The Scientific Committee noted that an updated stock assessment of *D. eleginoides* in Division 58.5.1 inside the French EEZ was presented at WG-FSA, which included the results of the POKER 3 survey and fishery data up until September 2014. The Scientific Committee noted France's commitment to carry out ageing, which is currently under way, and recommended that year-class strength (YCS) should not be estimated until age data were available.

3.119 The Scientific Committee also endorsed the recommendations for further work identified by WG-FSA (Annex 7, paragraph 4.35).

#### Management advice

3.120 The Scientific Committee agreed that the CASAL assessment with fixed YCS as described in WG-FSA-14/36 Rev. 1 could be used to provide management advice for 2014/15. Although the long-term yield was not calculated, the current catch limit of 5 100 tonnes satisfied the CCAMLR decision rules.

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

#### *Dissostichus eleginoides* Heard Island (Division 58.5.2)

3.122 Discussion by WG-FSA is in Annex 7, paragraphs 4.12 to 4.32.

3.123 In 2013/14, the catch limit for *D. eleginoides* was 2 730 tonnes. Fishing was conducted by one trawl and three longline vessels and the total reported catch up to 20 September 2014 was 1 909 tonnes.

3.124 The Scientific Committee noted the discussion on the revised stock assessment in Division 58.5.2 in Annex 7, paragraphs 4.13 to 4.19.

3.125 The Scientific Committee congratulated Australia on embarking on the work required to address the concerns of WG-FSA-13, SC-CAMLR-XXXII and WG-SAM-14 and considered that Australia had addressed all its recommendations. The Scientific Committee particularly noted the substantial improvement of the assessment model and that, with and without tagging data, the median trajectory of the stock did not move below the target levels during the projection period, in contrast to the assessment presented to WG-FSA-13.

3.126 The Scientific Committee noted that the addition of more tagging data from the expanding longline fishery in Division 58.5.2 should have a high priority.

3.127 The Scientific Committee noted that two revised assessment models with alternative periods of estimated YCS were evaluated during WG-FSA. The revised model with estimated YCS for 1986–2009 and including tag data for 2012 and 2013 was recommended to be used to provide management advice. This revised assessment model estimated median  $B_0$  to be 108 586 tonnes and the median SSB status in 2014 at 0.65 of  $B_0$ . Applying the CCAMLR decision rule, the model estimated a precautionary catch limit of 4 410 tonnes.

3.128 The Scientific Committee discussed the level of *D. eleginoides* catches taken from the entire Kerguelen Plateau. It noted that there is fish movement between Divisions 58.5.1 and 58.5.2 (Annex 7, paragraph 4.15), but that where a stock is harvested by a number of fisheries, it is more precautionary to assess parts of the stock individually as it is done for Divisions 58.5.1 and 58.5.2, as opposed to a joint assessment. It also noted that the current stock status were estimated above the target level with 0.66 in Division 58.5.1 and 0.65 in Division 58.5.2, and that catch levels for both divisions satisfied the CCAMLR decision rules.

3.129 The Scientific Committee supported the ongoing research undertaken by Australia and suggested further consideration be given to the incorporation of tag data in the assessment, re-estimation of growth parameters, particularly as more data characterising size at age in older year classes become available. The Scientific Committee also recommended that the method to estimate survey catchability  $q$  in the model be presented to WG-SAM along with sensitivities around these calculations, and that the inclusion of survey data as biomass and proportions at age should be investigated in the future model runs. It further noted that an updated assessment will be presented to WG-FSA-15.

3.130 Australia noted that it will continue to correspond with WG-FSA and the Scientific Committee Members in the development of the assessment for this stock as new information becomes available.

3.131 Dr V. Bizikov (Russia) noted that the catch limit for toothfish in the Heard Island area (Division 58.5.2) recommended by WG-FSA for 2014/15 (4 410 tonnes) is 61% greater than in the previous season (2 700 tonnes). He called attention of the Scientific Committee to the fact that this rapidly increasing fishery is still carried out, in part, using bottom trawls which are banned elsewhere in the CCAMLR Area according to CMs 22-05 and 22-06. He reiterated the concern expressed by some Members last year and pointed out that the bottom trawling constitutes the most damaging method of fishing benthic habitats and as such should be excluded from practice within CCAMLR fisheries as soon as possible (SC-CAMLR-XXXII/01, paragraph 3.118).

3.132 Dr Constable drew the attention of the Scientific Committee to Annex 7, paragraph 6.3, which presented the results of an eight-year study in Division 58.5.2 on the

effects of bottom fishing on benthic habitats in the region. He advised that all representatives of the Scientific Committee have been provided with a hard copy of this report. It is also available as a PDF (WG-FSA-14/P06). In advance of the discussion on bottom fisheries generally, he summarised that less than 1.5% of all the biomass in waters under 1 200 m, which is where trawl fishing has been undertaken, are estimated to have been damaged by all bottom fishing activities since 1997 in this division. 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. He noted that trawl fishing is now only a small part of the fishery in Division 58.5.2 and is concentrated in its traditional grounds, thereby not contributing to further effects of fishing on these habitats. The study also refined the management system for monitoring and managing bottom fishing activities. This system will ensure that bottom fisheries in the region will continue to avoid causing significant adverse impacts on benthic habitats.

#### Management advice

3.133 The Scientific Committee recommended a catch limit of 4 410 tonnes for 2014/15.

#### *Dissostichus eleginoides* Crozet Islands (Subarea 58.6)

3.134 Discussion by WG-FSA is in Annex 7, paragraphs 4.38 to 4.41.

3.135 The fishery for *D. eleginoides* at Crozet Islands is conducted in the French EEZ, which includes parts of Subarea 58.6 and Area 51 outside the Convention Area. In 2013/14, the catch limit for *D. eleginoides* was 700 tonnes. Fishing was conducted by six vessels using longlines and the total reported catch up to 20 September 2014 was 382 tonnes.

3.136 The Scientific Committee noted that an updated stock assessment of *D. eleginoides* in Subarea 58.6 was presented at WG-FSA, which included fishery data up until September 2014. The model included estimated levels of depredation by killer whales from generalised additive model (GAM) analyses of the fishery data. The Scientific Committee welcomed this updated stock assessment, and recommended that age frequencies be included once age data are available and that YCS be estimated as a sensitivity analysis. It further recommended that alternative estimates of whale depredation, as estimated in WG-FSA-14/10 (Annex 7, paragraph 3.30), be investigated further in future models.

#### Management advice

3.137 The Scientific Committee agreed that the CASAL model with fixed YCS as described in WG-FSA-14/36 Rev. 1 could be used to provide management advice for 2014/15. Although a maximum catch limit was not calculated, the current catch limit of 700 tonnes, with the addition of an allowance for 60 tonnes of killer whale depredation, satisfied the CCAMLR decision rules.

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

*Dissostichus eleginoides* Prince Edward and Marion Islands (Subareas 58.6 and 58.7) and Area 51 inside the South African EEZ

3.139 Discussion by WG-FSA is in Annex 7, paragraph 4.42.

3.140 The Scientific Committee noted that South Africa had set a catch limit of 450 tonnes for 2013/14 in the Prince Edward and Marion Islands and that two vessels were allowed to conduct fishing in this area. An assessment model used to set the catch limit has recently been updated in South Africa, which enabled the incorporation of more data and was used to set the 2014/15 catch limit. The Scientific Committee noted that the catch limit for 2014/15 is likely to be similar to last season's catch limit.

Management advice for *D. eleginoides* at Prince Edward and Marion Islands (Subareas 58.6 and 58.7) inside the EEZ

3.141 The Scientific Committee was unable to provide management advice for the fishery in the South African EEZ at the Prince Edward Islands.

Management advice for *D. eleginoides* at Prince Edward Islands (Subareas 58.6 and 58.7 and Division 58.4.4) outside the EEZ

3.142 No new information was available on the state of fish stocks in Subareas 58.6 and 58.7 and Division 58.4.4 outside areas of national jurisdiction. The Scientific Committee therefore advised that the prohibition of directed fishing for *D. eleginoides*, described in CM 32-02, remain in force.

#### Fish and invertebrate by-catch

3.143 The Scientific Committee noted the discussion by WG-FSA on data related to different by-catch species, including skates, in a number of management areas (Annex 7, paragraphs 8.1 to 8.17). It endorsed the formation of a CCAMLR e-group to carry out the following recommendations:

- (i) Photographic identification guides: while identification guides have been developed for problematic taxa by various nations, intersessional work could usefully compare these guides (including their consistency), collate representative photographs and develop a draft guide that could be used across the CCAMLR area. Initial work should focus on one taxonomic group (e.g. skates) before including further taxa in the future.

- (ii) Photographic maturity key for skates: photographs of the different maturity stages of Antarctic skates could also usefully be collated.
- (iii) Develop a targeted program to facilitate the collection of relevant identification material and samples for skates (e.g. photos of diagnostic characters and tissue samples) to allow for improved taxonomic studies in the future.
- (iv) Checking of morphometric and other biological data for skates on the CCAMLR database: given the discrepancies in the CCAMLR database, a CCAMLR e-group should work with the Secretariat to identify (and correct where possible) errors and suggest ways of improving data checks in the future.

3.144 The Secretariat was requested to lead the e-group and all the contributors are asked to send relevant photographs and any regional/national guides to the Secretariat ([observer.scheme@ccamlr.org](mailto:observer.scheme@ccamlr.org)).

3.145 The Scientific Committee noted the advice from WG-EMM-14 that reporting of finfish by-catch in the commercial data from the krill fishery was in all cases consistently lower than the frequency of occurrence derived from observer data (Annex 6, paragraph 2.37). The Scientific Committee recalled that the reporting of fish by-catch (other than in the 25 kg samples collected by observers) was a vessel responsibility and this data should be reported in the C1 data forms.

3.146 WG-EMM (Annex 6, paragraphs 2.37 to 2.40) agreed that data from fish by-catch could provide a potentially important source of information on krill-associated pelagic fish, for which very little routine sampling occurs. The Scientific Committee noted that the increase in observer coverage in the krill fishery provided an opportunity for improved data collection and encouraged the appropriate review of this by-catch data by both WG-EMM and WG-FSA.

3.147 Dr Barrera-Oro drew the attention of the Scientific Committee to the significant levels of by-catch of *C. gunnari* in the krill fishery operating in the southern zone of the Scotia Arc, Subareas 48.1 and 48.2, which were evaluated using data from the CCAMLR Scheme of International Scientific Observation (SISO) (WG-EMM-14/31 Rev. 1). In addition, a document presented at WG-FSA (WG-FSA-14/66) provided historic information on fish by-catch in the krill fishery also indicating that *C. gunnari* was one of the species most frequently caught. He noted the discordance, in terms of conservation, of the present situation of this species: while advanced juveniles/adult fish are protected by CM 32-02, the early stages (larvae), which are currently taken by the krill fishery, are not protected under any conservation measure. In reference to Annex 6, paragraph 2.39, he expressed that in the region of the southern Scotia Arc, the krill fishery has a role in the recovery of previously overexploited stocks such as *C. gunnari*.

3.148 Dr Barrera-Oro indicated that because of the fish by-catch, the operations of the krill fishery close to the coast and/or at shallower depths have the potential to interfere with critical phases of the life cycle of inshore species that have been overexploited by the commercial finfish fishery in the 1970s. Two examples are the nototheniids *Notothenia rossii* and *Gobionotothen gibberifrons*, which are still now in the process of recovery. Thus, krill fishing depths might be another element to be considered in the formulation of measures for the protection of fish at their early stages.

## Exploratory fisheries

3.149 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 2013/14; 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](http://www.ccamlr.org/node/75667)). No new fishery was conducted in 2013/14.

3.150 The Scientific Committee noted that management areas in five exploratory fisheries for *Dissostichus* spp. were closed by the Secretariat in 2013/14. These closures were triggered by catches of *Dissostichus* spp. approaching the relevant catch limits (CCAMLR-XXXIII/BG/01), and the catch limits in the fishery in Subarea 88.2 were exceeded. The Scientific Committee noted that up to 14 vessels had fished in Subarea 88.2 in January 2014 and the fishery had experienced a rapid increase in fishing effort following the closure of the fishery in Subarea 88.1 on 17 January 2014 (Annex 7, Figure 1).

3.151 Notifications for exploratory fisheries for *Dissostichus* spp. were submitted by nine Members for a total of 24 vessels in Subarea 88.1, nine Members and 23 vessels in Subarea 88.2, two Members and two vessels in Division 58.4.3a, four Members and four vessels in Subarea 48.6, four Members and four vessels in Division 58.4.1 and three Members and three vessels in Division 58.4.2 (Annex 7, Table 3 and CCAMLR-XXXIII/BG/02).

3.152 The Scientific Committee noted that these notifications followed a pattern similar to previous seasons with most notifications being for fishing in Subareas 88.1 and 88.2 (nine Members and 19 vessels in Subarea 88.1 and eight Members and 18 vessels in Subarea 88.2).

3.153 The Scientific Committee noted the relatively large number of notifications in Subarea 88.2 and agreed that information on vessels' priorities for fishing in Subareas 88.1 and 88.2 would be informative in order to evaluate the notifications. It also noted that overruns of the catch limit in Subarea 88.2 and the resulting impacts on tag-overlap statistics in the subarea could be related to overcapacity in this subarea. This matter was referred to the Commission for further consideration.

3.154 The Scientific Committee recalled that the requirements for notifications for exploratory fisheries (CM 21-02) were implemented in order to:

- (i) evaluate the distribution, abundance and demography of the target species, leading to an estimate of the fishery's potential yield
- (ii) review the fishery's potential impacts on dependent and related species
- (iii) allow the Scientific Committee to formulate and provide advice to the Commission on appropriate harvest catch levels, as well as effort levels and fishing gear, where appropriate.

3.155 The Scientific Committee thanked WG-SAM and WG-FSA for their work in reviewing research plans for activities in exploratory and other toothfish fisheries. It noted that the advice provided in their reports primarily related to paragraph 3.154(i), and that the Scientific Committee also needed to develop advice on all such fisheries' potential impacts on dependent and related species for the proposed activities in the coming season, for it to fully satisfy the requirements of CM 21-02 and provide the Commission with the advice it requires to ensure these fisheries are consistent with Article II of the Convention.

3.156 The Scientific Committee sought advice from the Commission on the priorities and elements of work associated with reviewing the potential impacts of exploratory fisheries on dependent and related species. The Scientific Committee also noted that extensive developments have taken place in recent years in relation to research fishing in exploratory fisheries, closed fisheries and other areas, and that the requirements of CM 21-02 and related measures (e.g. CMs 21-01 and 24-01) may require review. The Scientific Committee welcomed the offer by Dr Jones to coordinate this review in the intersessional period pending the decision of the Commission.

#### *Dissostichus* spp. Subarea 88.1

3.157 The exploratory fishery for *Dissostichus* spp. in Subarea 88.1 operated in accordance with CM 41-09 and associated measures. In 2013/14, the catch limit for *Dissostichus* spp. was 3 044 tonnes including 43 tonnes set aside within the SSRUs 881J, L catch limit for the sub-adult survey.

3.158 Fishing was conducted by 20 vessels using longlines. The fishery closed on 17 January 2014 and the total reported catch was 2 900 tonnes plus 25 tonnes from the sub-adult survey.

3.159 SSRUs B, C and G were closed on 19 December 2013, SSRUs H, I and K were closed on 11 January 2014 and SSRUs J and L and the whole fishery were closed on 17 January 2014; the total catch of *Dissostichus* spp. in these management areas ranged from 87% to 100% of the catch limits.

#### Management advice

3.160 The Scientific Committee recommended that its advice from 2013 with a catch limit for *D. mawsoni* in Subarea 88.1 of 3 044 tonnes be carried forward in its entirety for 2014/15.

#### *Dissostichus* spp. Subarea 88.2

3.161 The exploratory fishery for *Dissostichus* spp. in Subarea 88.2 operated in accordance with CM 41-10 and associated measures. In 2013/14, the catch limit for *Dissostichus* spp. was 390 tonnes. Fishing was conducted by 14 vessels using longlines. The fishery closed on 26 January 2014 and the total reported catch was 426 tonnes.

3.162 SSRU H was closed on 24 January 2014 and SSRUs C, D, E, F and G and the whole fishery were closed on 26 January 2014; the catch limits for *Dissostichus* spp. in that fishery were exceeded (Annex 7, paragraph 3.3 and Figure 1) and the total catch of *Dissostichus* spp. in the management areas ranged from 103% to 122% of the catch limits.

3.163 The Scientific Committee recalled that at its meeting last year it had been unable to provide consensus advice on catch limits for *Dissostichus* spp. in Subarea 88.2 for the 2013/14 fishing year and that it had identified a work plan to address this issue. It had considered that three actions were necessary to provide robust management advice for this fishery, that:

- (i) Members review stock structure relative to stock assessments for a number of regions, including Area 88 (SC-CAMLR-XXXII, paragraph 3.76i)
- (ii) WG-SAM consider how an assessment of stock abundance can be developed for this southern area, recognising that few tags had been recaptured from SSRUs 882C–G and that fishing there has been conducted on an intermittent basis and not in spatially consistent locations (SC-CAMLR-XXXII, paragraph 3.167)
- (iii) the assessment of toothfish in SSRUs 882C–H be reconsidered by WG-SAM with specific consideration of the potential for localised depletion and tag mixing and stock identity (SC-CAMLR-XXXII, paragraph 3.169).

3.164 The Scientific Committee noted that there had been considerable progress in addressing these issues in the intersessional period and that papers concerning all three issues had been discussed by WG-SAM (Annex 5, paragraphs 2.7 to 2.17) and by WG-FSA (Annex 7, paragraphs 5.14 to 5.44).

3.165 With respect to the stock structure, the Scientific Committee noted the conclusions from WG-SAM (Annex 5, paragraph 2.8) which recommended that the existing management approach be continued and that additional research would be useful to further test or develop stock hypotheses. The Scientific Committee also recalled that, to date, there had been no recorded instances of tagged fish moving between SSRU 882H and SSRUs 882C–G and that only two tagged fish had been recaptured from these southern SSRUs. However, despite the absence of movement data from tagged fish, it nevertheless considered that the most likely explanation was that the majority of the adult spawning fish in the northern seamounts in SSRU 882H had come from the southern SSRUs, consistent with the pattern in the Ross Sea region and East Antarctica (Annex 7, paragraph 5.29).

3.166 With respect to the assessment of toothfish, the Scientific Committee noted that considerable effort had been undertaken to try and understand and interpret the patterns in the tag-recapture data from SSRU 882H (Annex 7, paragraph 5.27 and Figure 6). It noted:

- (i) declining recaptures by year of release in SSRU 882H indicating a loss of tagged fish from the seamounts and annual immigration of untagged fish
- (ii) increasing rate of decline in recaptures by year of release, i.e. recaptures of tags released in more recent years are declining at a faster rate than the declines observed in tags released in earlier years
- (iii) all estimates of biomass on the seamounts from tag recaptures are biased high – with the least biased being those from fish which have been at liberty for one year
- (iv) simulations indicate that the trends observed in the tag-recapture data are difficult to replicate but could be replicated with an exploitation rate on the seamounts of around 20% and an immigration and emigration of tagged fish at around 20%.

3.167 In considering the management advice on catch limits for SSRU 882H provided by WG-FSA (Annex 7, paragraph 5.32), the Scientific Committee agreed that the two options

provided were not, in fact, mutually exclusive. The two options were both based on tag-based Petersen estimates of biomass, but differed in the number of years the tagged fish had been at liberty and hence their applicability to different parts of the population. The estimate of 200 tonnes was based on tagged fish at liberty for one year and therefore applied only to the population in SSRU 882H. The estimate of 619 tonnes was based on tagged fish at liberty for all years and therefore may apply to the entire stock in SSRUs 882C–H.

3.168 The Scientific Committee recalled that the southern SSRUs 882C–G have never been formally assessed, and that the early catch limits for Subarea 88.2 were based on a catch-per-unit-effort (CPUE) by analogy method (SC-CAMLR-XXIII). In 2011, the southern SSRUs were included in the assessment for the first time, but the catch limit was split between the northern and southern SSRUs based on the historical catch (SC-CAMLR-XXX, paragraph 3.177). The Scientific Committee therefore agreed on the need to develop an estimate of abundance and robust catch limits for SSRUs 882C–G.

3.169 The Scientific Committee agreed that the best way to develop an estimate of abundance for the southern SSRUs was to constrain fishing effort to previously fished locations where tags were available and where fishing was not overly restricted by sea-ice. It noted the advice from WG-FSA-14 (Annex 7, paragraph 5.43) and endorsed its recommendation that all fishing sets be completed within the boxes that define the bounds of the four identified fishing grounds (Annex 7, Table 4 and Figure 2). It also noted that an ice analysis carried out over the last 10 years (presented in WG-FSA-14/54) had demonstrated that at least two, and occasionally all, of these four fishing grounds are available for fishing each year (Annex 7, paragraph 5.34).

3.170 The Scientific Committee further noted that the estimates of biomass from each of the four fishing grounds based on the CPUE by analogy method ranged from 2 834 tonnes to 4 913 tonnes and equalled a total of 15 000 tonnes (WG-FSA-14/59, Table 7). Based on an exploitation rate of 0.04, a precautionary catch limit for each of these four grounds ranged from 112 to 195 tonnes and a total of 600 tonnes. Although these estimates were uncertain, they provided some reassurance that a total catch of 419 tonnes for the southern SSRUs could be considered precautionary for a short-term period of two years.

3.171 The Scientific Committee considered the large number of vessels which had notified to fish in this subarea and also the need to have some flexibility to deal with the variable ice conditions. It also noted that at least two of the fishing grounds were open each year and that the estimated precautionary catch limit in each of the fishing grounds ranged from 112 to 195 tonnes. The Scientific Committee therefore agreed that a maximum catch limit of 200 tonnes for up to two years could be applied to each of the fishing grounds, and that no more than 419 tonnes should be taken from these SSRUs as a whole.

3.172 The Scientific Committee also agreed that it was necessary to increase the number of tag recaptures in the southern SSRUs and that the best way to achieve this was by increasing the tagging rate to at least 3 fish per tonne. However, the Scientific Committee also noted the discussion of differential tagging rates in the same management area discussed by WG-FSA-14 (Annex 7, paragraph 5.34) and agreed that these differential tagging rates, when combined with different size compositions, could trigger false positives in the tag-overlap statistic. It therefore recommended that tag-overlap statistics be calculated separately for each of SSRU 882H and SSRUs 882C–G.

3.173 In harmonising these discussions, the Scientific Committee developed a two-year research plan which will cease at the end of 2015/16 with the following components:

- (i) the plan will be in place for 2014/15 and 2015/16. Results of this research plan will be summarised and presented for review by WG-SAM and WG-FSA for further recommendations by the Scientific Committee in 2016
- (ii) the catch limit for SSRU 882H will be 200 tonnes
- (iii) the fishing in SSRUs 882C–G will be restricted to the four fishing grounds identified in Figure 1 (see also Annex 7, Table 4 and Figure 7)
- (iv) the combined catch limit for SSRUs 882C–G will be 419 tonnes, with no more than 200 tonnes to be taken from any one of the fishing grounds identified in paragraph 3.173(iii)
- (v) toothfish will be tagged at the rate of 3 fish per tonne in SSRUs 882C–G and 1 fish per tonne in SSRU 882H
- (vi) tag-overlap statistics will be calculated separately for each of SSRU 882H and SSRUs 882C–G.

3.174 The Scientific Committee noted that the combined approach of an increase in the tagging rate, an increase in catches, and a concentration of effort results in the predicted number of tag recaptures increasing to 11 in 2014/15 and to 37 in 2015/16. The Scientific Committee further noted that an increased number of tag recaptures would assist with reducing the uncertainty over stock structure in the Amundsen Sea and Ross Sea regions. It therefore recommended that the Commission endorse this research plan for the next two years.

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

3.175 The Scientific Committee considered general progress on research in data-poor exploratory and other fisheries reported by WG-SAM (Annex 5, paragraphs 3.1 to 3.5) and WG-FSA (Annex 7, paragraphs 5.121 to 5.130). The Scientific Committee noted the criteria that WG-FSA had used to formulate development of advice on catch limits for research fishing in the new and exploratory and other data-poor fisheries as outlined in Annex 7, paragraph 5.123, as well as the protocols used to select which tagged fish should be used and definition and renaming of research blocks. It also noted that Annex 7, Table 5, provides an update of local biomass where appropriate and indicates numbers of tag recaptures and likely tag availability in 2014/15. The Scientific Committee agreed that this advice describes an excellent process to guide research to achieve stock assessments in data-poor areas.

3.176 The Scientific Committee agreed that the catch limits in Annex 7, Table 5, are appropriate to achieve the aims of the research programs proposed in exploratory and other fisheries and recommended that these be considered as management advice by the Commission for catch limits for 2014/15. It also clarified that those limits are expected to remain for the duration of the proposed research programs, provided that they are reviewed by the working groups in light of information derived from research activities.

3.177 The Scientific Committee agreed that a map illustrating the location of all the research fishing plans approved for 2014/15 be included to assist the Commission in its deliberations (Figure 2).

3.178 The Scientific Committee also discussed the feasibility of research programs which include a large number of research blocks that are unlikely to be able to be surveyed in a single year by the proposed number of vessels due to the limited time window of access due to sea-ice. The Scientific Committee noted that the inclusion of multiple blocks as proposed increases the feasibility of the research in at least a subset of the proposed research blocks. The Scientific Committee agreed that, with the exception of the proposed research areas in SSRUs 5842A and C, where no research blocks are currently identified, Japan and the Republic of Korea could conduct research fishing in the research blocks designated by the Commission in 2013. In order to advance the research in an efficient manner, the Scientific Committee further agreed that the two programs focus on priority areas and recommended that Japan focus its research in Subarea 48.6 while Korea focus in Division 58.4.1, and schedule research at a time when sea-ice is likely to be at a minimum in the research blocks.

3.179 The Scientific Committee noted SC-CAMLR-XXXIII/09, discussing a general approach to assigning research catch limits for effort-limited surveys to address differences between expected and actual research catches. This approach involves carryover of uncaught catch limits, and the Scientific Committee noted that similar carryover provisions have been considered in situations where sea-ice affects access to fishing grounds. Carryover provisions for research fishing would need to be consistent with the Scientific Committee's advice on CCAMLR-sponsored research (SC-CAMLR-XXVII, paragraphs 8.9 to 8.11). The Scientific Committee recommended that this issue be further considered by the Commission.

#### *Dissostichus* spp. Subarea 48.6

3.180 The exploratory fishery for *Dissostichus* spp. in Subarea 48.6 operated in accordance with CM 41-04 and associated measures. In 2013/14, the catch limit for *Dissostichus* spp. was 538 tonnes. Research fishing was conducted in two research blocks by two vessels using longlines and the total reported catch up to 20 September 2014 was 153 tonnes. SSRU D was closed on 10 February 2014 following completion of research fishing and the total catch of *Dissostichus* spp. in that SSRU was 50 tonnes (100% of the catch limit).

3.181 The Scientific Committee noted that the research jointly undertaken by Japan and South Africa to date appears to be producing encouraging results, with 42 tagged fish recaptured in 19 months of research, and could lead to an assessment in the northern part of Subarea 48.6 in 2015. However, it also expressed concern with respect to the possible increase in IUU activity in the area, which could have negative impacts on the stocks in the region and the operation of the research being undertaken.

3.182 Research proposals to fish in Subarea 48.6 in 2014/15 had been submitted by Japan (to be conducted with South Africa) and the Republic of Korea. The Scientific Committee noted that the proponents had requested several variations to the previous research plan, including increased flexibility under adverse ice conditions, whether catch limits not taken in one year could be rolled over to the following year and an increase in catch limit from 50 to 100 tonnes

in research block 486\_3, and that these issues had already been discussed by WG-SAM (Annex 5, paragraphs 3.11 to 3.20) and by WG-FSA (Annex 7, paragraphs 5.54 to 5.59).

3.183 The Scientific Committee noted that the ice analysis undertaken at WG-FSA had greatly assisted in understanding the dynamics of sea-ice conditions in the southern research blocks (Annex 7, Figure 12). The Scientific Committee acknowledged that sea-ice analysis in some of the southern research blocks of Subarea 48.6 indicated that research activities in consecutive years may be difficult and that there was a need to allow for some flexibility. It recommended that the results of the ice analyses be included in its report to the Commission (Figure 1) and also tasked the Secretariat with providing a compilation of previous discussions on the need for flexibility due to ice conditions for the Commission.

3.184 Mr S. Nakatsuka (Japan) noted that Japan had requested some additional flexibility in vessel activities in the southern research blocks because of the sometimes heavy and variable sea-ice conditions as indicated by the sea-ice analysis (Figure 1). He noted that having additional, but limited, flexibility on the shelf area might provide data on tag recaptures, although noting that this is less likely outside of the research blocks. He was not seeking endorsement of this flexibility at the Scientific Committee and was prepared to present Japan's case further to the Commission.

3.185 The Scientific Committee noted the advice from WG-SAM (Annex 5, paragraph 3.15), that rolling over catch limits would be associated with a high degree of uncertainty and associated risks, as there is an absence of knowledge relative to biomass and productivity in these areas and thus a risk for the stock to be negatively impacted. In the absence of an analysis characterising the potential risk that carrying over research catch limits will not overly impact the stock, the Scientific Committee was unable to provide further advice on the issue at this stage.

3.186 The Scientific Committee noted that WG-FSA had discussed a proposal to increase the research catch in research block 486\_3 from 50 to 100 tonnes (Annex 7, paragraph 5.58). However, it agreed with the advice from WG-FSA that it was important to remain consistent when undertaking a planned multiyear research activity. Consistency across survey seasons will ensure that the signals coming from the research will not be compromised by alterations of the research design during the course of the planned activity. At the end of the planned research, changes to the attributes of the design, or recommendations that other approaches should be explored, can be advised.

3.187 The Scientific Committee therefore recommended that the research catch limits from last year be retained for 2014/15. The recommended catch limits are as follows:

SSRUs A and G	<i>Dissostichus eleginoides</i>	28 tonnes
	<i>Dissostichus mawsoni</i>	170 tonnes
SSRUs B and C	<i>Dissostichus</i> spp.	190 tonnes
SSRU D	<i>Dissostichus</i> spp.	50 tonnes
SSRU E	<i>Dissostichus</i> spp.	100 tonnes.

3.188 The Scientific Committee agreed that the priority research areas in Subarea 48.6 should be the two northern research blocks in SSRUs A and G (blocks 486\_1 and 486\_2), followed by the three southern research blocks in SSRUs B, C, D, and E (research blocks 486\_3, 486\_4 and 486\_5).

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

3.189 The exploratory fishery for *Dissostichus* spp. in Division 58.4.3a operated in accordance with CM 41-06 and associated measures. In 2013/14, the catch limit for *Dissostichus* spp. was 32 tonnes. Research fishing was conducted in the research block by two vessels using longlines. The fishery was closed on 31 August 2014 following completion of research fishing and the total catch of *Dissostichus* spp. was 32 tonnes (100% of the catch limit).

3.190 The Scientific Committee noted that France and Japan proposed to continue this research in 2014/15 and that WG-SAM had provided advice to refine these proposals (Annex 5, paragraphs 3.32 to 3.38).

3.191 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. It encouraged further development of these models in the intersessional period, taking into account the points identified by WG-FSA in Annex 7, paragraph 5.86, and be further reviewed by WG-SAM-15.

3.192 The Scientific Committee endorsed the advice of WG-FSA and recommended:

- (i) retaining the catch limit of 32 tonnes for research conducted in this division in 2014/15, based on an updated Petersen biomass estimate (Annex 7, paragraph 5.92)
- (ii) removal of prescribed soak times or spatial locations for research fishing activities conducted by France and Japan in 2014/15 (Annex 7, paragraph 5.94)
- (iii) further collection and analysis of data on the relationship between soak times, spatial distribution of fishing and the rate of catch and condition of skates (Annex 7, paragraph 5.94).

3.193 The Scientific Committee also welcomed the proposal by France to tag and release skates during research fishing in this division.

3.194 The Scientific Committee noted that substantial number of tags were now being recaptured in this fishery and there was an expectation that a robust assessment was likely for this division in the near future. It therefore requested that WG-SAM-15 consider how the data collection plan for this fishery may be modified once an assessment is available for the toothfish fishery in this division.

*Dissostichus* spp. Divisions 58.4.1 and 58.4.2

3.195 The exploratory fishery for *Dissostichus* spp. in Division 58.4.1 operated in accordance with CM 41-11 and associated measures. In 2013/14, the catch limit for *Dissostichus* spp. was 724 tonnes. Research fishing was conducted in the research block by one vessel using longlines and the total catch was 101 tonnes. No research fishing was carried out in Division 58.4.2.

3.196 The Scientific Committee noted that Japan, the Republic of Korea and Spain proposed to conduct research in these Divisions in 2014/15. It further noted that WG-SAM had provided advice to refine these proposals (Annex 5, paragraphs 3.25 to 3.31).

3.197 The Scientific Committee noted that Spain had been unable to complete depletion experiments in SSRU 5841C within the 42 tonnes allocated. It noted that Spain had continued the research after discussion with the Secretariat and Japan, and the research had concluded after 54 tonnes were taken, within the catch limit for this SSRU.

3.198 The Scientific Committee requested the Commission consider a mechanism that would provide the flexibility necessary if more than 42 tonnes are required to complete the experiment in 2014/15.

3.199 It also endorsed the advice in Annex 7, paragraph 5.99, that the priority for this research is to return to the areas where depletions have been observed, that lines should be set close together to ensure that variability in CPUE observed can be attributed to local depletion rather than variation in toothfish density across an area. It also encouraged the development of an ageing program to further the development of stock assessments in this region.

3.200 The Scientific Committee endorsed the recommendation by WG-FSA to conduct a review of the Spanish depletion experiment at WG-SAM-15, with the review taking account of the issues identified in Annex 7, paragraph 5.100.

3.201 The Scientific Committee noted the discussion of the Korean proposal to release satellite pop-up tags and endorsed the recommendation to release all three tags in a single location. It also welcomed the collaboration between New Zealand and the Republic of Korea to establish an ageing program for toothfish in Korea.

3.202 The Scientific Committee noted that all proposals for research in this region included blocks periodically affected by sea-ice. It noted the analyses conducted by WG-FSA that indicated that research blocks are most likely to be ice-free in February (e.g. Annex 7, Figure 12). It consequently endorsed the advice of WG-FSA-14 that research by Japan and the Republic of Korea in 2014/15 be focussed on those block(s) designated in 2013 that have a high number of tags available for recapture and that are likely to be accessible. Given that no further information on stock status or productivity was available, the Scientific Committee recommended that the same catch limits apply to these research blocks in 2014/15 as were recommended in 2013/14.

3.203 The Scientific Committee acknowledged that sea-ice posed a significant obstacle to progressing stock assessments based on tag recaptures in many exploratory fisheries. It therefore requested that WG-SAM-15 review research methods to develop stock assessments in these areas, taking into account the experience and data collected from research activities conducted in exploratory toothfish fisheries in areas affected by sea-ice, habitat modelling of toothfish, sea-ice maps and the operational capabilities of fishing vessels.

3.204 The Scientific Committee encouraged the inclusion of sea-ice data in the further development of circumpolar toothfish habitat models, such as those usefully presented in WG-FSA-14/65, noting that such models would assist the Scientific Committee in advising on future research on toothfish.

*Dissostichus* spp. Subarea 48.2

3.205 The Scientific Committee noted the proposal by Ukraine to conduct research fishing in Subarea 48.2 under CM 24-01 and the review of this proposal by WG-SAM-14 (Annex 5, paragraphs 4.1 to 4.5) and WG-FSA-14 (Annex 7, paragraphs 5.45 to 5.46).

3.206 The Scientific Committee welcomed the revised proposal by Ukraine and noted the undertaking that results for the first year of research to develop an assessment will be reviewed by WG-SAM-15. It endorsed the advice of WG-FSA (Annex 7, paragraph 5.48) that the research plan in Subarea 48.2 proceed with an effort limit of 30 lines and catch limit of 75 tonnes of *Dissostichus* spp., tagging 5 toothfish per tonne, with a minimum tag overlap of 80%.

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

3.207 The Scientific Committee noted that Japan had conducted research fishing in Divisions 58.4.4a and 58.4.4b in 2013/14 and that France and Japan proposed to conduct research in this division in 2014/15. It further welcomed the substantial progress made in developing a stock assessment using CASAL for this division and endorsed the advice of WG-FSA for further development of this model (Annex 7, paragraph 5.86).

3.208 The Scientific Committee endorsed the management advice provided by WG-FSA that the research fishing proposed by France and Japan proceed in this division with a catch limit of 25 tonnes in research block C and 35 tonnes in block D. It further requested that research activities be coordinated between France and Japan so that selectivity and catch rates can be standardised across the vessels and impacts of depredation minimised.

*Dissostichus* spp. in Subarea 88.1 and SSRUs 882A–B

Multiyear research plan for the Ross Sea

3.209 The Scientific Committee noted that a 3–5 year research plan had been developed for the Ross Sea toothfish fishery by New Zealand, Norway and the UK (Annex 7, paragraph 5.120). The research plan aims to address information needs for management of the Ross Sea region *D. mawsoni* population focusing on improved biological parameters for stock assessment and improved understanding of ecosystem effects of fishing. The Scientific Committee welcomed the plan noting that the plan was consistent with the principles of a data collection plan as described in CM 21-02. The Scientific Committee encouraged other Members to review and operationally support the plan and looked forward to progress on the topics identified.

Catch limits for research surveys

3.210 The Scientific Committee also discussed the spatial assignment of catch limits for the three proposed research surveys in the Ross Sea region (Subarea 88.1 and SSRUs 882A–B)

and the general approach to assigning research catch limits for effort-limited surveys to address the difference between expected and actual research catches. It also recalled the need for research fishing to be consistent with the Scientific Committee's advice on CCAMLR-sponsored research (SC-CAMLR-XXVII, paragraphs 8.9 to 8.11).

3.211 Regarding the assignment of research survey catch limits in the Ross Sea region, it was agreed that:

- (i) there is compelling scientific evidence for linkages within the Ross Sea region from tagging studies and stock structure papers
- (ii) consequently, the stock assessment for the Ross Sea region accounts for all the toothfish in the open and closed SSRUs in Subarea 88.1 and SSRUs 882A–B
- (iii) currently catch limits for the northern, slope and shelf SSRUs are prorated based on the CPUE by seabed analogy method.

3.212 The Scientific Committee recommended that there be a separate single multiyear research catch limit for the Ross Sea region for all approved research surveys. The Scientific Committee recalled a similar approach had been trialled for the first two sub-adult surveys in 2012 and 2013 in the Ross Sea where a catch limit had been set for a two-year period (SC-CAMLR-XXX, paragraph 3.174). The remaining catch in the Olympic fishery could be allocated proportional to CPUE by seabed area analogy, consistent with the existing approach to apportioning the catch limits under CM 41-09. It agreed that the Commission consider a new separate conservation measure be established describing the approved research activities and their locations in the Ross Sea.

3.213 It also recommended that the catch limits in these conservation measures be reviewed each year in accordance with the size of the anticipated catches which would be expected from the approved research surveys, as well as any revisions to the assessment of the stock in the Ross Sea region derived from research activities and exploratory fishing.

3.214 The Scientific Committee draws the attention of the Commission that these arrangements could be better considered as part of the development of data collection plans by the Scientific Committee for exploratory fisheries as per CM 21-02, paragraph 2. As such, there would be no need for future proposals to be submitted under CM 24-01 but as proposals for research to be included in the data collection plan.

#### Ross Sea sub-adult survey

3.215 The Scientific Committee noted that WG-FSA had considered an updated survey report of results of the three sub-adult surveys completed to date, noting that the 2014 survey also showed that high catch rates of large toothfish were observed in McMurdo Sound relative to the other survey areas. The Scientific Committee also agreed that the age structure and standardised CPUE derived from commercial data do not index the age structure or abundance in the area and that the survey is necessary to collect information on future recruitment.

3.216 The Scientific Committee endorsed the recommendations from WG-SAM-14 to carry out the survey in 2015 with an exploratory stratum near Terra Nova Bay and recommended that the proposed survey be carried out in 2015. The Scientific Committee agreed that the survey should comprise 60 sets with a catch limit of 68 tonnes. The Scientific Committee also noted that the catch limit for previous sub-adult surveys had been taken from the shelf catch limit.

#### SSRUs 882A–B

3.217 The Scientific Committee noted that two research proposals had been submitted to carry out research in SSRUs 882A–B:

- (i) a multiyear survey by Russia in the southern region of SSRU 882A (WG-FSA-14/13) whose primary aim is to better understand toothfish movement and distribution relative to the remainder of the Ross Sea stock
- (ii) a multiyear survey by New Zealand, Norway and the UK (WG-FSA-14/61) aimed at collecting biological information on toothfish and bathymetry in the northern part of SSRUs 882A–B.

3.218 The Scientific Committee noted that both proposals had been reviewed by WG-SAM (Annex 5, paragraphs 4.16 to 4.23). It also noted that WG-SAM had agreed that both research designs were appropriate to meet their respective objectives (Annex 5, paragraphs 4.17 and 4.18), that both surveys would provide new information to parameterise the spatial population model (SPM) in locations for which data are currently limited or unavailable (Annex 5, paragraph 4.23) and made recommendations on survey design (Annex 5, paragraph 4.19). WG-SAM also recommended that the Members harmonise the two proposals to the extent possible in advance of WG-FSA-14 (Annex 5, paragraph 4.20). WG-SAM recommended that the proponents take account of these comments and submit the revised versions to WG-FSA for review.

3.219 The Scientific Committee noted that both proposals had been revised and submitted to WG-FSA where they were discussed in paragraphs 5.111 to 5.119. WG-FSA noted that both proposals had been improved by incorporating the advice from WG-SAM. However, the proposals were inconsistent regarding where the catch limits for the surveys should be taken from. The multi-member survey proposed that the catch limit should be taken out of the existing catch limit for the Ross Sea fishery, whereas the Russian survey proposed that the catch limit should be additional to the Ross Sea catch limit.

3.220 With respect to the proposal by New Zealand, Norway, and the United Kingdom, the Scientific Committee encouraged the participating vessels to fish in SSRU 881C adjacent to SSRU 882A, using the standardised gear configuration to enhance the comparison between the two areas and also noted that the participating vessels have a good tagging performance history.

3.221 The Scientific Committee recommended the bathymetry mapping and survey go ahead as an effort-limited ‘prospecting’ phase research design with a maximum of 6 900 hooks per set and 17 250 hooks per cluster of stations, 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 an upper catch limit of 50 tonnes per vessel deducted from the catch limit from the Ross Sea region was appropriate for the scope of the research and recommended that the Commission consider appropriate options to account for the survey catches, noting that a proposal for this purpose was submitted by New Zealand (SC-CAMLR-XXXIII/09).

3.222 With respect to the proposal by Russia, the Scientific Committee noted that a previous proposal for research fishing in this area had been developed by WG-FSA-13 and had been discussed by the Scientific Committee in 2013 (SC-CAMLR-XXXII, paragraphs 3.151 to 3.160), but had not been endorsed by the Commission (CCAMLR-XXXII, paragraphs 5.33 to 5.37).

3.223 The Scientific Committee noted that the objective of the Russian proposal is to sample a previously fished area to recover tagged toothfish that were either tagged in the area or have moved into the area, hypothesised to be mainly from the Ross Sea slope and provide data to be used by the SPM of the Ross Sea region, although it noted that an alternative life history and stock structure hypothesis had been proposed by the proponents.

3.224 The Scientific Committee noted that the Russian proposal (WG-FSA-14/13) had included that the catch limit should be additional to the Ross Sea catch limit. It further noted that if the catch was to be taken additional to the Ross Sea catch limit then it was unable to complete a review because it had not received any advice from WG-FSA on the implications of this additional catch for the application of the decision rules to the stock in the Ross Sea region (Annex 7, paragraph 5.115).

3.225 Russia informed the Scientific Committee that it agreed that the catch limit for the survey should be deducted from the catch limit from the Ross Sea region.

3.226 The Scientific Committee therefore recommended that if the survey in the southern part of SSRU 882A was undertaken within the catch limit for the Ross Sea region, then a catch limit of 100 tonnes (60 tonnes inside the main box and 40 tonnes in the area outside the box) would be appropriate to achieve the objectives of the research.

3.227 The Scientific Committee 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 (Annex 7, paragraph 5.116). It recalled the discussion of the Commission in 2013 regarding the rationale for the revision of the boundary between Subareas 88.1 and 88.2 (CAMLR-XXXIII, paragraphs 5.34 and 5.37). The Scientific Committee also recalled that the Commission had revised boundaries of management areas in the past to more clearly be associated with whole stocks (e.g. Division 58.4.3b; CCAMLR-XX, paragraphs 7.16 to 7.20).

3.228 The Scientific Committee recalled its advice from last year on the issue of the boundaries of Subareas 88.1 and 88.2 (paragraph 3.160) and requested that the Commission consider this issue again.

3.229 The Scientific Committee noted that the advice from WG-FSA on catch limits for the proposed Russian survey in SSRU 88.2A is primarily based on consideration of the 'distribution, abundance, and demography of the target species', rather than a full assessment of potential impacts on dependent and related species because of time constraints (see

paragraph 3.154). The Scientific Committee recalled that during its meetings in 2013 it previously advised that research fishing ‘could be conducted along the southeastern continental slope [of SSRU 882A], provided that the science supports the objectives [of the Ross Sea Region MPA] in this area’ (SC-CAMLR-IM-I, paragraph 2.31(iv) and SC-CAMLR-XXXII, paragraphs 3.155 and 3.156). The Scientific Committee also noted that the specific objectives of the Ross Sea Region MPA include both facilitating research and several protection objectives (SC-CAMLR-XXXIII/BG/23 Rev. 1).

*Dissostichus* spp. Subarea 48.5 Weddell Sea

3.230 The Scientific Committee noted that WG-FSA was unable to provide any advice regarding the proposal by Russia to continue research in Subarea 48.5 in 2014/15 (Annex 7, paragraph 5.80) and noted that inconsistencies existed in the data used to develop the research plan for 2014/15 and that held by the Secretariat.

3.231 The Scientific Committee further investigated the data submitted by the *Yantar 35* in 2012/13 and 2013/14, including comparison between reported haul location and VMS locations, catch-size distribution, relationship between hauling speed and the number of fish caught per unit effort and standardised hauling times in relation to catches. However, after noting that some data appeared anomalous with patterns that required detailed investigation, it was unable to conclude this analysis and agreed it was therefore 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).

3.232 The Scientific Committee thanked Russia for its willingness to undertake further analysis of the data collected 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. The Scientific Committee requested that Russia finalise this analysis and present its results for consideration by WG-SAM-15. It further agreed that all the data collected on board the vessel should be quarantined until the Scientific Committee can make clear conclusions and provide advice.

3.233 The Scientific Committee noted that the research design developed in 2013 and 2014 was derived from the quarantined data and that research to advance knowledge regarding this data-poor area in the future would need to be consistent with the original research objectives approved in 2012.

3.234 Dr Bizikov noted that Russia seeks a timely solution to revising the plans such that research fishing can take place in the 2014/15 season. He further noted that the data from this effort is essential at this point in time given the international efforts to develop an MPA for this region.

## **Incidental mortality arising from fishing operations**

### Incidental mortality associated with fisheries

4.1 In addition to the summary brought forward from WG-FSA summarised in Annex 7, paragraphs 8.22 to 8.27, the Scientific Committee was also made aware of the following background papers relevant to this agenda item: SC-CAMLR-XXXIII/BG/15 Rev. 1 and XXXIII/BG/31.

4.2 SC-CAMLR-XXXIII/BG/15 Rev. 1 provided information on levels of seabird by-catch in fisheries adjacent to the CAMLR Convention Area following a request made by France at CCAMLR-XXXII. The summary presented most recent by-catch data held by ACAP and reported on the status of the development of a by-catch data reporting and assessment framework. It stressed that the data had not been further analysed, was ongoing work, and represented only data that was provided by Parties to date. It concluded that there is a general need to improve levels of by-catch reporting by regional fisheries management organisations (RFMOs) and that in some cases there is a need to develop or refine data collection and reporting protocols and highlighted initiatives currently in place to address this issue.

4.3 Mr W. Papworth (ACAP) noted that the paper was a response to a request at SC-CAMLR-XXXII to provide information on seabird by-catch in adjacent fisheries to SC-CAMLR-XXXIII. The paper summarised recent-season data submitted as part of their online reporting. That dataset included 94 fisheries. For some fisheries data was available from 2004, when ACAP formally came into force. He noted that the data in Annexes 1 and 2 have not been assessed or analysed by ACAP and are presented as reported by Parties and Range States. ACAP does not hold seabird by-catch data on high-seas fisheries but through its RFMO engagement strategy and related initiatives is working to help progress efforts to improve data collection and reporting activities by RFMOs. He explained that the quality and reliability of collected data is limited, as in some RFMOs there is poor compliance despite protocols in place, or protocols are still under development. Further, the methods to review the efficacy of seabird by-catch mitigation measures are not always established in all RFMOs. He drew attention to its intersessional group established to consider minimum elements and methods to form part of an assessment of these mitigation methods which have been adopted by tuna RFMOs; that group will also seek to work with CCSBT. He ended with an appeal to CCAMLR Members that are also RFMO contracting parties to help facilitate data reporting and seabird conservation measure implementation within those RFMOs and expressed ACAP's willingness to provide further updates of this report in future years upon request of CCAMLR.

4.4 The Scientific Committee endorsed several recommendations from WG-FSA (Annex 7, paragraph 8.27) regarding requirements for night-time setting and bottle testing in longline fisheries. The Commission was advised to revise CMs 25-02 and 41-02 through 41-11 (see Table 1). In amending these conservation measures the key definition of night setting in CM 25-02 should be retained, and example text provided in WG-FSA-14/24 should be considered.

4.5 Dr Constable highlighted SC-CAMLR-XXXIII/BG/30 Rev. 1, which lays out the management arrangements in place for Statistical Division 58.5.2 – Heard Island and McDonald Islands. He drew the attention of the Scientific Committee to Australia's continued

management measures in place and transparent governance structure, both of which aim for Australia to meet or exceed the obligations under the CAMLR Convention in this division. Australia strongly supports the CCAMLR precautionary approach as a method to manage risk of impacts on Antarctic marine living resources as defined in Article I of the Convention in order to meet the objectives in Article II. Dr Constable noted that Australia does not regard that the precautionary approach means no fishing but, rather, that catches are adjusted according to available data and maintaining the same acceptable level of risk. The management approach that Australia takes is to take steps to conserve non-target species. In the case of direct effects of fishing, Australia seeks first to avoid impacts on non-target species. If that is not possible, then measures are set in place to mitigate impacts. Lastly, it seeks to ensure that, where mortality is unavoidable, mortality is not likely to cause significant effects on those species or the ecosystem. Dr Constable emphasised that Australia does not have different views on management in Division 58.5.2 than it has on the rest of the Convention Area.

## Marine debris

4.6 WG-FSA-14/68 compiled information submitted to the Secretariat by South Africa, the UK and Uruguay on marine debris data collected from beach surveys, seabird colonies, marine mammal entanglements and hydrocarbon soilings. The review found that non-fishing-related items (such as packaging or plastics) were the most frequent type of debris, and that fishing-related debris items originated mostly from longline and trawl equipment. The levels of debris in albatross nests at Bird Island continue to decline, consisting mainly of plastics, but items originating in fishing (hooks, lines) are frequently found in nests of wandering albatrosses. Marine mammal entanglements remain relatively constant or on the decline. The paper concluded that no long-term trends are seen within the Convention Area but that debris levels and composition varied between years. It cautioned that the extrapolation of data from Area 48 to the entire Convention Area is limited as long-term monitoring data is not available, and encouraged Members to engage in monitoring and data submission to the Secretariat.

4.7 SC-CAMLR-XXXIII/BG/31 noted that, during the time series of 24 years of observation of beach marine debris in Subarea 48.3, the total number of items of debris collected in 2014 was the third-highest overall, and the highest in recent years. The Scientific Committee noted that this apparent increase in marine debris was a cause of concern and should be identified as an issue for future evaluation.

## **Spatial management of impacts on the Antarctic ecosystem**

### Bottom fishing and vulnerable marine ecosystems

5.1 The Scientific Committee noted the preliminary assessments of the potential for proposed bottom-fishing activities to have significant adverse impacts on vulnerable marine ecosystems (VMEs), which had been submitted by Australia (SC-CAMLR-XXXIII/BG/03), Japan (SC-CAMLR-XXXIII/BG/04), the Republic of Korea (SC-CAMLR-XXXIII/BG/05), New Zealand (SC-CAMLR-XXXIII/BG/06), Norway (SC-CAMLR-XXXIII/BG/07), Russia (SC-CAMLR-XXXIII/BG/08), South Africa (SC-CAMLR-XXXIII/BG/09), Spain (SC-CAMLR-XXXIII/BG/10), Ukraine (SC-CAMLR-XXXIII/BG/11) and the UK (SC-CAMLR-XXXIII/BG/12).

5.2 The Scientific Committee noted the following notifications of encounters with VMEs or potential VMEs (CCAMLR-XXXIII/BG/01):

(i) VME notifications (CM 22-06)

No VME notification was submitted under CM 22-06 in 2013/14. However, since 2008, the Secretariat has received a total of 46 notifications of encounters with VMEs: 22 notifications in Subarea 48.1; 13 in Subarea 48.2; 2 in Division 58.4.1; and 9 in Subarea 88.1 (2013 Report on Bottom Fisheries and Vulnerable Marine Ecosystems – [www.ccamlr.org/node/83655](http://www.ccamlr.org/node/83655)). All notified VMEs are currently afforded protection: Subarea 88.1 (CM 22-09) and general closures to bottom fishing activities in Subareas 48.1 and 48.2 (CMs 32-02 and 32-03).

(ii) VME indicator notifications (CM 22-07)

One VME indicator notification (5.9 VME indicator units) was submitted in accordance with CM 22-07 in 2013/14. This notification was made in Subarea 88.2. No new VME risk areas were declared in 2013/14.

5.3 The Scientific Committee noted that since 2008, the Secretariat has received a total of 156 VME-indicator notifications from exploratory bottom fisheries: 1 notification in Subarea 48.2, 2 in Subarea 48.6, 104 in Subarea 88.1 and 49 in Subarea 88.2. No notification has been received from exploratory fisheries in Divisions 58.4.1, 58.4.2, 58.4.3a and 58.4.3b. These VME indicator notifications have led to the declaration of 64 VME risk areas: 48 risk areas in Subarea 88.1 and 16 risk areas in Subarea 88.2. In addition, 6 VME fine-scale rectangles in Subarea 88.1 and 2 in Subarea 88.2 have been identified.

5.4 The Scientific Committee noted and endorsed the agreement by WG-FSA (Annex 7, paragraph 6.2) with regard to the Secretariat's plan to develop a web-based interface to provide an annually updated repository of the VME registry which would include information about currently designated VMEs (defined as both lines and areas), VME risk areas and VME fine-scale rectangles. The Secretariat had also indicated that VME locations and metadata would be added to the CCAMLR online GIS using the same terminology as in the registry. The web-based interface would provide updated information about the status of VMEs in the Convention Area without the need to update an annual report. The Scientific Committee also agreed that until formal reviews of CMs 22-06 and 22-07 were conducted, the current management advice regarding the management of impacts to VMEs is as compiled and provided in the 2013 Report on Bottom Fisheries and Vulnerable Marine Ecosystems ([www.ccamlr.org/node/83655](http://www.ccamlr.org/node/83655)).

5.5 Dr Constable drew the attention of the Scientific Committee to the discussion on bottom fisheries reflected in paragraph 6.3 of the WG-FSA report (Annex 7) and pointed out that this year, Australia completed its eight-year research program to, firstly, assess the effects of bottom fisheries on benthic habitats in Division 58.5.2 Heard Island and McDonald Islands and, secondly, to develop methods for a management system that will result in bottom fisheries avoiding significant adverse impacts on these habitats (SC-CAMLR-XXXIII/BG/30 Rev. 1). The report of this research program entitled 'An assessment of the vulnerability of benthic habitats to impact by demersal gears', which had been provided to all delegations in hard copy, highlights that less than 1.5% of all the biomass in waters under 1 200 m are

estimated to have been damaged by all bottom fishing activities since 1997 in Division 58.5.2. 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. The research program demonstrated that, with the marine reserve as an integral part of the management system, bottom fisheries are having only negligible (and no significant adverse) impacts on bottom habitats and organisms in Division 58.5.2. Australia now has a refined computational procedure and management strategy to continue to monitor and manage bottom fisheries.

5.6 The Scientific Committee noted the comprehensive nature of the report and how it encompassed an impact assessment of current fisheries as well as providing strategy for managing bottom fisheries in the region. It was also noted that the report could usefully form a template for assessing the impacts of bottom fishing in other parts of the Convention Area.

5.7 Dr Constable noted the general requirements for advising on the effects of bottom fishing activities on Antarctic marine living resources and drew the attention of the Scientific Committee to the specific requirements under CMs 22-06 and 22-07 to provide advice on the effects of fishing in benthic environments. The results of the research program carried out in Division 58.5.2 provides a template for the reviews expected under these measures. Reporting the effects of fisheries under CM 21-02 should occur annually and be cross-referenced to the reporting under CMs 22-06 and 22-07.

5.8 In relation to bottom fisheries to which CMs 22-06 and 22-07 apply, the Scientific Committee agreed that the relevant CCAMLR working groups consider and advise on whether the current fisheries are having no significant adverse impacts as required by Article II of the CAMLR Convention. The Scientific Committee also recommended a review of whether the current management arrangements are sufficient for these fisheries to avoid causing significant adverse impacts on vulnerable marine ecosystems. This should be a priority to support the review required in CM 22-06, paragraph 15.

5.9 The Scientific Committee supported the review of VME-related conservation measures, which was mandated in the measures themselves. The review of CM 22-06 should also address the question of whether Annex A to this measure could be removed. It recognised that this review could be part of the benchmarking process for each stock (Annex 7, paragraph 5.10) and agreed that WG-EMM and WG-FSA should carry out the necessary reviews of CMs 22-06 and 22-07. The Scientific Committee looked forward to the findings of the review on managing bottom fisheries in the Convention Area.

5.10 Recognising the increasingly full agendas of the working groups, it was noted that workload prioritisation is important. To ease the review procedure, the Scientific Committee invited Members to submit their analyses to the working groups. On the basis of their deliberations, the working groups should submit to the Scientific Committee in 2015 any outcomes of that work along with a list of further work (including, as appropriate, terms of reference for the review) that may form a future work program.

## Marine Protected Areas

### Domain 1 – Western Antarctic Peninsula and South Scotia Sea

5.11 The Scientific Committee noted recent progress on the development of MPAs in Domain 1 (Annex 6, paragraph 3.19), including progress achieved during a recent bilateral Chilean–Argentine meeting for identifying candidate MPAs. Twenty-nine conservation objectives were identified, with data and shapefiles (spatial distribution layers) available for 20 of these.

5.12 The Scientific Committee welcomed the progress made by Chile and Argentina and acknowledged the leading role played by Dr Arata in the project. It agreed that the project provided a clear demonstration of the MPA development process, including the iterative process between scientists and policy-makers in defining MPA objectives, a process consistent with the approach previously recommended by the Scientific Committee (SC-CAMLR-XXIX, paragraph 5.16).

5.13 The Scientific Committee noted the deliberations by WG-EMM that recognised that Domain 1 was defined to cover the krill-centric ecosystem as well as important links between the South Orkney Islands and the Antarctic Peninsula, and, consequently, that it was important to consider how spatial protection and harvesting might interact across the region. The Scientific Committee endorsed the conclusion by WG-EMM (Annex 6, paragraph 3.23) that Domain 1 should be maintained as a single planning domain.

5.14 The Scientific Committee endorsed the proposal (SC-CAMLR-XXXIII/BG/20 and Annex 6, paragraph 3.25) to hold a Second CCAMLR Technical Workshop on the Development of MPAs in Domain 1 during 2015, to address policy considerations and the evaluation of different MPA scenarios. It also endorsed the proposed terms of reference for the Workshop, which were:

- (i) review the available data that support the existing specific conservation objectives:
  - (a) perform a critical analysis of existing data
  - (b) identify data that are missing but which might be considered critical for the MPA planning process
  - (c) agree on the scope of data to be included in the process in the future, as new data arises
- (ii) consider different candidate MPA scenarios submitted by Members:
  - (a) Members participating in the technical workshop should develop candidate MPA proposals using their preferred protection targets and costs selected from the conservation objectives already defined for Domain 1 (WG-EMM-14/40, Table 1), or other conservation requirements, e.g. reference areas
  - (b) where participating Members do not have the technical expertise to develop candidate MPA proposals, they should consider their preferred protection targets and costs

(iii) undertake a sensitivity analysis of different scenarios:

(a) explore the sensitivities associated with using different scenarios in order to identify those targets and costs driving the variability between scenarios.

5.15 SC-CAMLR-XXXIII/BG/20 provides further details about the proposed Second CCAMLR Technical Workshop on the Development of MPAs in Domain 1. The Scientific Committee endorsed the proposal to hold the workshop in Buenos Aires, Argentina, potentially in late May or early June 2015, co-convened by Drs Arata and E. Marschoff (Argentina). The Scientific Committee recognised that there would be considerable benefit in considering Domain 3 and 4 (the Weddell Sea MPA Planning Region) at the same workshop and asked Drs Arata and Marschoff to liaise with Prof. T. Brey (Germany) accordingly (paragraphs 5.21 and 5.23).

5.16 The Scientific Committee recognised that the outputs from the workshop will help facilitate a roadmap for preparing future candidate MPA proposals for Domain 1.

5.17 The Scientific Committee noted progress on the development of a network of MPAs in the vicinity of Akademik Vernadsky Station. Previous work led to outline proposals for MPAs in the Stella Creek and Skua Creek areas. Subsequently, additional scuba dive surveys have been carried out to enhance available information on biodiversity and community composition. The Scientific Committee noted the change of name from 'Network of marine protected areas' to 'Network of special investigation/research areas' (SC-CAMLR-XXIX, paragraph 5.28).

#### Domains 3 and 4 – Weddell Sea

5.18 The Scientific Committee noted the outcome of WG-EMM discussions on the development of a proposal for MPA(s) in the Weddell Sea (MPA Planning Domains 3 and 4) (Annex 6, paragraphs 3.1 to 3.18). It also noted the summary of information provided by Germany on the state of data processing, the scientific analyses undertaken and a report on the international workshop held in Germany in April 2014 (SC-CAMLR-XXXIII/08). This workshop was attended by 41 participants from 13 CCAMLR Member States. It greatly fostered the involvement of international expertise in the identification of further information and data, and in the development of objectives for the Weddell Sea MPA(s).

5.19 As part of further work on the scientific basis in support of the development of a Weddell Sea MPA(s), pelagic regionalisation based on environmental data has been completed, compilation and analysis of a substantial amount of relevant data has been undertaken and an extensive draft background document has also been developed (SC-CAMLR-XXXIII/BG/02).

5.20 The Scientific Committee congratulated Germany for the comprehensive and clear compilation of information and data in the draft background document.

5.21 The Scientific Committee welcomed and endorsed the progress made by Germany and the workshop participants. It agreed that the draft scientific background document (SC-CAMLR-XXXIII/BG/02) should be regarded as a foundation reference document for the

Weddell Sea MPA planning; it should be posted on the CCAMLR website at an appropriate location. The Scientific Committee encouraged the proponents to continue the project with the engagement of interested Members. A further international workshop could be useful to address some of the next steps (paragraph 5.15).

5.22 The Scientific Committee also noted WG-EMM discussions on the incorporation of additional datasets in the Weddell Sea MPA planning process, including toothfish longline surveys, exploratory toothfish fishery data, Adélie penguin habitat use, and the possible inclusion of cetacean sightings data (Annex 6, paragraphs 3.3 to 3.5).

5.23 The Scientific Committee endorsed the Weddell Sea pelagic regionalisation as a useful characterisation of the pelagic environment (WG-EMM-14/19, Figure 7). It further noted the importance of considering the boundaries of the Weddell Sea planning domain with the neighbouring Planning Domain 1 at the tip of the Antarctic Peninsula and agreed that work on the development of MPAs in this area should be undertaken collaboratively with the Domain 1 planning process (paragraph 5.15).

5.24 The Scientific Committee also endorsed advice from WG-EMM-14 that the process of developing the datasets would be facilitated by considering these in relation to a list of specific protection objectives consistent with those indicated in CM 91-04, paragraph 2. It agreed that there may be a hierarchy of objectives for this region and endorsement of any relative levels of protection associated with different protection objectives is a decision for the Commission.

5.25 The Scientific Committee noted that WG-EMM-14 had also examined proposals for possible joint research by Russian and German scientists in the eastern part of the Weddell Sea to enhance the collation and utilisation of data required for MPA development, focussing specifically on ichthyoplankton, Antarctic krill in the northwest Weddell Sea and the toothfish life-cycle, including a proposed survey on the shelf for smaller fish.

5.26 It was further noted that WG-EMM-14 had discussed a systematic conservation planning process, where protection objectives include the protection of particular life-history stages of the target species, and had suggested the usefulness of an exercise to examine historical data in the context of the hydrodynamic model framework for the northern Weddell Sea and Scotia Sea.

5.27 Prof. Brey gave a presentation to the Scientific Committee on the next steps in the process of finalising the scientific background document and the establishment of a first draft MPA proposal for consideration at next year's meetings of WG-EMM, the Scientific Committee and the Commission respectively. In order to continue the productive cooperation with all Members in the further development of these products and to ensure an open and transparent process, a CCAMLR e-group (Weddell Sea MPA) has recently been established on the CCAMLR website.

5.28 On behalf of the Weddell Sea MPA project team, Dr Hain and Prof. Brey thanked all Members and experts for their efforts to contribute to the Weddell Sea MPA project so far and hoped for their further dedicated involvement and contributions.

5.29 Russia informed the Scientific Committee that it is closely collaborating with Germany in the research and analyses to develop the necessary documentation for a Weddell

Sea MPA proposal in accordance with CM 91-04. The Weddell Sea is an interesting and challenging area for science. Just last year, spawning sites of icefish (*Chaenodraco wilsoni*) were discovered on the shelf of the southern Weddell Sea with a density of more than two nests per square metre. The Russian Federation further noted the importance of cooperation between CCAMLR Members in the implementation and operationalisation of a Weddell Sea MPA(s), and looked forward to continuing engagement.

5.30 The Scientific Committee noted that a set of specific conservation objectives for a Weddell Sea MPA will be developed, inter alia, on the basis of the input received at the international expert workshop, the results of the still ongoing scientific data analyses and the deliberations on the CCAMLR e-group.

#### Domain 7 – East Antarctica

5.31 The Scientific Committee noted the discussions at WG-EMM-14 on the development of a representative system of MPAs in Planning Domain 7, East Antarctica (Annex 6, paragraphs 3.30 to 3.36). The Working Group had considered a report bringing together the information provided to the Scientific Committee and its working groups on the East Antarctic Planning Domain since 2010. This report was structured according to the MPA Report sections originally proposed in 2012, with an additional section on threats. A section on the identification of planning locations identified seven possible areas for inclusion in the East Antarctica representative system of MPAs (RSMPA). Four of these seven areas were highlighted as contributing to the RSMPA; these have been revised with updated boundaries that have been negotiated intersessionally among Members.

5.32 The Scientific Committee reviewed the three MPA planning reference documents that were submitted by Australia, France and the EU as an update to the MPA Report originally submitted to WG-EMM (SC-CAMLR-XXXIII/BG/38, XXXIII/BG/39 and XXXIII/BG/40). Updates were based on advice received from the working group, including recommendations to incorporate further data and to more clearly highlight the methods and data used to develop each scenario.

5.33 SC-CAMLR-XXXIII/BG/38 provided background information on the planning domain, and on the seven areas initially proposed, with the rationale behind that work. SC-CAMLR-XXXIII/BG/39 described the proposed representative system, which includes four areas for protection. SC-CAMLR-XXXIII/BG/40 described the research and monitoring work that has been completed and that is currently underway to support the establishment of these MPAs.

5.34 The Scientific Committee welcomed the three reference documents, noting that the very large amount of information consolidated therein has been previously reviewed by WG-EMM and the Scientific Committee, and that the suggestions from WG-EMM-14 have been taken into account. It endorsed the advice that the MPA planning reference document format is a good way to synthesise information for ease of reference and agreed that it would be useful to place such documents on the CCAMLR website (see paragraph 5.48) as living documents.

5.35 Dr Ichii noted that the inclusion of recent information on the dynamic nature of the ecosystem, and especially on whales and penguins, is a useful update to the document. However, it is not clear whether the activities outlined in the research and monitoring plan can contribute to the understanding of ecosystem dynamics and climate change in the region. While predator data are more readily available through current monitoring programs, it may be difficult to obtain data on prey since no time-series data exist for this region. Dr Ichii also expressed concern about the resources available for future research and suggested that it will be necessary to secure further funds for research and monitoring to support the MPA.

5.36 Dr Constable expressed his thanks for the feedback provided on these reference documents and appreciation for the cooperation of other Members. He reaffirmed the commitment of Australia to research and monitoring in the East Antarctic region, noting that two surveys have been undertaken in support of krill conservation measures in the region, and two further proposals to undertake research and long-term monitoring in the proposed MPAs are currently under consideration for approval. Dr Constable invited all Members to contribute to research and monitoring in this region, noting that Australia would be pleased to help coordinate and collaborate in such activities.

5.37 Dr Bizikov noted that the objectives of each area are now more clearly defined, but he expressed concern about how monitoring and management will be carried out with regard to the conservation objectives for benthic communities, given the expensive nature of benthic research. He noted that from the perspective of toothfish research this area is data poor and suggested that closing large marine areas would exacerbate this situation. While accepting that the MPA needs to be established in order to stimulate scientific research, he noted that there should be a clear understanding on how the research and monitoring plan will be realised in practice.

5.38 Dr Bizikov also introduced SC-CAMLR-XXXIII/BG/02, which reflects general concerns regarding the establishment of an MPA in East Antarctica. This paper notes that although the number of proposed areas in East Antarctica is now smaller than in the original proposal, the total area is still very large. It also notes that the current proposal is based on data that are 8 to 9 years old, and that no new data have been incorporated. Benthic communities proposed for protection are not currently subject to any threat, since bottom fishing is not permitted in areas shallower than 500 m. The rectangular boundaries of the proposed areas are poorly justified, and the variability of the environment and biogeography are not sufficiently taken into account. The paper expresses concern that the MPA will have an adverse effect on activities in East Antarctica and could lead to increased IUU fishing in the region if there are no legally operating vessels there. It also suggests that it will be difficult to understand the region in the absence of scientific information from fisheries and that a proper study of this very large area is impossible without fishing vessels as a platform for scientific research.

5.39 In response, Dr Constable noted that the points in this paper and those on research and monitoring plans are matters for consideration by the Commission. Regarding the potential consequences for fisheries, he drew the attention of the Scientific Committee to the summary of an analysis on the effects on fisheries in SC-CAMLR-XXXIII/BG/38 (pp. 88–90) and XXXIII/BG/39 (p. 61), which indicates that catch rates and yield for toothfish and krill would not be affected by the proposed MPAs. Dr Constable expressed support for research to be

undertaken also by fishing vessels within the MPAs and the East Antarctic region and noted that the preamble of the draft conservation measure states that CCAMLR licensed fishing vessels can provide useful platforms for research and monitoring.

5.40 Dr Zhao suggested that the analysis of potential effects of the MPA on catch rates is not valid because it does not consider the cost of displacing fishing activities.

5.41 Drs Watters and V. Siegel (EU) expressed support for the scientific justification of the proposed MPA boundaries. They also disputed the assertion that biogeography has not been sufficiently considered, noting that the East Antarctica RSMPA concept was founded on the notion of biogeographic provinces, and that the supporting documents clearly state how the MPAs are designed to represent these different provinces.

5.42 The Scientific Committee agreed that every Member is encouraged to participate in MPA research and monitoring.

5.43 The Scientific Committee drew the attention of the Commission to the following points regarding research and monitoring plans:

- (i) research and monitoring plans need to include elements related to reviewing MPAs and their management, and may include research relating to key knowledge gaps
- (ii) research and monitoring plans need to be clear in what they will deliver to support management
- (iii) results from research undertaken under research and monitoring plans, including that arising from reference areas, need to be reported and shared. (Reference areas will be useful to understand the dynamics of populations and the ecosystem)
- (iv) research to support assessment of fish stocks can be undertaken in MPAs, where it is consistent with the objectives of the MPAs
- (v) benthic research is an example of what might be a difficult element of research and monitoring plans to be achieved because of their expense
- (vi) research and monitoring plans need to be practical and achievable but will not be able to be implemented or confirmed until there is a conservation measure; only when the MPAs are binding can a budget commitment be achieved
- (vii) the conduct of activities of research and monitoring plans are open to all CCAMLR Members and their involvement is welcomed, especially given the potentially expensive nature of such research
- (viii) there needs to be a mechanism to ensure satisfactory progress in implementing the research and monitoring plan, especially for those reference areas where baseline information is needed to achieve objectives
- (ix) fishing vessels could be used for research in a research and monitoring plan

(x) research and monitoring plans need to include research to validate results from analyses used to determine the boundaries of MPAs

(xi) that it is not necessary for a research and monitoring plan to be financed by proponent(s) at the time of MPA proposal.

5.44 The Scientific Committee noted that review processes would be expected to enable regular updating of the MPAs and their management on the basis of new data arising from the research and monitoring work.

#### Domain 8 – Ross Sea

5.45 The Scientific Committee noted the papers by New Zealand and the USA describing the chronology of previously submitted scientific documents, updated maps and analyses supporting MPA planning in the Ross Sea region (SC-CAMLR-XXXIII/BG/23 Rev. 1) and new research consistent with a proposed draft research and monitoring plan for a Ross Sea region MPA (SC-CAMLR-XXXIII/BG/24).

#### MPA Reports

5.46 Noting the discussions at WG-EMM-14 (Annex 6, paragraphs 3.64 to 3.69), the Scientific Committee agreed that there was a distinction between an MPA Report and documents supporting MPA planning and proposals ('MPA planning reference documents') in different planning domains or regions. It agreed that the latter could include: (i) documents providing background information, (ii) descriptions of spatial data used in the planning process, (iii) methodological descriptions of approaches, and (iv) documents containing or describing the MPA proposals. Information contained in all of these reference documents would then form the basis of future MPA Reports, which were expected to be developed in support of MPAs after adoption of those MPAs.

5.47 The Scientific Committee recommended that MPA planning reference documents should be assembled on a regional or MPA planning domain basis. In this context, it would be helpful for the information presented for the Weddell Sea and MPA Planning Domain 1 to be assembled as such MPA planning reference documents. However, there should be flexibility for proponents to decide on the extent to which they may also wish to develop synthesis or summary documents, as the requirement for such documents may vary between planning domains.

5.48 In order to make MPA planning reference documents accessible to all Members, the Scientific Committee agreed that they could be placed on the CCAMLR website under a separate 'Conservation' tab, with an area for Member access only. This area could then 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.

5.49 The Scientific Committee agreed that the development of the content of MPA Reports would best be undertaken by WG-EMM. However, it acknowledged the high existing workload of WG-EMM, and the need to prioritise tasks accordingly (paragraph 13.2). It was

noted that the MPA Report represents an executive summary for discussion at, and subsequently agreed to by, the Scientific Committee and used to support the MPA once established.

#### General MPA issues

5.50 Japan introduced its MPA checklist proposal (CCAMLR-XXXIII/27) and welcomed any feedback comments from Members. The Scientific Committee noted CCAMLR-XXXIII/BG/20 and XXXIII/BG/24 Rev. 2 submitted by ASOC.

#### South Orkney Islands southern shelf MPA (Domain 1)

5.51 The Scientific Committee noted recent discussions at WG-EMM related to the South Orkney Islands southern shelf MPA (SOISS MPA) (Annex 6, paragraphs 3.39 to 3.62) and considered revised versions of the MPA Report (SC-CAMLR-XXXIII/BG/19) and the research and monitoring plan (SC-CAMLR-XXXIII/11).

5.52 The Scientific Committee noted that the MPA Report and the research and monitoring plan had both been revised following recommendations from WG-EMM in 2013 and 2014. These recommendations included clarification of the protection objectives, information about how monitoring activities could compare the status of features inside the MPA with those outside and the elaboration of research activities that could also contribute to the wider planning process for Domain 1 (Annex 6, paragraphs 3.46 and 3.55).

5.53 The MPA Report is structured according to the sections initially proposed by WG-EMM (SC-CAMLR-XXXI, Annex 6, paragraphs 3.73 to 3.76), modified to take into account comments from the e-group requested by the Scientific Committee (SC-CAMLR-XXXII, paragraph 5.18). The report contained sections on (i) description of the region, (ii) regional and specific objectives (as defined in previous proposal papers), (iii) a summary of historical and recent activities, and (iv) a summary of research and monitoring activities and results available since 2009. Finally, it included an assessment of the MPA and effects of human activities, including the extent to which the MPA objectives have been achieved, as well as an analysis of current and potential threats.

5.54 The MPA Report demonstrates the range of research activities that have been undertaken since 2009, related to the specific objectives of the MPA, and monitoring activities to evaluate the extent to which these objectives are being met. These are cross-referenced to the research and monitoring plan and to other papers submitted to WG-EMM describing the results of recent research. It also describes the requirements for new research and monitoring (Annex 6, paragraphs 3.42).

5.55 The final section of the MPA Report provides an assessment of the South Orkney Islands southern shelf MPA and the effect of activities; it concludes that the scientific basis supporting the protection of the features within the MPA remains the same as at the time of its adoption. However, the report also noted that five years is a short time frame in which to assess regional ecological characteristics and that fully analysed results from some of the research and monitoring activities carried out during recent years will only start to become available during the next reporting period.

5.56 The Scientific Committee welcomed the research and monitoring plan and the MPA Report, and agreed that these documents provided a good format for describing research and monitoring activities. In particular, they provided information on research activities that are completed or ongoing by cross-referencing to other published papers or CCAMLR working group documents.

5.57 Dr Bizikov thanked the authors of the MPA Report and the research and monitoring plan for their careful work and suggested that these documents allowed the Scientific Committee to see what had been successful or not – and what CCAMLR ought to be doing with the SOISS MPA.

5.58 Dr Bizikov presented document SC-CAMLR-XXXIII/01 with the analysis of the first five-year reference period of the South Orkney Islands southern shelf MPA. He noted that the MPA in Subarea 48.2 exists for five years but still, it has no research and monitoring plan approved by the Scientific Committee. He expressed his delegation's view regarding documents (SC-CAMLR-XXXIII/11 and XXXIII/BG/19) and focused in particular on the following concerns:

- (i) according to the MPA Report (SC-CAMLR-XXXIII/BG/19) few researches have been accomplished within or around the South Orkney MPA between 2009 and 2014
- (ii) it is not clear how investigations that are carried out outside South Orkney MPA would meet objectivities of this MPA
- (iii) at present, there are no criteria allowing objective assessment of whether or not the specific aims of the MPA in Subarea 48.2 have been achieved
- (iv) the research and monitoring plan for 2015–2019 submitted to the Scientific Committee is arranged in the most general terms that makes impossible to assess whom and how will implement this plan.

Taking into account abovementioned concerns, Dr Bizikov concluded that the Russian Delegation could not consider the South Orkney MPA report for the period 2009–2014 (SC-CAMLR-XXXIII/BG/19) as successful.

5.59 The Scientific Committee agreed with the general approach for the review of CM 91-03, as outlined in WG-EMM-14/26, noting that information relevant to the review can be found in the MPA Report and research and monitoring plan (Annex 6, paragraph 3.60).

5.60 Mr W. Yang (China) also welcomed the research and monitoring plan and recalled that China had originally proposed before the adoption of the MPA in 2009 that such a plan should be developed. Some Members said such a plan should be made in the Commission but during the 2009–2013 the plan has not been developed. He added that the MPA Report indicated that data related to research activities were not derived from new field data, but from reanalyses of existing research. He noted that activities such as the results from acoustic surveys and from mooring activities were not presented. He drew the attention of Members to the conclusions in the MPA report that there is no evidence that characteristics in MPAs have changed and he questioned how conclusions can be drawn with such limited scientific information.

5.61 Dr Trathan noted that CM 91-03 was agreed before CM 91-04 and that at the time of adoption of CM 91-03 there was no requirement for a research and monitoring plan. However, the EU had indicated that it was seeking to harmonise CM 91-03 with CM 91-04 and hence the research and monitoring plan (SC-CAMLR-XXXIII/11) was developed in accordance with CM 91-04.

5.62 Dr Siegel reported that the MPA Report provided details of ongoing research, including reference to Norwegian acoustic surveys (e.g. WG-EMM-14/16), Argentine research surveys (e.g. WG-EMM-14/06 Rev. 1), UK/Argentine penguin tracking research (Dunn et al., 2011; WG-EMM-14/25), UK/Norwegian oceanographic modelling (WG-EMM-14/08), UK analyses of sea-ice (WG-EMM-14/11), UK geomorphic classification work (WG-EMM-14/P01) and Australian pelagic bioregionalisation work (WS-MPA-11/6). In addition, he noted that other relevant work is ongoing and has been notified to WG-EMM; this includes:

- (i) UK/USA oceanographic moorings inside and outside the MPA (WG-EMM-14/25)
- (ii) international pelagic work scheduled for 2015/16 (SC-CAMLR-XXXIII/BG/33 Rev. 1)
- (iii) the forthcoming international workshop on penguin tracking (WG-EMM-14/03)
- (iv) UK use of airborne aerial survey techniques (WG-EMM-14/05).

5.63 Dr Siegel noted that the results from these projects are not yet complete and will only emerge over time; however, he noted that it was important to recognise the amount of work that has been initiated directly because of the MPA.

5.64 Prof. K. Kovacs (Norway) reported that the Norwegian penguin tracking work at the South Orkney Islands was also directly related to the SOISS MPA.

5.65 Dr Hain reported on research from the German research vessel *Polarstern* in the context of the International Austral Late Winter Expedition ANTXXIX/7 which took place in the northern Weddell Sea from south of the South Orkney Islands to the southwest and east of the South Sandwich Islands. This cruise focussed on locating spawning and nursery areas for Antarctic krill. The preliminary findings confirmed the importance of sea-ice for the life cycle of krill, while further results will become available over the coming year. The results have important implications for the SOISS MPA and will contribute to the achievement of its objectives.

5.66 Dr Bizikov noted that not all research activity was related to the MPA and expressed doubt as to whether activities that have always taken place can be related to some objectives. He suggested that some work is not related to the objectives of the SOISS MPA. He recalled that research and monitoring plans were not required when the SOISS MPA was designated, and that CM 91-04 had not been agreed. However, he needed to understand what had been done in the current reporting period. Dr Bizikov noted that the Norwegian acoustic surveys were originally intended for Bouvet Island, while analyses of geomorphology and sea-ice distribution were hard to link to the protection objectives. He recognised that research on penguins was valuable, but that this was more appropriate to marine areas close to the South Orkney Islands.

5.67 Dr Trathan indicated that Table 4 in SC-CAMLR-XXXIII/BG/19 provided details of each specific MPA objective, the relevant research activities, the specific activities undertaken between 2009 and 2014 and the status of current research.

5.68 Dr Bizikov questioned how the research and monitoring plan would be implemented.

5.69 Dr Trathan responded that the Commission had already agreed that research and monitoring plans are the responsibility of all Members. However, he pointed out that the EU and collaborators had made considerable efforts to put together a research plan which had been supported by WG-EMM (Annex 6, paragraphs 3.54 and 3.60). He noted that the development of a research plan takes time to fund, and results take time to accumulate. Dr Trathan assured Dr Bizikov that there is an ongoing impetus to fulfil the plan.

5.70 Mr Yang expressed concerns regarding the differences of protection objectives described in the MPA Report and research and monitoring plan from CM 91-03, but recognised that these were issues for the Commission. He agreed that the format of the MPA report is appropriate but the content of the MPA report and the research and monitoring plan need to be discussed in detail.

5.71 Dr Bizikov introduced SC-CAMLR-XXXIII/01 and highlighted that the research and monitoring plan did not address the MPA protection objectives. He questioned how reference areas or work in Antarctic Specially Managed Areas close to the islands was relevant to the SOISS MPA.

5.72 Dr Trathan noted that the specific protection objectives contained in SC-CAMLR-XXXIII/01 differed from those described in the research and monitoring plan, which comprised:

- (i) to protect representative examples of pelagic marine ecosystems, biodiversity and habitats in the Southern Scotia Arc region
- (ii) to protect representative examples of benthic marine ecosystems, biodiversity and habitats in the Southern Scotia Arc region
- (iii) to protect areas important to critical life-history stages for Adélie and chinstrap penguins
- (iv) to protect key ecosystem processes associated with the South Orkney Islands southern shelf region.

5.73 Dr D. Freeman (New Zealand) highlighted that both the MPA Report and the research and monitoring plan had been favourably reviewed by WG-EMM (Annex 6, paragraphs 3.39 to 3.62). She noted that WG-EMM had recommended a number of changes and that these had been incorporated. Dr Freeman noted that significant amounts of monitoring had been undertaken and further research was planned.

5.74 Dr Trathan noted that the Commission has not provided specific guidelines about how it would undertake its review of the SOISS MPA. He suggested that the Scientific Committee would therefore need to inform the Commission that:

- (i) a research and monitoring plan has been developed and that it had been reviewed and welcomed by WG-EMM
- (ii) no Member has tabled any evidence to suggest that the marine ecosystem in the SOISS MPA has changed in any way that would alter our view about the protection objectives
- (iii) that results from the current review period are not yet fully available, but that new data and results will become available during the next review period. Further, that additional information will become available because of the science already initiated and because of new science that is planned.

5.75 Dr Constable suggested that much of this discussion should be remitted to the Commission, where the review of CM 91-03 will be undertaken. He recalled that CM 91-03 was established prior to CM 91-04. He suggested that the EU had provided a research and monitoring plan consistent with the needs of CM 91-04, but the degree to which they need to be the same is a matter for the Commission. Dr Constable noted that the Commission will need to decide how the research and monitoring plan should be prioritised.

5.76 Following substantive discussion, the Scientific Committee endorsed the advice from WG-EMM (Annex 6, paragraph 3.69) that SC-CAMLR-XXXIII/BG/19 provides an appropriate MPA Report for the South Orkney Islands southern shelf MPA.

## **IUU fishing activity**

6.1 The Scientific Committee discussed the spatial distribution of potential IUU fishing activity during 2013/14 based on automatic identification system (AIS) data and recent sightings of fishing vessels and gear (CCAMLR-XXXIII/BG/28 Rev. 1). AIS and sightings data provide limited information on vessel movements and fishing activities, but these data cannot currently be used to estimate IUU catches.

6.2 It was noted that sightings of fishing gear need to be considered carefully and would not necessarily indicate IUU fishing activity. For example, while observations of gillnets would indicate IUU fishing, free floating buoys are sighted and may originate from legal fishing activities. In the future, maps depicting the locations and numbers of gear sightings should also indicate the types of gear that were observed.

6.3 The Scientific Committee considered the requirement under CM 10-02 that vessels report all other vessel sightings in the Convention Area to their Flag State, which is then responsible for reporting such sightings to the Secretariat. These data were not provided in 2014 but are intended to be used for quantifying levels of IUU surveillance and developing a vessel-detection model that may ultimately improve estimates of IUU fishing effort. The Scientific Committee referred the apparent lack of reporting required by CM 10-02 to SCIC.

6.4 The Scientific Committee noted a joint proposal submitted by France and the Secretariat to implement a pilot initiative to detect the presence of IUU fishing vessels in the Convention Area using satellite imagery (CCAMLR-XXXIII/07). It was agreed that the proposed use of satellite imagery would be a positive step towards improving estimates of IUU fishing activity.

## **CCAMLR Scheme of International Scientific Observation**

7.1 The Scientific Committee considered the advice contained in the WG-FSA-14 report (Annex 7, paragraphs 7.1 to 7.7).

7.2 In discussion, some Members queried whether the observer data that is not collected independently from the vessel should be removed from observer tasks and logbook reporting requirements (Annex 7, paragraph 7.7ii). They noted that recent incidences of anomalous CPUE highlighted the importance of vessel-independent observer data collection.

7.3 In response, it was clarified that this recommendation related only to data collection that could not be carried out by observers independently from information provided by vessel crew. Members would have the opportunity for further input into observer form redesign as this was progressed intersessionally through the Scheme of International Scientific Observation (SISO) e-group (Annex 7, paragraph 7.7iii).

7.4 Following this clarification, the Scientific Committee endorsed the recommendations in Annex 7, paragraph 7.7.

7.5 WG-FSA sought clarification from the Scientific Committee as to the utility of the observer data collected on board vessels for which data had been quarantined (Annex 7, paragraphs 3.10 and 7.7vii). Some Members noted that tagged fish released by vessels with quarantined data had been recaptured. Others noted that as there could be no match between release and recapture location, the data could not be validated.

7.6 The Scientific Committee agreed that data which has been quarantined would not be released under a general data request, but that metadata regarding quarantined data would be provided in response to any data request. This would alert users as to the data's status. Further, the Scientific Committee agreed quarantined data would be made available on specific request, including for assessing the sensitivity of stock assessment projections to alternative biomass removal scenarios.

7.7 The Scientific Committee recommended that the issue of potential non-compliance with associated conservation measures regarding observer data on vessels with anomalous CPUE be considered by SCIC.

7.8 SC-CAMLR-XXXIII/10 presented an update on the CCAMLR observer training program accreditation scheme (COTPAS).

7.9 Dr Petrov highlighted SC-CAMLR-XXXIII/BG/18, which provided comments on the SISO review (SC-CAMLR-XXXII/07 Rev. 1). He also noted that he was not against small modifications in the observer logbooks and cruise reports but he does not support a centralised accreditation scheme. He also sought clarification as to how Article XXIV will be adhered to under a proposed central accreditation system. Some Members questioned whether there had been agreement to establish a centralised accreditation scheme.

7.10 In discussion, it was noted that the Scientific Committee had endorsed COTPAS and invited Members to participate in a trial of the initial review and technical peer review (SC-CAMLR-XXX, paragraphs 7.19 to 7.20). Further, the Commission had endorsed the recommendations from the Scientific Committee and welcomed the offer from Australia to participate in the trial (CCAMLR-XXX, paragraph 10.2).

7.11 The Scientific Committee agreed to the establishment of the CCAMLR TPRG e-group to conduct a technical review. The Committee encouraged national technical coordinators, or nominees, to participate in the review.

7.12 The Scientific Committee considered the advice contained in the WG-EMM-14 report (Annex 6, paragraphs 2.31 to 2.35 and 2.37) and welcomed the removal of those logbook forms/parts of forms that were functionally redundant, where little or no data had ever been submitted and there now existed more practical ways to access the information and welcomed the revised krill observer logbook forms.

7.13 The Scientific Committee noted that one of the forms, K8 ‘Change of Fishing Ground’, being suggested for removal, is designed to help understand the operation of the fishery, which could assist discussion in progressing the feedback management approach. However, the Scientific Committee noted that direct engagement with vessel captains that have become possible recent years is now a more effective means of gaining an understanding of the fishing strategy of individual vessels.

7.14 The Scientific Committee considered the advice contained in the WG-EMM-14 report (Annex 6, paragraphs 2.41 to 2.44) and CCAMLR-XXXIII/16 and XXXIII/18 regarding proposals to increase observer coverage in the krill fishery.

7.15 The Scientific Committee acknowledged the advantages in having 100% scientific observer coverage in improving green weight and fish by-catch estimates in the krill fishery, which currently are not reported consistently across the fleet (paragraphs 3.5 and 3.145).

7.16 There was general support that having 100% observer coverage was scientifically desirable, as agreed during the WG-EMM-14.

7.17 Some Members noted that there were specific reasons that a mandatory level of 100% would be problematic: the long periods of time that krill vessels are at sea (compared to other vessels in CCAMLR fisheries) made this logistically challenging. They stressed further that an increase in the quality of the data provided by observers is of greater value than an increase in observer coverage and noted that there were fishery-dependent issues.

7.18 The Scientific Committee recommended that the general elements of CM 51-06 be retained for 2014/15 but that the Commission needs to decide on the appropriate level of observer coverage based on the former arguments.

7.19 Dr Werner made the following statement:

‘In reference to our paper CCAMLR-XXXIII/BG/25 “Krill: the power lunch of Antarctica”, I would like to make very brief comments on the issue of scientific observers on krill fishing vessels. We are glad to see that this year two papers have been submitted to this meeting by Chile and the Ukraine on the need to increase the observer coverage in the krill fishery. As already advised by the Scientific Committee in previous years, 100% scientific observation across all vessels in the krill fishery is the best way to achieve systematic observer coverage, meaning a level of coverage that ensures data collection across all areas, seasons, vessels, and fishing methods. A robust scientific observation program is necessary to understand the overall behaviour and impact of the fishery and is also fundamental to collect biological data – a factor

that currently limits CCAMLR's ability to monitor and manage the krill fishery. As we have heard, in the last meeting of WG-EMM, the working group agreed that in addition to collecting data scientific observers could also provide guidance in assisting the crew to estimate the green weight of krill caught. Furthermore, some krill fishing operators are concerned that transshipment operations are not fully covered by observers, allowing for catch underreporting. Thus, 100% observer coverage will not only improve the availability of krill fishing data to WG-EMM, but will also secure full observation coverage during transshipment operations. As we have heard, the Working Group concluded that there was a general desire to increase the level of observer coverage, recognizing that it was important to identify specific concerns that Members might have with increasing the level of observer coverage. Thus, ASOC considers that, after many years of partial coverage of the krill fishery, it is crucial for CCAMLR to finally adopt a 100% observer in the krill fishery.'

## **Climate change**

8.1 The advice from WG-EMM on issues of climate change is provided in Annex 6, paragraphs 5.8 to 5.10. Paragraph 5.8 summarised work which ICED undertook with respect to fisheries management in the Southern Ocean. ICED convened a workshop in November 2013 on 'Southern Ocean Food Webs and Scenarios of Change'. ICED is currently preparing a paper on plausible quantitative scenarios of how the Southern Ocean ecosystems may change, the future role that sea-ice may play in governing ecology in the Southern Ocean and challenges in projecting future scenarios for Southern Ocean ecosystems.

8.2 Dr Constable drew the Scientific Committee's attention to ICED's offer of assisting CCAMLR with its work on climate change. The Scientific Committee encouraged Members to contact ICED and use its expertise in developing work for CCAMLR.

8.3 ICED provided a plan of its future work and addressed seven topics with respect to krill which will be useful for the work of WG-EMM in the future (Annex 6, paragraph 5.10).

8.4 The Scientific Committee noted that development of a feedback management strategy for the krill fishery offers the opportunity to adapt to the impacts of climate change.

8.5 The Scientific Committee noted an important paper on ocean acidification published in 2013 which had been provided for the information of WG-EMM in July 2014: S. Kawaguchi et al. Risk maps for Antarctic krill under projected Southern Ocean acidification. *Nature Climate Change*, 3: 843–847, doi: 10.1038/nclimate1937.

8.6 ASOC presented CCAMLR-XXXIII/BG/21 which proposes that all CCAMLR papers and Fisheries Reports include information about climate change impacts (including from ocean acidification). To the extent that it is practicable, the UK supported the adoption of the draft resolution.

## Scientific research under CM 24-01

9.1 Dr Arata informed the Scientific Committee that Chile was unable to undertake its research as planned for Subareas 48.1 and 48.2 in the coming year. The Scientific Committee was sorry to hear of this delay and looked forward to seeing research outcomes in the future.

9.2 The Scientific Committee noted the following notifications under CM 24-01:

- (i) COMM CIRC 14/94 – SC CIRC 14/47: Norway notified a research program in Subarea 48.2 related to:
  - (a) krill abundance, distribution and demography
  - (b) potential connections between krill and penguins and seals in the region
  - (c) escapement of krill from trawl nets.
  
- (ii) COMM CIRC 14/96 – SC CIRC 14/49: The UK notified a research program in Subarea 48.3 with the following aims:
  - (a) to determine icefish standing stock to produce an assessment of icefish stock size for the derivation of a catch limit, and for investigations into icefish population structure and management
  - (b) to determine toothfish pre-recruitment population structure to contribute to the estimates of sustainable yield and assessments of the status of the toothfish stock
  - (c) to collect biological data on the other major demersal fish species in the area, such as *C. gunnari*, *Chaenocephalus aceratus* and *N. rossii*.

9.3 The Scientific Committee encouraged Members to undertake research activities in support of its work.

## Cooperation with other organisations

Cooperation with the Antarctic Treaty System

Committee for Environmental Protection (CEP)

10.1 The CEP Observer to SC-CAMLR (Dr Penhale) reported on topics of mutual interest that were discussed during the 17th Meeting of the CEP, held in Brasilia, Brazil (28 April to 2 May 2014; SC-CAMLR-XXXIII/BG/13). She informed the Scientific Committee that an Intersessional Contact Group on Climate Change was in its second year of work to develop a CEP Climate Change Response Work Plan.

10.2 Dr Penhale also noted that the CEP had considered a paper on fostering coordinated climate change monitoring, which included a recommendation to continue support for cooperation between CEP and SC-CAMLR through periodic joint workshops. The CEP welcomed the idea of holding a second joint workshop with SC-CAMLR and considered that the general scope of such a workshop could be 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.

10.3 The Scientific Committee welcomed the idea and proposed scope of a second Joint CEP–SC-CAMLR Workshop and agreed it should be held in 2016. It also agreed that the terms of reference for the workshop could be based on elements such as those identified during informal intersessional CEP discussions led by Dr Penhale:

- (i) identifying those drivers or effects for which measurable responses are required to support the goals of the CEP and SC-CAMLR
- (ii) reviewing existing monitoring programs to determine whether the data is sufficient to assess climate change impacts or whether new approaches are needed
- (iii) defining mechanisms for practical cooperation, including the sharing of data and information.

10.4 In addition, New Zealand noted that several of the recommendations from the 2010 Antarctic Treaty Meeting of Experts on Climate Change and Implications for Antarctic Management and Governance addressed cooperation between CEP and SC-CAMLR and that these matters could usefully be considered during a joint workshop.

10.5 The Scientific Committee agreed to establish a steering committee, co-convened by Drs Penhale and Grant and including the CEP and SC-CAMLR Chairs, to consult with representatives on both committees and further develop the workshop terms of reference and an agenda for initial consideration at the 2015 CEP meeting. Interested individuals from both the CEP and SC-CAMLR are invited to join the steering committee, which will report on its work intersessionally via Circulars as appropriate. The Scientific Committee agreed that, as for the first joint workshop in 2009, the proposed workshop should be open to the official observers of both committees. In particular, it was noted that SCAR's work in the area of climate change would provide valuable input to the workshop.

#### Scientific Committee for Antarctic Research

10.6 Prof. Hindell presented the annual report of SCAR activities of interest to CCAMLR (SC-CAMLR-XXXIII/BG/17). In particular, he noted that:

- (i) in the last 12 months the Expert Group on Birds and Marine Mammals (EGBAMM) has been reorganised into eight subcommittees, several of which are of particular interest to CCAMLR, such as the groups on Antarctic Wildlife Health, Remote Sensing of Animal Populations, Alien Species and the Retrospective Analysis of Antarctic Tracking Data
- (ii) the group examining retrospective tracking data on birds and mammals recently published a paper detailing areas of ecological importance for East Antarctica. A workshop scheduled for 1–5 May 2015 will be held in Cambridge, UK, to further progress this work

- (iii) the first SCAR Antarctic and Southern Ocean Science Horizon Scan identified impacts of human activities on animals and fish population as a focus for future research
- (iv) the *Southern Ocean Biogeographic Atlas* was launched in New Zealand as an end product of the Census of Marine Life. Copies of this have been made available to all Members electronically. SCAR is now working on a dynamic version of this atlas that will be continuously updated.

10.7 The Scientific Committee congratulated SCAR on the publication of the *Southern Ocean Biogeographic Atlas* and noted that many CCAMLR Members contributed content. The suggestion was put forward and endorsed that the Secretariat draw attention to this publication through the CCAMLR website, and potentially via the online CCAMLR GIS. The Scientific Committee also noted that the Secretariat is collaborating with the editors of the Atlas to establish links between the Atlas's data sets and shape files and the CCAMLR GIS. The interactions that have taken place between the Southern Ocean Observing System (SOOS) (SC-CAMLR-XXXIII/BG/17, Appendix 1) and WG-EMM were also positively noted.

Reports of observers from other international organisations

#### FAO

10.8 The Scientific Committee noted the joint report from the FAO and CCAMLR secretariats on the implementation of a project on sustainable fisheries management and biodiversity conservation of deep-sea living marine resources and ecosystems in the Areas Beyond National Jurisdiction (ABNJ) (SC-CAMLR-XXXIII/BG/36). This project is an international collaboration, led by the FAO with financial support from the Global Environment Facility (GEF), which aims to achieve sustainability in the use of deep-sea living resources and biodiversity conservation in ABNJ through the systematic application of an ecosystem approach.

10.9 CCAMLR is participating in the project through the contribution of information, background material and relevant expertise in conservation, ecosystem monitoring and management of deep-sea fisheries and VMEs (SC-CAMLR-XXXIII/BG/36, Table 1). This contribution is coordinated by the CCAMLR Secretariat and it is hoped that it will include expert contributions from CCAMLR Members and from CCAMLR Chairs and Conveners. Project outcomes, including improved sustainable management practices for deep-sea fisheries and improved approaches for protecting VMEs, may also provide new information and contributions to the work of the Scientific Committee.

10.10 The Scientific Committee noted the report on the ABNJ Deep Seas Project and, while supporting the initiative in principle, also expressed concern that there are many activities that currently involve expert opinion from CCAMLR. As the workload of the CCAMLR subgroups is currently considerable, a strategy committee to prioritise commitments was suggested. Members also expressed a desire to view and contribute to correspondence between the Secretariat and the FAO. An e-group for this purpose is currently available (ABNJ Deep Seas Project e-group), and in future a COMM CIRC will be sent to Members requesting comments before significant correspondence is undertaken.

## ARK

10.11 The Association of Responsible Krill Fishing Companies (ARK) presented its report to the Scientific Committee (SC-CAMLR-XXXIII/BG/35). It advised that it now had four members and noted that the catch in the fishery in 2013/14 was higher than in previous years, with most of the reported catch being taken by ARK members. ARK noted its support for 100% observer coverage on krill vessels and expressed concern at the low standard of some vessels in terms of hull suitability for working in ice. It suggested that the Commission help define minimum ice class standards for licensed vessels.

10.12 ARK has made great progress this year in advancing cooperation both within the industry and with scientists working within CCAMLR. It noted that its workshop in Punta Arenas, Chile, was very successful and identified a number of topics that could be addressed by scientists working in collaboration with fishing operators, including:

- (i) the issue of krill flux at all scales
- (ii) the biological condition of krill during the winter season
- (iii) standardisation and calibration of acoustic equipment on fishing vessels
- (iv) collection of oceanographic and meteorological data by fishing vessels
- (v) the impact of fishing vessels on krill aggregations.

10.13 ARK agreed to coordinate correspondence groups to investigate ways in which scientists and fishing operators can work together to come up with some practical proposals to address these issues. The aim will be to provide some concrete proposals in the form of background papers to WG-EMM and SG-ASAM in 2015.

10.14 ARK noted that many of these issues will be relevant to the development of feedback management in the krill fishery. The development of feedback management will require increased cooperation between scientists and krill fishery operators and ARK is prepared to play a constructive role in this process.

10.15 The Scientific Committee expressed thanks for the report and their support for the ARK initiative.

## COLTO

10.16 The COLTO Observer (Mr M. Exel) thanked CCAMLR for the invitation to attend meetings again this year. For the second consecutive year, COLTO sponsored a \$1 000 reward for tag returns in 2013/14 to encourage crew to return tags from toothfish, which are vital for stock assessments and improved understanding of stocks. Mr Exel, with the assistance of the CCAMLR Secretariat, was delighted to announce the winners of the CCAMLR tag-return lottery (drawn at random from all reports of recaptured toothfish in 2013/14) as follows:

- 1st prize: \$400 to *San Aspiring* (New Zealand), tag recaptured on 10 March 2014; fish released on 8 April 2012 in Subarea 48.4 and had moved only 2 km
- 2nd prize: \$350 to *Seljevaer* (Norway), tag recaptured on 13 December 2013; fish released on 2 December 2011 in Subarea 88.1 and had moved 10 km

- 3rd prize: \$250 to *San Aspiring* (New Zealand), tag recaptured on Christmas Day 2013, fish released on 26 January 2008 in Subarea 88.1 and had moved only 49 km.

10.17 COLTO congratulated the winners, and all the crew and officers who participated in the tagging program in toothfish fisheries.

## ASOC

10.18 ASOC and the krill fishing company Aker BioMarine (Aker), a member of ARK, informed the Scientific Committee that in 2013/14 an intersessional group collaborated to create a fund to support research and monitoring activities conducted by ARK members in Area 48.

10.19 This joint initiative is being organised by ASOC, the Pew Charitable Trusts, WWF and Aker. Aker has committed to providing the initial financial contributions to the fund for its first year of operation. In addition the fund will receive contributions from krill product consumers and krill consumer brand owners to ensure continuation of this work in the years to come. ASOC are finalising the legal aspects of the fund to be administered by a newly created non-governmental organisation registered in Oslo, Norway.

10.20 The selection of research and monitoring projects to be awarded money from the fund will be undertaken with the advice and guidance of a Science Advisory Group (SAG), represented by CCAMLR scientists. This will ensure transparency in the selection of projects and will fill needed gaps to bring CCAMLR closer to establishing a feedback management system for the krill fishery.

10.21 ASOC intends to announce a first call for proposals shortly after CCAMLR-XXXIII. Aker has committed US\$500 000 for the first year and will distribute an initial US\$250 000 in the first call. A second call will be announced in due course.

10.22 Once completed, ASOC will share the call for proposals with the Secretariat to ensure appropriate dissemination of this information.

10.23 The Scientific Committee thanked ASOC and Aker for developing this initiative and agreed it is a good step forward in improving collaboration between industry, non-governmental organisations (NGOs) and scientists.

## Reports from observers at meetings of other international organisations

### IWC

10.24 Dr Currey presented the CCAMLR Observer's Report (SC-CAMLR-XXXIII/BG/22) on the 66th Meeting of the Scientific Committee of the IWC, held in Bled, Slovenia, 12 to 24 May 2014, under the chairmanship of Dr T. Kitakado (Japan). The report summarises the main topics including information on Southern Ocean cetaceans of relevance to CCAMLR. The IWC Scientific Committee thanked Dr Kock for his service as Observer to SC-CAMLR

and made two observer appointments. Dr Watters was appointed to represent the IWC Scientific Committee's Working Group on Ecosystem Modelling at WG-EMM. Dr Currey was appointed to represent the IWC Scientific Committee at SC-CAMLR.

10.25 A proposal for a two-day Joint IWC–CCAMLR Workshop, to be convened in advance of the 2016 SC-IWC meeting, was also detailed. The workshop will focus on the development and application of multi-species models of the Antarctic marine ecosystem, which would be of relevance to the provision of scientific advice which addresses the objectives of both commissions. A budget request was put forward to cover the cost of attendance of SC-IWC-invited participant(s) and this was approved at the recent meeting of the IWC in Protoroz, Slovenia, in September 2014. The SC-IWC requested Dr Currey liaise with an equivalent group from SC-CAMLR, with a view to establishing a joint steering group for the workshop.

10.26 The Scientific Committee endorsed the formation of a steering group to progress a Joint IWC–CCAMLR Workshop. A preliminary list of members was drawn up consisting of Drs Ichii, Kawaguchi, Prof. Kovacs, Drs Trathan and Watters, with Dr Kawaguchi volunteered as the convener of this steering group. It was suggested that the CCAMLR Secretariat could begin liaising with the IWC Secretariat, noting that the workshop was proposed to take place in advance of the SC-IWC meeting in 2016; the IWC Secretariat would thus probably be primarily responsible for the arrangements for this workshop. Should subsequent workshops be proposed, the next could occur in advance of a CCAMLR meeting to share workshop organising responsibilities.

#### Krill stakeholder workshop

10.27 The Scientific Committee welcomed the report of a two-day workshop hosted by BAS, ICED and WWF in June 2014 (SC-CAMLR-XXXIII/BG/34) entitled 'Understanding the Objectives of krill fishing and conservation in the Scotia Sea and Antarctic Peninsula region'. The workshop was attended by 22 participants from science organisations, krill fishing industry and conservation NGOs. The organisers of the workshop agreed that it revealed a cooperative and productive relationship between the three sectors and the outcomes of the workshop included:

- (i) shared cross-sector commitment to maintaining a healthy ecosystem and support for management of the krill fishery that minimises the risk of negative impacts on ecosystem health
- (ii) general agreement that current levels of fishing have a low risk of significant impacts but that there is no need to increase catch limits
- (iii) the need to improve availability of clear information to improve cross-sector understanding of the state of the ecosystem, the current management approach for the krill fishery and the CCAMLR decision-making process
- (iv) the need to formulate a research and development strategy to support progress in the management of the krill fishery
- (v) the need to enhance CCAMLR working practices including broader participation to support progress in the management of the krill fishery.

10.28 The Scientific Committee welcomed the outcomes of the workshop and endorsed the recommendation by WG-EMM (Annex 6, paragraph 5.13) of the development of a set of FAQs on krill to be posted on the CCAMLR website.

#### Future cooperation

10.29 SC-CAMLR-XXXIII/BG/16 detailed meetings of potential relevance to the Scientific Committee. Members were encouraged to review these.

10.30 SC-CAMLR-XXXIII/BG/37 detailed a draft proposal for GEF funding, provided by South Africa, to support capacity building and training for GEF-eligible CCAMLR Members. The Scientific Committee welcomed the suggestion that the Secretariat take on the role of project development for this proposal and encouraged other Members to investigate GEF funding options in this paper.

#### **Forecast Budget for 2015**

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 also agreed to one scientific scholarship of up to A\$20 000 over two years under the General Science Capacity Fund.

#### **Advice to SCIC and SCAF**

12.1 On behalf of the Scientific Committee, the Chair transmitted the Scientific Committee's advice to SCIC and SCAF. The advice to SCAF is summarised in Item 11. The advice to SCIC was derived from the Scientific Committee's consideration of quarantined data (paragraphs 3.66 to 3.71), tag-overlap statistics (paragraphs 3.79 to 3.83) and fishing capacity (paragraphs 2.10 and 3.152) and the release of untagged toothfish in exploratory fisheries (Annex 7, paragraph 5.42).

#### **Scientific Committee activities**

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

13.1 The Scientific Committee recognised the need to determine a mechanism to develop a multiyear work plan, in order to set both short- and long-term priorities for the work of the Committee and its working groups. An important component of this prioritisation process should be to draw the attention of the Commission to the difficulties the Scientific Committee faces on providing advice on a wide range of issues each year. The Scientific Committee requested the Commission consider what advice was required on how frequently that advice should be updated.

13.2 The Convener of WG-EMM noted that while there were a range of important issues being considered by that Working Group, the current priority is based around the staged approach to developing feedback management in the krill fishery.

13.3 In order to make the work conducted in the meetings of the Scientific Committee and the working groups more efficient, the Scientific Committee Chair requested that papers submitted for consideration are directed towards specific issues with associated agenda items. He also requested that Members consider whether there was a need to change the structure of the agenda and how the Scientific Committee undertook its work.

13.4 The Scientific Committee encouraged Members to consider potential ways in which its work could be streamlined and to submit papers on the subject for consideration by the working groups. In addition, the Scientific Committee Chair agreed to work with the Secretariat to compile an inventory of future work proposed by the working groups and to work with working group conveners to prepare an SC CIRC setting out the options for the future work program.

13.5 The Scientific Committee noted that it would be desirable to have a standard format for summarising the commitments by proponents of research fishing proposals and how they relate to the advice from the Scientific Committee to the Commission, following their review and endorsement. It requested advice from the Commission on the types of information that they would wish to see summarised on which they could base their endorsement and subsequent review of these activities.

#### Intersessional activities

13.6 The Scientific Committee warmly welcomed the offer from the Republic of Korea and Poland to host the working group meetings in 2015 and agreed to the following meetings in 2015:

- (i) SG-ASAM (Busan, Republic of Korea, March 2015) (Convener: Dr Zhao)
- (ii) WG-SAM (Warsaw, Poland, date to be confirmed) (Convener: Dr Parker)
- (iii) WG-EMM (Warsaw, Poland, date will be confirmed on Monday of next week) (Convener: Dr Kawaguchi)
- (iv) WG-FSA (CCAMLR Headquarters, Hobart, Australia, 5 to 16 October 2015) (Convener: Dr Belchier).

#### CCAMLR Scientific Scholarship Scheme

13.7 The Chair of the scholarship review panel (Dr Arata) noted that since its inception in 2011 there have been four scholarships awarded:

- (i) The first scholarship recipient (in 2012/13), Rodrigo Wiff from Chile, participated for two years in WG-SAM and WG-FSA, contributing to analysis of

data-poor fisheries. Notably, in conjunction with this participation, Chile sent a second researcher, who is now studying for his PhD in Tasmania and will continue to contribute to future work of WG-FSA.

- (ii) The second recipient (2013/14), Mercedes Santos from Argentina, not only signalled the return of Argentina to the work of WG-EMM but also is currently co-investigator in the project supported by the CEMP Special Fund.
- (iii) The third scholarship (2013/14), Xinliang Wang from China, has been a very active participant in the work of SG-ASAM and WG-EMM, developing significant advances in the use of acoustic data from fishing vessels for the direct assessment of krill, developing new methods and implementing ideas developed in SG-ASAM.
- (iv) The most recent recipient (2014/15), Anna Panasiuk-Chodnicka from Poland, coincided with Poland joining the CEMP program and also participating in a project supported by the CEMP Special Fund to work on improving the monitoring of penguin colonies in support of CEMP.
- (v) Each scholarship granted has meant not only an individual contribution to the working groups, but an integral involvement of the country's recipient of the scholarship in the activity of the working groups of the Scientific Committee.

13.8 The Scientific Committee agreed that the science scholarship scheme was creating very positive outcomes and expressed its appreciation for the work of the recipients and the review panel.

13.9 Lic Santos extended her thanks for the opportunity provided by the Scholarship scheme to contribute to CCAMLR and expressed her thanks to the Secretariat and to all of the participants of WG-EMM and looked forward to making an ongoing contribution to the CCAMLR working groups. In particular she thanked her mentors Dr Barrera-Oro and J. Hinke (USA). Dr Barrera-Oro noted his great satisfaction in seeing the objectives and spirit of the scholarship being fulfilled and that the scheme had been so successful in achieving its objective of capacity development and hoped that this would be exemplified by Lic Santos's ongoing contribution to CCAMLR.

13.10 This year, two applications for the scholarship scheme from one Member were reviewed by a Scholarship Review Panel chaired by the Senior Vice-Chair (Dr Arata) and included the Scientific Committee Vice-Chair (Dr Welsford), conveners of the working groups (Drs Kawaguchi, Belchier and Hanchet), experienced members of the Scientific Committee (Drs Barrera-Oro and M. Vacchi (Italy)) and the Science Manager (Dr Reid).

13.11 The applications were rated by panel members according to the following five criteria:

- (i) scientific and other qualifications of the applicant
- (ii) relevance of the scientific background and proposed area of research to the work priorities and work plan of the Scientific Committee
- (iii) once selected, the extent to which it will strengthen the scientific capacity and engagement in the work of the Scientific Committee of the applying Member

- (iv) strength of the linkages of the mentor scientist(s) and the applicant
- (v) justification for the budget requested.

13.12 After careful consideration of both applications, the review panel awarded this year's CCAMLR scientific scholarship of up to of A\$20 000 over two years to Aleksandr Sytov, who will work on the relationship between environmental variables and the spatial-temporal dynamics of krill catch and effort. Aleksandr will have the support of Dr Kasatkina as mentor, who is a researcher with extensive experience of WG-EMM. The Scientific Committee congratulated Aleksandr and noted that he will also receive the support of the international community in the same way that all scholarship recipients have.

13.13 Dr Petrov thanked the CCAMLR Scholarship Review Panel for the award of this scholarship and noted his happiness that young Russian scientists will become a part of the work of the Scientific Committee and, like the previous recipients, that they will make contributions to CCAMLR data and match the high level and requirements that the Scientific Committee and Commission set.

13.14 In noting the small number of applications for the scholarship scheme this year, the Scientific Committee encouraged all Scientific Committee representatives to consider whether the scholarship offered a potential mechanism to enhance their engagement in the working groups.

#### Invitation of experts and observers

13.15 The Scientific Committee agreed that all Observers invited to the 2014 meeting would be invited to participate in SC-CAMLR-XXXIV.

#### Invitation of experts to the meetings of working groups

13.16 The Scientific Committee thanked the Scientific Committee Chair for the preparation of a discussion paper (SC-CAMLR-XXXII/09) on how to resolve issues surrounding the invitation of experts to the meetings of working groups and recommended that this paper be considered by all of the Working Groups and their comments be considered by the Scientific Committee in 2015.

#### Next meeting

13.17 The next meeting of the Scientific Committee will be held from 19 to 23 October 2015.

## **Secretariat-supported activities**

14.1 The Scientific Committee noted SC-CAMLR-XXIII/10 on the accessibility, availability and publication of papers submitted to the Scientific Committee and its working groups. The Secretariat noted that this paper, which had incorporated comments through the working groups, presents a proposal for making the science within CCAMLR more accessible in response to the greater visibility of the work of CCAMLR created by the searchable index of working group papers on the CCAMLR website. The Scientific Committee agreed that the revised paper should be considered by the working groups and considered more substantially by the Scientific Committee next year.

### External review of assessments

14.2 The Scientific Committee did not have the time to discuss the issue of an external review of assessments but endorsed the advice that had been provided by WG-FSA-14 (Annex 7, paragraph 10.4) and WG-SAM-14 (Annex 5, paragraphs 2.31 to 2.33).

## **Election of Vice-Chair**

15.1 Dr Arata's term as Vice-Chair ended with this meeting and the Scientific Committee sought nominations for a new Vice-Chair. Dr Welsford nominated Dr Grant and this nomination was seconded by Dr Watters. Dr Grant was unanimously elected to the position for a term of two regular meetings (2015 and 2016). A very warm welcome was extended to the incoming Vice-Chair who thanked the Committee for this honour.

15.2 The Scientific Committee Chair thanked Dr Arata for his excellent support as Vice-Chair over the last two years and in dealing with the CCAMLR Scientific Scholarship Scheme.

## **Other business**

### ICES Symposium on acoustics

16.1 Dr Zhao informed the Scientific Committee that the 7th ICES-sponsored Symposium on 'Marine Ecosystem Acoustics (Some Acoustics) – observing the ocean interior in support of integrated management' will be held in Nantes, France, from 25 to 28 May 2015. The deadline for abstract submission is 19 December 2014 (further details <http://someacoustics.sciencesconf.org>).

## **Adoption of the report**

17.1 The report of the Thirty-third 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 open and detailed engagement in this meeting and the intersessional work of the Scientific Committee. He also thanked the conveners of SG-ASAM, WG-EMM, WG-FSA and WG-SAM, subgroup coordinators and rapporteurs for their excellent work and the Secretariat for its extensive support. The Scientific Committee undertook a huge amount of work in 2014 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 Zhao, on behalf of the Scientific Committee, thanked the outgoing vice-chair, Dr Arata, for his excellent support over the past two years.

18.3 On behalf of the Scientific Committee, Dr Constable congratulated Dr Jones for his outstanding role in guiding the Scientific Committee through a large number of complex issues, and his gentle and patient chairing of this meeting.

18.4 The Scientific Committee also thanked the Secretariat for the new, web-based system which facilitated the development of report text and related work (paragraph 1.5). The system worked successfully during the meeting and allowed participants to efficiently contribute text during the meeting and at adoption. The Scientific Committee encouraged the continued development of this system.

## **References**

Dunn, M., J. Silk and P. Trathan. 2011. Post-breeding dispersal of Adélie penguins (*Pygoscelis adeliae*) nesting at Signy Island, South Orkney Islands. *Polar Biol.*, 34: 205–214.

Table 1: Seabird mitigation requirements in CCAMLR longline fisheries conservation measures.

Conservation measure	Management area	Mitigation requirement
41-02	Subarea 48.3	Night setting only
41-03	Subarea 48.4	CM25-02, paragraph 5 exemption CM 24-02 and 3 bird limit
41-04	Subarea 48.6	CM25-02, paragraph 5 exemption CM 24-02 and 3 bird limit
41-05	Division 58.4.2	CM25-02, paragraph 5 exemption CM 24-02 and 3 bird limit
41-06	Division 58.4.3a	CM25-02, paragraph 5 exemption CM 24-02 and 3 bird limit*
41-07	Division 58.4.3b	CM25-02, paragraph 5 exemption CM 24-02 and 3 bird limit*
41-08	Division 58.5.2	CM25-02, paragraph 5 exemption CM 24-02 and 3 bird limit*
41-09	Subarea 88.1	CM25-02, paragraph 5 exemption CM 24-02 and 3 bird limit
41-10	Subarea 88.2	CM25-02, paragraph 5 exemption CM 24-02 and 3 bird limit
41-11	Division 58.4.1	CM25-02, paragraph 5 exemption CM 24-02 and 3 bird limit

\* Also linked to a seasonal closure exemption.

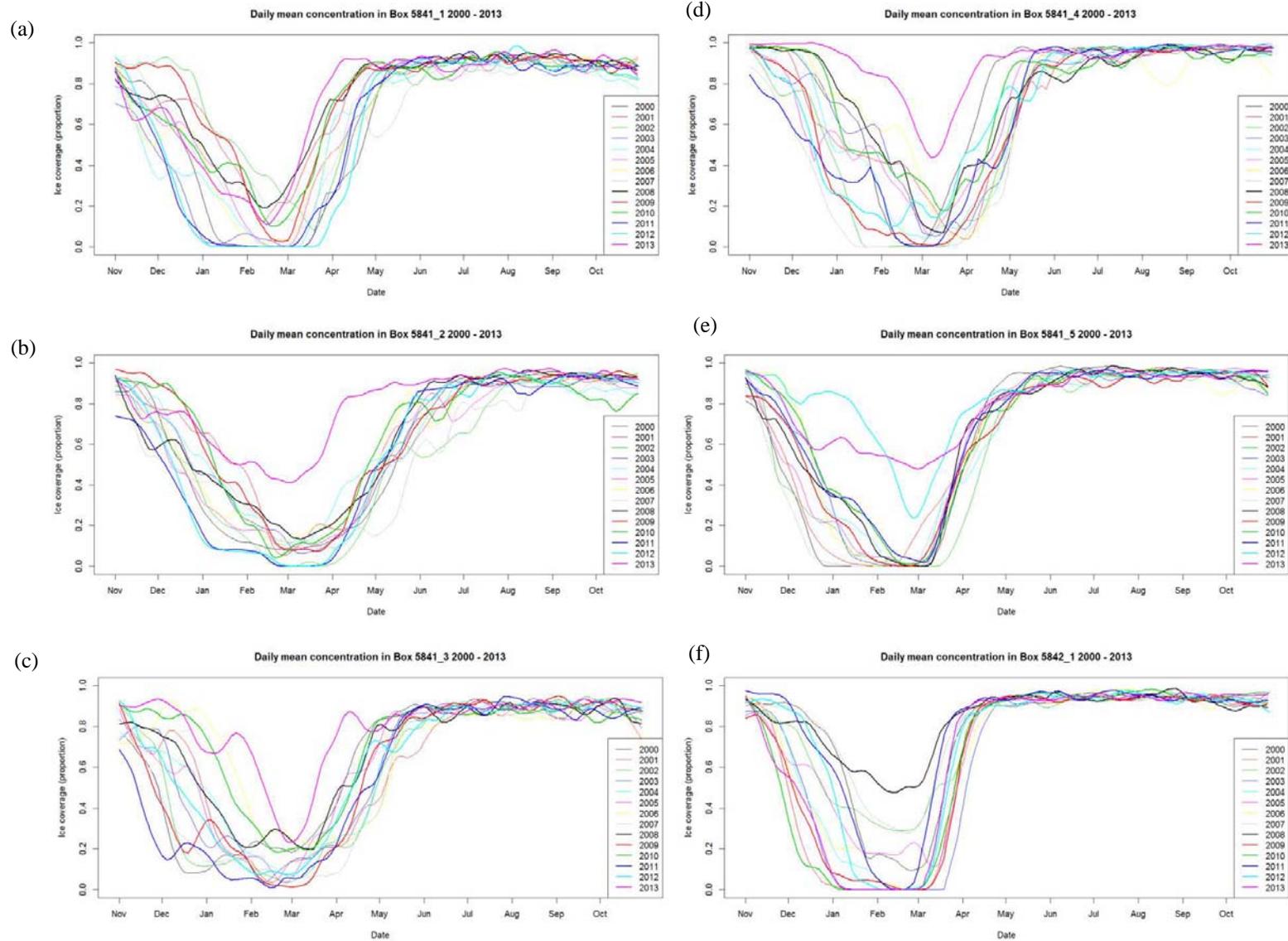


Figure 1: Daily mean sea-ice concentration within research blocks in (a)–(e) Division 58.4.1, (f) Division 58.4.2 (based on analysis presented in WG-FSA-14/54 in which an area was considered fishable when sea-ice concentration was less than 60%).

(continued)

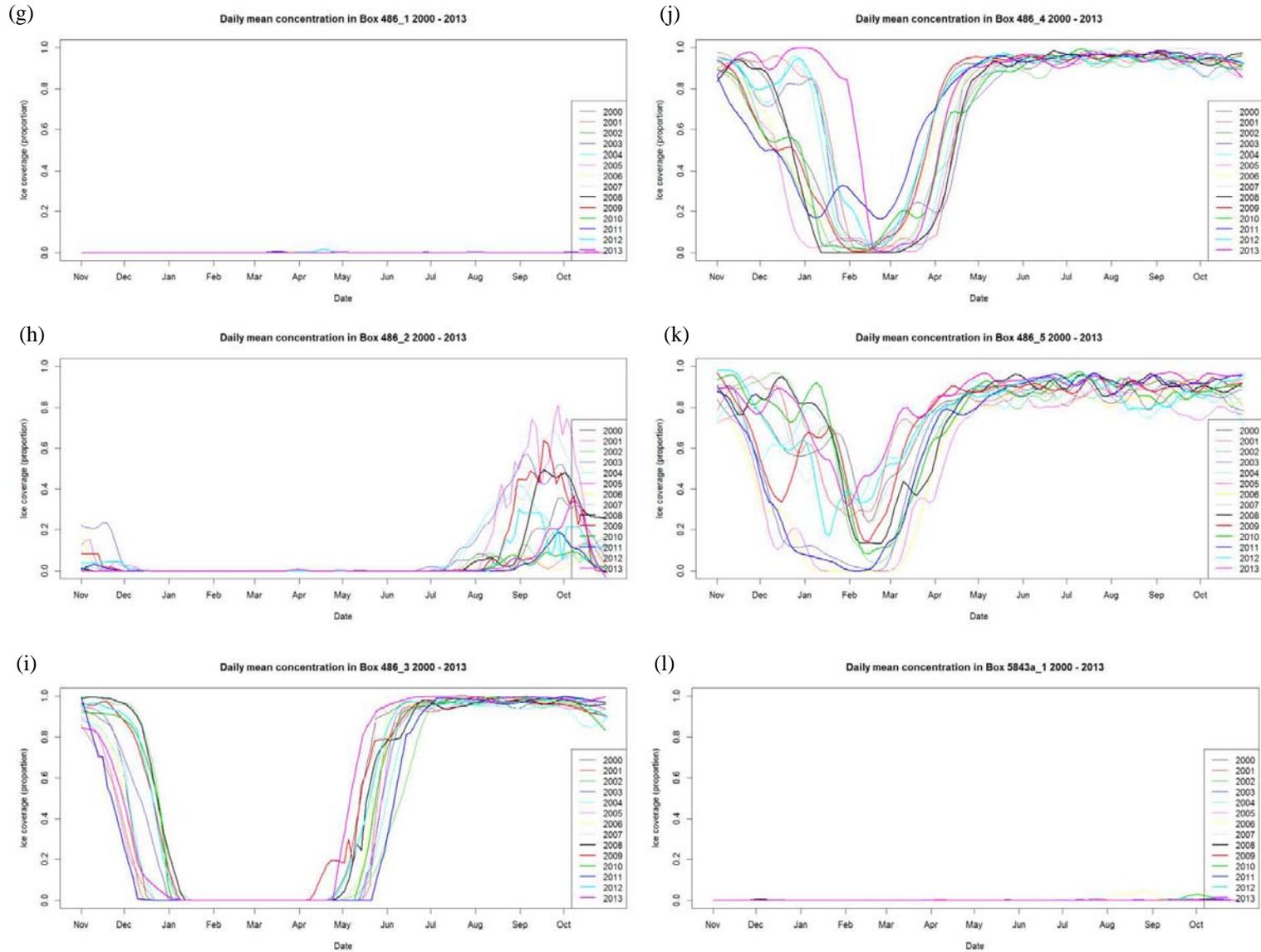


Figure 1 (continued): Daily mean sea-ice concentration within research blocks in (g)–(k) Subarea 48.6, (l) Division 58.4.3a (based on analysis presented in WG-FSA-14/54 in which an area was considered fishable when sea-ice concentration was less than 60%).

(continued)

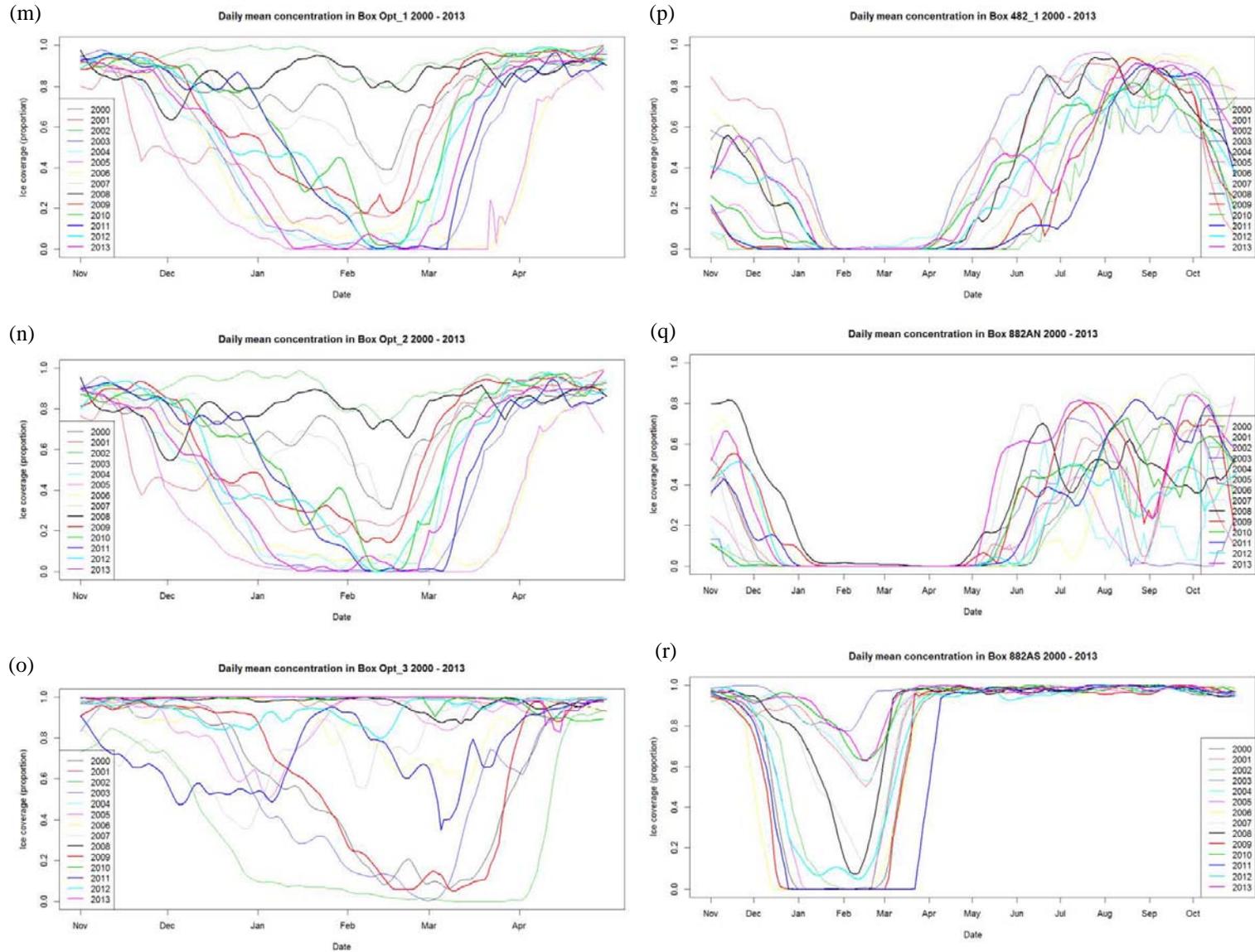


Figure 1 (continued): Daily mean sea-ice concentration within research blocks in (m)–(o) Subarea 48.5, (p) Subarea 48.2, (q)–(r) Subarea 88.2 SSRU A (based on analysis presented in WG-FSA-14/54 in which an area was considered fishable when sea-ice concentration was less than 60%).

(continued)

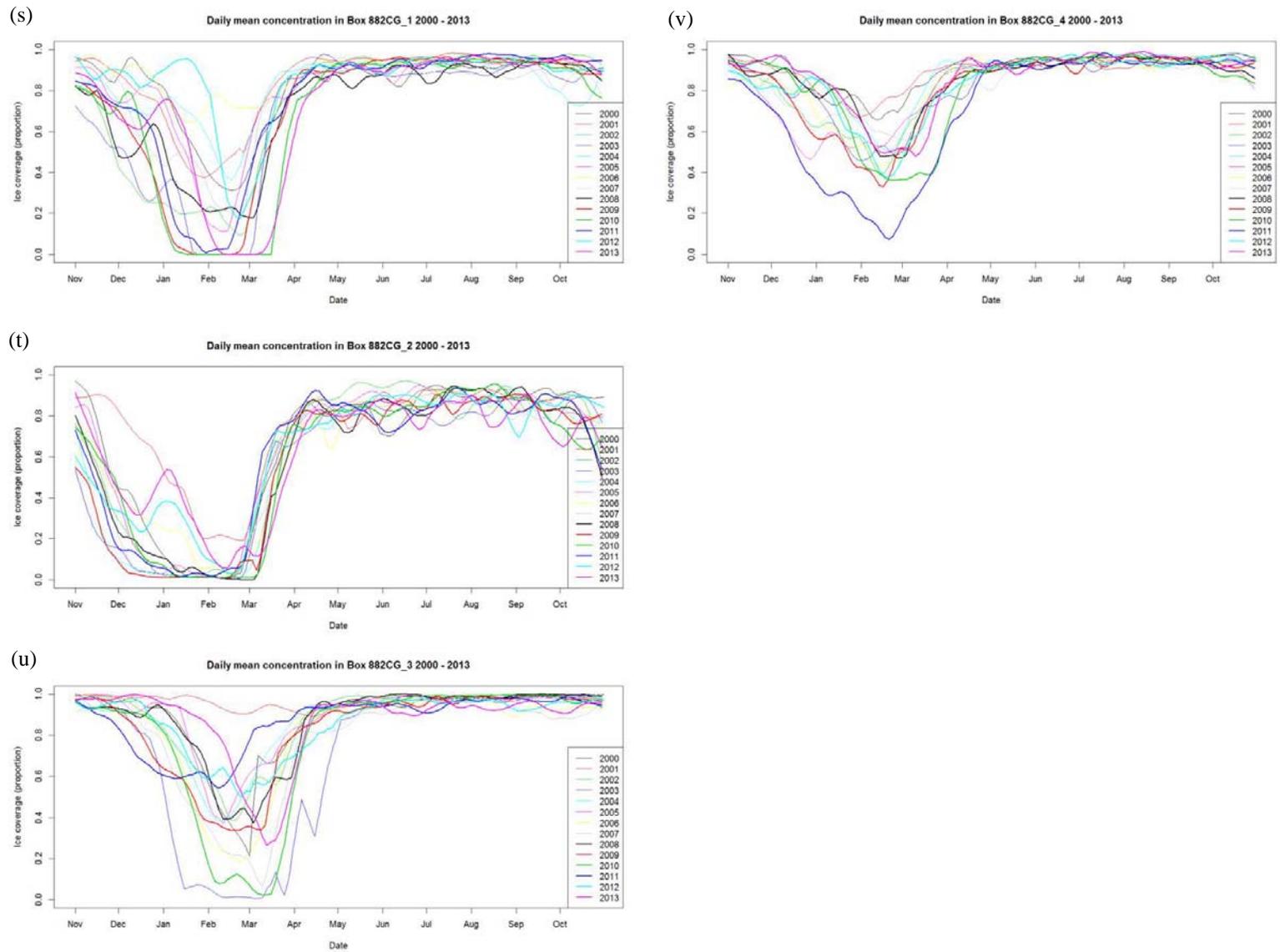


Figure 1 (continued): Daily mean sea-ice concentration within research blocks in (s)–(v) Subarea 88.2 SSRUs C–G (based on analysis presented in WG-FSA-14/54 in which an area was considered fishable when sea-ice concentration was less than 60%).

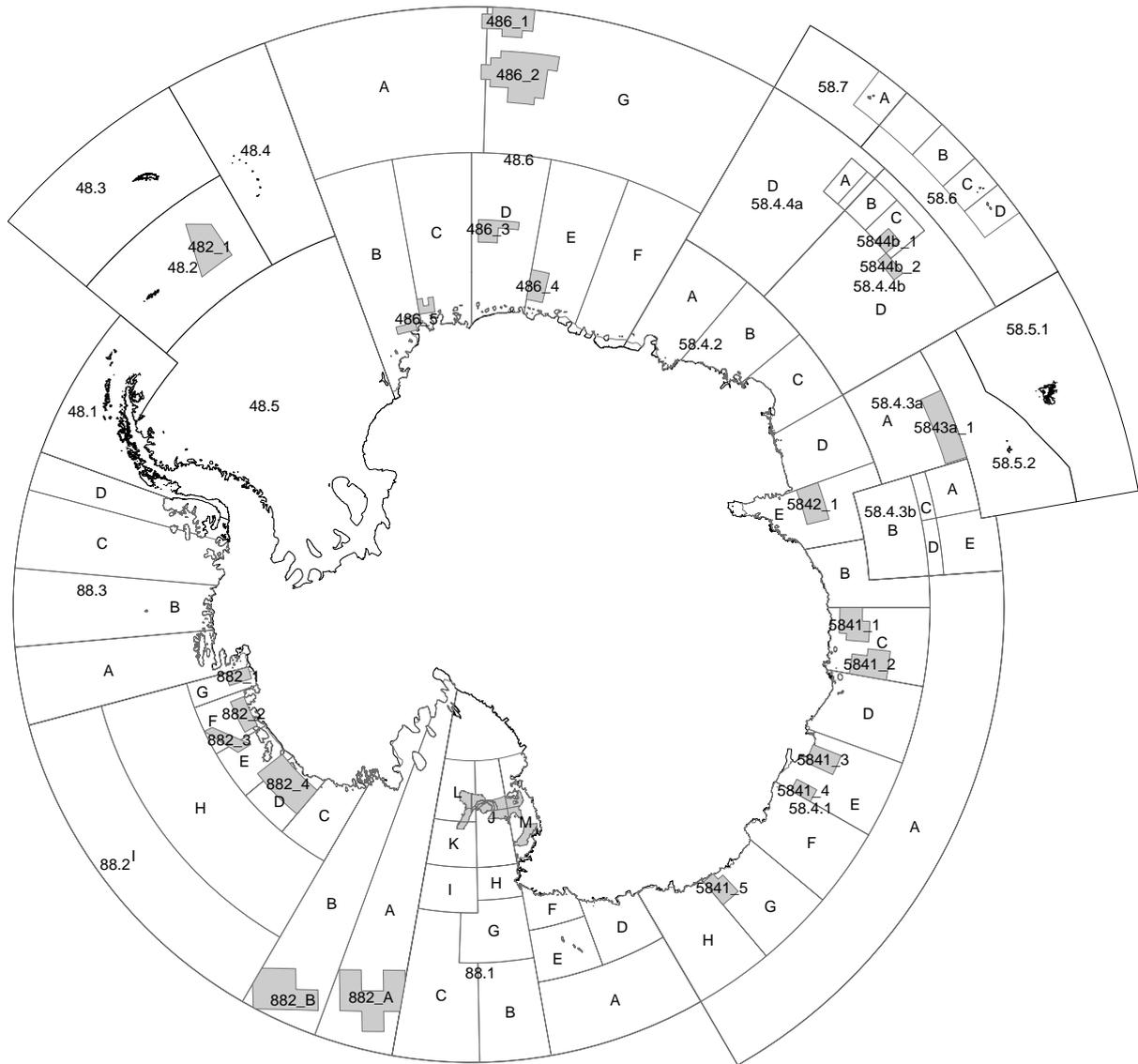


Figure 2: Location of research blocks where research fishing is proposed in exploratory fisheries for *Dissostichus* spp. and closed areas in 2014/15. The exploratory fisheries are located in Subareas 48.6, 88.1 and 88.2 and Divisions 58.4.1, 58.4.2 and 58.4.3a. The boundaries of small-scale research units (SSRUs) are also shown.

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**List of documents**



## **List of documents**

SC-CAMLR-XXXIII/01	The South Orkney Islands Southern Shelf Marine Protected Area – SOISS MPA Delegation of Russia
SC-CAMLR-XXXIII/02	Designation of an MPA in East Antarctica Delegation of Russia
SC-CAMLR-XXXIII/03	Report of the Working Group on Ecosystem Monitoring and Management (Punta Arenas, Chile, 7 to 18 July 2014)
SC-CAMLR-XXXIII/04	Report of the Working Group on Fish Stock Assessment (Hobart, Australia, 6 to 17 October 2014)
SC-CAMLR-XXXIII/05	Report of the Working Group on Statistics, Assessments and Modelling (Punta Arenas, Chile, 30 June to 4 July 2014)
SC-CAMLR-XXXIII/06	Report of the Meeting of the Subgroup on Acoustic Survey and Analysis Methods (Qingdao, People’s Republic of China, 8 to 11 April 2014)
SC-CAMLR-XXXIII/07	Comments and suggestions for the development of a feedback management system for the krill fishery Delegation of the Russian Federation
SC-CAMLR-XXXIII/08	Progress report on the scientific basis in support of the development of a CCAMLR MPA in the Weddell Sea (Antarctica) Delegation of Germany
SC-CAMLR-XXXIII/09	Assignment of research catch limits for effort-limited research proposals in fisheries with pre-existing non-zero catch limits Delegation of New Zealand
SC-CAMLR-XXXIII/10	Update on the CCAMLR observer training program accreditation scheme (COTPAS) Secretariat
SC-CAMLR-XXXIII/11	Research and monitoring plan for the South Orkney Islands southern shelf marine protected area (MPA Planning Domain 1, Subarea 48.2) Delegation of the European Union

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- SC-CAMLR-XXXIII/BG/01 Catches in the Convention Area  
2012/13 and 2013/14  
Secretariat
- SC-CAMLR-XXXIII/BG/02 Scientific background document in support of the  
development of a CCAMLR MPA in the Weddell Sea  
(Antarctica) – Version 2014  
Delegation of Germany
- SC-CAMLR-XXXIII/BG/03 Preliminary assessment of the potential for proposed  
bottom-fishing activities to have significant adverse impacts  
on vulnerable marine ecosystems  
Delegation of Australia
- SC-CAMLR-XXXIII/BG/04 Preliminary assessment of the potential for proposed  
bottom-fishing activities to have significant adverse impacts  
on vulnerable marine ecosystems  
Delegation of Japan
- SC-CAMLR-XXXIII/BG/05 Preliminary assessment of the potential for proposed  
bottom-fishing activities to have significant adverse impacts  
on vulnerable marine ecosystems  
Delegation of the Republic of Korea
- SC-CAMLR-XXXIII/BG/06 Preliminary assessment of the potential for proposed  
bottom-fishing activities to have significant adverse impacts  
on vulnerable marine ecosystems  
Delegation of New Zealand
- SC-CAMLR-XXXIII/BG/07 Preliminary assessment of the potential for proposed  
bottom-fishing activities to have significant adverse impacts  
on vulnerable marine ecosystems  
Delegation of Norway
- SC-CAMLR-XXXIII/BG/08 Preliminary assessment of the potential for proposed  
bottom-fishing activities to have significant adverse impacts  
on vulnerable marine ecosystems  
Delegation of Russia
- SC-CAMLR-XXXIII/BG/09 Preliminary assessment of the potential for proposed  
bottom-fishing activities to have significant adverse impacts  
on vulnerable marine ecosystems  
Delegation of South Africa

SC-CAMLR-XXXIII/BG/10	Preliminary assessment of the potential for proposed bottom-fishing activities to have significant adverse impacts on vulnerable marine ecosystems Delegation of Spain
SC-CAMLR-XXXIII/BG/11	Preliminary assessments of the potential for proposed bottom-fishing activities to have significant adverse impacts on vulnerable marine ecosystems Delegation of Ukraine
SC-CAMLR-XXXIII/BG/12	Preliminary assessment of the potential for proposed bottom-fishing activities to have significant adverse impacts on vulnerable marine ecosystems Delegation of the United Kingdom
SC-CAMLR-XXXIII/BG/13	Committee for Environmental Protection: 2014 Annual Report to the Scientific Committee of CCAMLR CEP Observer to SC-CAMLR (Dr P. Penhale, USA)
SC-CAMLR-XXXIII/BG/14	Net diagrams and MED of CM 21-03 for Korean krill fishing vessels Delegation of the Republic of Korea
SC-CAMLR-XXXIII/BG/15	APIS II: A new circumpolar assessment of the status and trends of Antarctic pack-ice seals based on satellite remote sensing Submitted by SCAR
SC-CAMLR-XXXIII/BG/16	Calendar of meetings of relevance to the Scientific Committee in 2014/15 Secretariat
SC-CAMLR-XXXIII/BG/17	The Scientific Committee on Antarctic Research (SCAR) Annual Report 2013/14 Submitted by SCAR
SC-CAMLR-XXXIII/BG/18	On development of centralised preparation and accreditation scheme for scientific observers and CCAMLR Member countries Delegation of the Russian Federation
SC-CAMLR-XXXIII/BG/19	MPA Report for the South Orkney Islands southern shelf (MPA Planning Domain 1, Subarea 48.2) Delegation of the European Union
SC-CAMLR-XXXIII/BG/20	Invitation to the Second CCAMLR Technical Workshop on the Development of MPAs in Domain 1 Delegations of Argentina and Chile

- SC-CAMLR-XXXIII/BG/21 ARK Workshop for Krill Fishery Representatives and the Scientific Community to Share Information on Krill (5 and 6 July 2014, Punta Arenas, Chile)  
Submitted by ARK
- SC-CAMLR-XXXIII/BG/22 Observer's Report for the 2014 Annual Meeting of the Scientific Committee of the International Whaling Commission (Bled, Slovenia, 12 to 24 May 2014)  
CCAMLR Observer (R. Currey, New Zealand)
- SC-CAMLR-XXXIII/BG/23 Rev. 1 Chronology of previously submitted scientific documents, and updated maps and analyses supporting MPA planning in the Ross Sea region  
Delegations of New Zealand and the USA
- SC-CAMLR-XXXIII/BG/24 New research consistent with a proposed draft Research and Monitoring Plan for a Ross Sea region MPA  
Delegations of New Zealand and the USA
- SC-CAMLR-XXXIII/BG/25 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  
Delegation of Russia
- SC-CAMLR-XXXIII/BG/26 The designation of Marine Protected Areas (MPAs) in Antarctic waters  
Delegation of Russia
- SC-CAMLR-XXXIII/BG/27 Proposal by the Russian Federation to open areas of special scientific interest in the CCAMLR Convention Area (Part 1, Ross Sea and East Antarctica)  
Delegation of Russia
- SC-CAMLR-XXXIII/BG/28 MPAs in the area regulated by the Convention on the Conservation of Antarctic Marine Living Resources (background, plans and reality)  
Delegation of Russia
- SC-CAMLR-XXXIII/BG/29 Is it necessary to establish MPAs in Divisions 58.4.1 and 58.4.2 to protect krill resources from the impact of fishing?  
Delegation of Russia
- SC-CAMLR-XXXIII/BG/30 Rev. 1 Management arrangements in place for Statistical Division 58.5.2 – Heard Island and McDonald Islands  
Delegation of Australia

- SC-CAMLR-XXXIII/BG/31 Marine debris and entanglements at Bird Island and King Edward Point, South Georgia, Signy Island, South Orkneys and Goudier Island, Antarctic Peninsula 2013–2014  
Delegation of the United Kingdom
- SC-CAMLR-XXXIII/BG/32 Spatial distribution of krill fishery in Subarea 48.1:  
Implication for future surveys  
Delegation of the People’s Republic of China
- SC-CAMLR-XXXIII/BG/33 Rev. 1 Plans for a new international effort on the ecological assessment of interactions between krill and land-based predators in Area 48  
Delegations of the United Kingdom, Norway and the USA
- SC-CAMLR-XXXIII/BG/34 Bridging the krill divide: understanding cross-sector objectives for krill fishing and conservation  
Report of an ICED-BAS-WWF workshop on Understanding the Objectives for Krill Fishing and Conservation in the Scotia Sea and Antarctic Peninsula Region held at WWF’s Living Planet Centre, Woking, UK, 9th and 10th June 2014  
United Kingdom, Norway, Chile, ASOC and ARK
- SC-CAMLR-XXXIII/BG/35 Report to the Scientific Committee of CCAMLR by the Association of Responsible Krill Fishing Companies (ARK)  
Submitted by ARK
- SC-CAMLR-XXXIII/BG/36 Update on the ABNJ Deep Seas Project  
Submitted by the FAO and CCAMLR Secretariats
- SC-CAMLR-XXXIII/BG/37 Rev. 1 Proposal for GEF (Global Environment Facility) funding to support capacity building and training to the GEF-eligible CCAMLR Members  
Delegation of South Africa
- SC-CAMLR-XXXIII/BG/38 East Antarctica Planning Domain MPA Planning Reference Document #1: Draft MPA Report Part 1 – the Planning Domain and Candidate MPAs  
Delegations of Australia and France
- SC-CAMLR-XXXIII/BG/39 East Antarctica Planning Domain MPA Planning Reference Document #2: Draft MPA Report Part 2 – Descriptions of the proposed EARSMPA, the four highlighted MPAs and Activities in the Planning Domain  
Delegations of Australia and France

SC-CAMLR-XXXIII/BG/40 East Antarctica Planning Domain MPA Planning Reference Document #3: Draft MPA Report Part 3 – Research and Monitoring (update of SC-CAMLR-IM-I/BG/01) Delegations of Australia, France and the European Union

SC-CAMLR-XXXIII/BG/41 Relative densities of early Euphausiid larvae in the Weddell-Scotia Confluence  
Delegation of Argentina

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CCAMLR-XXXIII/01 Rev. 1 CCAMLR VMS data and search and rescue in the CAMLR Convention Area  
Secretariat

CCAMLR-XXXIII/02 Vacant

CCAMLR-XXXIII/03 Examination of the audited financial statements for 2013  
Executive Secretary

CCAMLR-XXXIII/04 Review of the 2014 budget, draft 2015 budget and forecast budget for 2016  
Executive Secretary

CCAMLR-XXXIII/05 A Review of CCAMLR's Translation Services:  
Summary of the ICG-SF Report  
Intersessional Correspondence Group – Sustainable Finance

CCAMLR-XXXIII/06 Executive Secretary's Report – 2014, including Third-Year Implementation Report for the Secretariat's Strategic Plan (2012–2014) and Third-Year Implementation Report for the Staffing and Salary Strategy (2012–2014)  
Executive Secretary

CCAMLR-XXXIII/07 IUU fishing in the CAMLR Convention Area: a new initiative to assess IUU fishing vessel presence  
Delegation of France and the CCAMLR Secretariat

CCAMLR-XXXIII/08 Rev. 1 Summary CCAMLR Compliance Report  
Secretariat

CCAMLR-XXXIII/09 Rev. 1 Independent Review of CCAMLR's Catch Documentation Scheme (CDS)  
CDS Review Panel

CCAMLR-XXXIII/10 Follow-up to the 2008 Performance Review  
Secretariat

CCAMLR-XXXIII/11	Summary of action (2010–2014) and options for future work Intersessional Correspondence Group – Sustainable Finance
CCAMLR-XXXIII/12 Rev. 2	Guiding Principles supporting sound management of CCAMLR finances Intersessional Correspondence Group – Sustainable Finance
CCAMLR-XXXIII/13	CCAMLR Secretariat Draft Strategic Plan (2015–2018) and associated Staffing and Salary Strategy Secretariat
CCAMLR-XXXIII/14 Rev. 1	CCAMLR’s Vessel Monitoring System (VMS) Request for Tender (RFT) VMS Technical Working Group
CCAMLR-XXXIII/15 Rev. 3	Implementation of Conservation Measures 10-06 and 10-07 CCAMLR IUU Vessel Lists Secretariat
CCAMLR-XXXIII/16	Proposed amendments to the CM51-06 on increase observer coverage in the krill fishery Delegation of Ukraine
CCAMLR-XXXIII/17	CCAMLR Symposium 2015 Delegations of Australia, Chile and the USA
CCAMLR-XXXIII/18	Modification of Conservation Measure 51-06 proposed in order to increase scientific observation coverage in krill fisheries Delegation of Chile
CCAMLR-XXXIII/19	Observations relating to IUU fishing in CCAMLR Area 58 and in the French EEZs around the Kerguelen and Crozet Islands for the 2013/2014 season and Summary of these observations over the decade 2004–2014 Delegation of France
CCAMLR-XXXIII/20	Prohibition of finning of sharks caught in the CAMLR Convention Area Delegations of Brazil, Chile, European Union and the USA
CCAMLR-XXXIII/21	A proposal for the establishment of a Ross Sea Region Marine Protected Area Delegations of New Zealand and the USA
CCAMLR-XXXIII/22	Statistical Subareas 88.1 and 88.2 exploratory toothfish fisheries: season start date change Delegation of New Zealand

CCAMLR-XXXIII/23	Proposal for a conservation measure establishing the East Antarctic Representative System of Marine Protected Areas Delegations of Australia, France and the European Union
CCAMLR-XXXIII/24	Review of the South Orkney Islands Southern Shelf MPA (MPA Planning Domain 1, Subarea 48.2) Delegation of the European Union
CCAMLR-XXXIII/25 Rev. 1	The holding of intersessional discussions between CCAMLR-XXXIII and CCAMLR-XXXIV on the adoption of trade-related measures by CCAMLR in order to promote compliance Delegation of the European Union
CCAMLR-XXXIII/26	Principal provisions of the Russian Federation regarding the proposal to establish an MPA in the Ross Sea Delegation of the Russian Federation
CCAMLR-XXXIII/27	Consideration on a standardised procedure to establish CCAMLR marine protected areas (MPAs) in accordance with the Conservation Measure 91-04 Delegation of Japan
*****	
CCAMLR-XXXIII/BG/01	Implementation of conservation measures in 2013/14: Fishing and related activities Secretariat
CCAMLR-XXXIII/BG/02	Fishery notifications 2014/15 summary Secretariat
CCAMLR-XXXIII/BG/03	The Secretariat's internship program: 2014 Secretariat
CCAMLR-XXXIII/BG/04	Thirty-first Session of the Committee on Fisheries (Rome, Italy, 9 to 13 June 2014) Final draft report: summary of items of interest to CCAMLR Executive Secretary
CCAMLR-XXXIII/BG/05	Summary report Thirty-Seventh Antarctic Treaty Consultative Meeting (Brasilia, Brazil, 28 April to 7 May, 2014) Executive Secretary
CCAMLR-XXXIII/BG/06	A review of CCAMLR's translation services: Intersessional Correspondence Group – Sustainable Finance

CCAMLR-XXXIII/BG/07	Conservation Measure 10-04 VMS Technical Working Group
CCAMLR-XXXIII/BG/08	Description of the General Fund Budget Secretariat
CCAMLR-XXXIII/BG/09	Marine Protected Areas in the Antarctic Treaty System Delegation of Russia
CCAMLR-XXXIII/BG/10	Report by the CCAMLR Observer (Namibia) to the 10th annual meeting of SEAFO (South East Atlantic Fisheries Organisation) (Swakopmund, Namibia, 9 to 13 December 2013) CCAMLR Observer (Namibia)
CCAMLR-XXXIII/BG/11 Rev. 1	Calendar of meetings of relevance to the Commission in 2014/15 Secretariat
CCAMLR-XXXIII/BG/12	Monitoring, control and surveillance activities undertaken by New Zealand during 2013/14 Delegation of New Zealand
CCAMLR-XXXIII/BG/13 Rev. 2	Implementation of Conservation Measure 10-05 CCAMLR's Catch Documentation Scheme (CDS) Secretariat
CCAMLR-XXXIII/BG/14 Rev. 2	The Price of Fish: A global trade analysis of Patagonian ( <i>Dissostichus eleginoides</i> ) and Antarctic toothfish ( <i>Dissostichus mawsoni</i> ) Secretariat
CCAMLR-XXXIII/BG/15 Rev. 1	Information on levels of seabird by-catch in fisheries adjacent to the CAMLR Convention Area Submitted by ACAP
CCAMLR-XXXIII/BG/16	Independent Review of CCAMLR's Catch Documentation Scheme (CDS) e-CDS User Manual Secretariat
CCAMLR-XXXIII/BG/17	Track changed version of the Proposal for a Conservation Measure establishing the East Antarctic Representative System of Marine Protected Areas (CCAMLR-XXXIII/23) Delegations of Australia, France and the European Union

CCAMLR-XXXIII/BG/18	Examples of the assessment of activities within the proposed East Antarctic Representative System of Marine Protected Areas (EARSMPA) (CCAMLR-XXXIII/23) Delegations of Australia, France and the European Union
CCAMLR-XXXIII/BG/19	Heard Island and McDonald Islands exclusive economic zone 2013/14 IUU catch estimate for Patagonian toothfish and Australia's observations on IUU activities in the 2013/14 fishing season Delegation of Australia
CCAMLR-XXXIII/BG/20	Global MPAs and marine reserves: lessons learned and implications for CCAMLR Submitted by ASOC
CCAMLR-XXXIII/BG/21	Incorporating climate change into CCAMLR's decisionmaking processes Submitted by ASOC
CCAMLR-XXXIII/BG/22 Rev. 1	Proposals on improving the governance and control of fishing vessels operating in the Southern Ocean Submitted by ASOC
CCAMLR-XXXIII/BG/23	Working together to end illegal, unreported and unregulated fishing in the Southern Ocean Submitted by ASOC and COLTO
CCAMLR-XXXIII/BG/24 Rev. 2	Maintaining CCAMLR's ambition on Marine Protected Areas Submitted by ASOC
CCAMLR-XXXIII/BG/25	Krill: the power lunch of Antarctica Submitted by ASOC
CCAMLR-XXXIII/BG/26	The investigation and subsequent results on the missing DCDs for the catches of the FVs <i>Insung No. 3</i> , <i>Insung No. 7</i> and the <i>Hongjin 707</i> Delegation of the Republic of Korea
CCAMLR-XXXIII/BG/27	The results of the investigation on the high CPUE recorded by the three Insung vessels in the CCAMLR Area Delegation of the Republic of Korea
CCAMLR-XXXIII/BG/28 Rev. 1	Mapping trends in activity of illegal, unreported and unregulated (IUU) fishing in the CAMLR Convention Area Secretariat

CCAMLR-XXXIII/BG/29	Observer's Report from the 65th International Whaling Commission CCAMLR Observer (Japan)
CCAMLR-XXXIII/BG/30	Report from the CCAMLR Observer (European Union) to the 87th Annual Meeting of the Inter American Tropical Tuna Commission (IATTC) (Lima, Peru, 12 to 18 July 2014) CCAMLR Observer (European Union)
CCAMLR-XXXIII/BG/31	Report from the CCAMLR Observer (European Union) to the 18th Plenary Session of the Indian Ocean Tuna Commission (IOTC) (Colombo, Sri Lanka, 1 to 5 June 2014) CCAMLR Observer (European Union)
CCAMLR-XXXIII/BG/32	Summary of activities of the Commission during the 2013/14 intersessional period Report of the Chair
CCAMLR-XXXIII/BG/33	Report from the CCAMLR Observer (Norway) to the 36th Annual Meeting of the Northwest Atlantic Fisheries Organization (Vigo, Spain, 22 to 26 September 2014) CCAMLR Observer (Norway)
CCAMLR-XXXIII/BG/34	Measures taken by Spain to fight IUU fishing in the CAMLR Convention Area during 2014 Delegation of Spain
CCAMLR-XXXIII/BG/35	Findings of the New Zealand Coroner's Office on the incident of the sinking of the <i>Insung No. 1</i> Delegation of New Zealand
CCAMLR-XXXIII/BG/36	Status of CCAMLR Special Funds Secretariat
CCAMLR-XXXIII/BG/37	Report from the CCAMLR Observer to the meeting of the Extended Commission for the 21st Annual Session of the Commission for the Conservation of Southern Bluefin Tuna (Auckland, New Zealand, 13 to 16 October 2014) CCAMLR Observer (Australia)
CCAMLR-XXXIII/BG/38	Report from the CCAMLR Observer (Chile) to the Second Meeting of the Commission of the South Pacific Regional Fisheries Management Organisation (SPRFMO) CCAMLR Observer (Chile)

CCAMLR-XXXIII/BG/39      Compilation of discussion on the issue of flexibility  
associated with research blocks where ice cover impedes  
research fishing  
Secretariat

CCAMLR-XXXIII/BG/40      EARSMPA proposal: current thinking – 29 October 2014  
Delegations of Australia, France and the European Union

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Other Documents

SC-CAMLR-XXXII/07      Review of the CCAMLR Scheme of International Scientific  
Rev. 1                      Observation (26 to 30 August 2013, CCAMLR  
                                    Headquarters, Hobart, Tasmania)  
                                    CCAMLR SISO Review Panel

SC-CAMLR-XXXII/09      Formalising the invitation and management of experts and  
observers to meetings of CCAMLR Scientific Committee  
subsidiary bodies  
Chair of the Scientific Committee

**Agenda for the Thirty-third Meeting  
of the Scientific Committee**



## **Agenda for the Thirty-Third Meeting of the Scientific Committee**

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 the 2013/14 season
    - 3.4.2 Notifications for new and exploratory fisheries in the 2014/15 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 considerations
  - 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 under Conservation Measure 24-01
- 10. Cooperation with other organisations
  - 10.1 Cooperation with Antarctic Treaty System
    - 10.1.1 Committee for Environmental Protection
    - 10.1.2 Scientific Committee for Antarctic Research
  - 10.2 Reports of observers from other international organisations
  - 10.3 Reports of representatives at meetings of other international organisations
  - 10.4 Future cooperation
- 11. Budget for 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 Scholarship Scheme
  - 13.4 Invitation of experts and observers to meetings of working groups
  - 13.5 Next meeting
- 14. Secretariat supported activities
- 15. Election of Vice-Chair
- 16. Other business
- 17. Adoption of report of Thirty-third Meeting
- 18. Close of meeting.

**Report of the Meeting of the Subgroup on  
Acoustic Survey and Analysis Methods**  
(Qingdao, People's Republic of China, 8 to 11 April 2014)

## Contents

	Page
<b>Introduction</b> .....	119
<b>Scientific use of acoustic data collected on fishing vessels targeting krill</b> .....	119
Overview of acoustic data submitted as part of the proof of concept .....	119
Development of protocols for data collection .....	121
Monitoring of echosounder performance .....	122
Acoustic data analysis protocols .....	124
Noise removal algorithms .....	124
Data processing software .....	125
Acoustic data from fishing vessels .....	125
<b>Recommendations to the Scientific Committee</b> .....	125
<b>Adoption of report</b> .....	126
<b>Close of the meeting</b> .....	126
<b>References</b> .....	126
<b>Tables</b> .....	127
<b>Figures</b> .....	132
<b>Appendix A:</b> List of Participants .....	136
<b>Appendix B:</b> Agenda .....	138
<b>Appendix C:</b> List of Documents .....	139
<b>Appendix D:</b> Draft instruction documentation on instrument setup: Simrad ES60 Open-ocean data logging .....	140
<b>Appendix E:</b> An example of determining echosounder system performance by seabed comparison .....	144
<b>Appendix F:</b> Inter-vessel comparison .....	146

**Report of the Meeting of the Subgroup  
on Acoustic Survey and Analysis Methods**  
(Qingdao, People's Republic of China, 8 to 11 April 2014)

## **Introduction**

1.1 The 2014 meeting of the Subgroup on Acoustic Survey and Analysis Methods (SG-ASAM) was held at the Yellow Sea Fisheries Research Institute (YSFRI), Chinese Academy of Fishery Science, Qingdao, People's Republic of China, 8 to 11 April 2014. The Co-conveners, Drs J. Watkins (UK) and X. Zhao (China), welcomed the participants (Appendix A). Dr Watkins thanked Dr Zhao for hosting the meeting at YSFRI; this was the first CCAMLR meeting hosted by China.

1.2 The Subgroup's work is currently focused on 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*) and other pelagic species such as myctophiids and salps (SC-CAMLR-XXX, paragraphs 2.9 and 2.10; SC-CAMLR-XXXI, Annex 4). Specifically, this meeting of SG-ASAM was convened to determine protocols for collection and analysis of acoustic data collected on board fishing vessels (SC-CAMLR-XXXII, paragraph 2.14).

1.3 The meeting's provisional agenda was discussed and adopted without change (Appendix B). The Subgroup agreed to focus its discussion on Item 2.

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

1.5 This report was prepared by Drs M. Cox (Australia), S. Fielding (UK), D. Ramm, K. Reid (Secretariat) and G. Skaret (Norway). Sections of the report dealing with advice to the Scientific Committee are highlighted (see also 'Advice to the Scientific Committee').

## **Scientific use of acoustic data collected on fishing vessels targeting krill**

Overview of acoustic data submitted as part of the proof of concept

2.1 The Subgroup recalled the objectives of the proof of concept (SC-CAMLR-XXXI, Annex 4, paragraphs 2.38 and 2.39) and the subsequent intersessional work on these issues that had been facilitated by the use of the SG-ASAM e-group<sup>1</sup> (SC-CAMLR-XXXI, paragraphs 2.12 and 2.13).

2.2 The Subgroup noted that the proof-of-concept program, which began in 2013, had two stages and that stage 1 (implemented in 2013) was designed to determine the current setup of sonar equipment on participating vessels and to establish the feasibility of vessels collecting position- and time-referenced acoustic data. To achieve stage 1, vessels were requested to

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<sup>1</sup> CCAMLR e-groups can be accessed from the [CCAMLR homepage](#) and are available to authorised users.

collect acoustic data over a period of 1 to 2 minutes, to complete the acoustic metadata form distributed as part of SC CIRC 13/46 and to submit the data file(s) and completed form to the Secretariat via email.

2.3 The Subgroup noted that stage 1 was an important step to provide a better understanding of the acoustic instrumentation on krill fishing vessels as well as the potential to collect the acoustic data and associated metadata required. The Subgroup also noted that, based on the number of vessels that had implemented stage 1 in 2013 and the intersessional work of the SG-ASAM e-group, the Scientific Committee had recognised that there was good momentum for ongoing work in developing protocols for stage 2 (SC-CAMLR-XXXII, paragraph 2.14).

2.4 The Subgroup welcomed the submission of stage 1 acoustic data from seven vessels (Table 1) which represented approximately 60% of the vessels engaged in the krill fishery in 2013/14. In addition, one vessel submitted images of echograms. All of the datasets submitted were collected using Simrad systems and all of the acoustic data files were submitted as ‘.raw’ (native format) files. Of the vessels that had not supplied stage 1 data, some had Furuno echosounder systems that did not have a facility to store acoustic data. Dr S.-G. Choi (Republic of Korea) informed the Subgroup that the vessel *Insung Ho* currently had echosounders that did not allow data collection/storage but that a Simrad system would be installed on board the vessel in 2014/15.

2.5 The Subgroup agreed that the acoustic data provided has proved the concept that these data could be collected by fishing vessels.

2.6 The Subgroup reiterated its interest in receiving data from all types of echosounder under stage 1, but noted that all of the data submitted in stage 1 were from Simrad systems. As a result, discussions during this meeting focused on analysis and data collection protocols designed for Simrad systems.

2.7 During the meeting all of the acoustic data files provided for stage 1 were successfully opened and reviewed using Echoview or LSSS. The Subgroup viewed each data file, and noted that, whilst acoustic noise (ping synchronisation and background) varied between vessels, all acoustic data submitted showed that krill fishing vessels could collect acoustic data and associated metadata required to provide information on the distribution and abundance of krill.

2.8 The Subgroup acknowledged that software packages used to view and analyse acoustic data during the meeting (Echoview, LSSS and Echolab) used proprietary software and thanked those participants who had brought these licensed packages to the meeting. The Subgroup noted that the Secretariat currently does not have the facility to analyse these acoustic data files; however, a demonstration version of Echoview or LSSS could be used to open and view data. The Subgroup agreed that the requirements for the Secretariat to develop this capacity would need to be reviewed during the development of the data-analysis protocols.

## Development of protocols for data collection

2.9 Given the success of stage 1, the Subgroup considered a timeline for the subsequent steps (Figure 1) in the procedure to use acoustic data from krill fishing vessels to provide information on the distribution and abundance of krill. The Subgroup agreed that the current focus should be to develop protocols for data collection that could be readily implemented on fishing vessels, and that the protocol for collecting acoustic data from transects should be developed first.

2.10 The Subgroup agreed that the development of data collection protocols, including the metadata requirements and instrument settings for acoustic data collection, should be based on existing protocols where available and should be for a particular activity type. In particular, the Subgroup recognised that existing IMOS protocols, developed for the use of ships of opportunity (SOOP) with Simrad equipment ([IMOS SOOP document](#)), provided a useful template from which to develop a specific protocol for the krill fishery.

2.11 The Subgroup agreed that there was substantial benefit in collecting data from pre-defined transects and supported the repetition of transects currently or previously undertaken as part of long-term time series for scientific research in Subareas 48.1, 48.2 and 48.3 (Figure 2). To facilitate the use of these transects by fishing vessels, the Subgroup provided the start and end waypoints (Table 2) and agreed a set of unique identifiers for each transect. The Subgroup agreed that while it would be beneficial for fishing vessels to collect data along transects (or parts of transects) currently undertaken during scientific research, new transects may be added in the future.

2.12 The Subgroup acknowledged that much of the information in a transect-specific protocol would be relevant for a fishing vessel when performing other acoustic data collection activities, including data collection from other transects.

2.13 The metadata requirements associated with acoustic data collection by a krill fishing vessel were separated into those that relate to the fixed installation of echo sounding equipment on the vessel and those that are specific to activities undertaken to collect acoustic data.

2.14 In respect of metadata concerning the fixed installation of echo sounding equipment on the vessel, the Subgroup suggested that the information in Table 3 could in future be requested as part of the notification of intention to fish for krill. The Subgroup requested the Secretariat to seek the additional information for those vessels notified for 2014/15. In particular, the Subgroup noted that providing the serial number of the transducer would allow many of the factory settings to be accessed from Simrad and would provide the basic data available for a vessel's echosounder equipment.

2.15 The Subgroup also noted that there would need to be a request made to Members engaged in the krill fishery to inform the Secretariat if the transducer specification changed in the period between the notification and the provision of acoustic data.

2.16 The key metadata requirements for acoustic data collected on transects are identified in Table 4 and the Subgroup recommended that all date and time data associated with acoustic data collection should be reported as UTC.

2.17 The Subgroup identified seven instrument settings/parameters that should be set to pre-specified values as part of the instrument setup for collecting acoustic data on transects (Table 5). While six of these parameters are vessel independent, the power setting for an individual frequency is dependent on the transducer beam width (Korneliussen et al., 2008). Vessel-specific guidance will need to be developed based on transducer type and calibration history.

2.18 The Subgroup developed draft instruction documentation on instrument setup for the 38 kHz, 7 degree beam width transducer by modifying the IMOS instructions (Appendix D). There was not sufficient time and resources to fully develop this document and it was recommended that this development be continued using the SG-ASAM e-group.

#### Monitoring of echosounder performance

2.19 The Subgroup agreed that the ability of any vessel to collect acoustic data and the associated metadata required to provide information on the distribution and abundance of Antarctic krill is contingent on the performance of the echosounder, both with respect to expectation (i.e. is the echosounder functioning as expected?) and with respect to a known standard (i.e. does the data from the echosounder agree with a known calibration standard?).

2.20 The Subgroup recognised that the standard sphere calibrations (e.g. as currently described by Foote et al., 1987) provided the best method by which to determine echosounder performance and provided the most accurate derived quantitative measures of krill abundance (see for example SC-CAMLR-XIX, Annex 4, Appendix G, paragraphs 3.10 to 3.12 and Tables 10 and 11).

2.21 The Subgroup noted that some fishing vessels have been calibrated using the standard sphere technique, for example, when the echosounder was installed. The Subgroup requested the results of these calibrations be made available to CCAMLR. It also encouraged the submission of any other subsequent data on calibrations performed on fishing vessel echosounders in order to better understand the variation over time and environmental conditions in echosounder performance.

2.22 The Subgroup reviewed eight years of TS gain values of the RRS *James Clark Ross* that indicated that variability in the TS gain varies within 0.5 dB at 38 kHz and 1 dB at 120 kHz, and this variability was at least partially driven by environmental (temperature) conditions during the calibration procedure.

2.23 The Subgroup noted that Brierley et al. (1998) identified markedly different (1.4 dB difference in volume backscattering strength ( $S_v$ ) gain at 38 kHz) calibration gain settings determined in waters of 16.6°C compared with Antarctic waters (2.3°C). However, the Subgroup noted that a greater understanding of uncertainty driven by the effects of temperature on calibration values may allow calibration of fishing vessels in ports to be used to derive quantitative estimates in the Antarctic.

2.24 The Subgroup agreed that, in order for acoustic data to be used to produce a quantitative estimate of krill biomass, a measure of echosounder system performance over time was required. These measures include internal testing as well as by reference to external standards, noting that each would have a different level of uncertainty (Table 6). The

Subgroup discussed a range of approaches to assess echosounder performance and encouraged Members to submit analyses that would investigate uncertainties around these methods.

2.25 The Subgroup agreed that appropriate processes for performing internal validation of the system should, at a minimum, be undertaken at the beginning and end of a fishing trip (Table 6).

2.26 The Subgroup noted that general functionality of a split-beam transducer can be checked by examining the single target distribution in the acoustic beam. For a properly functioning transducer, detected single targets should be distributed randomly across the acoustic beam (Figure 3a). If one or more quadrants of the transducer are malfunctioning, detected single targets may be distributed abnormally in the beam (Figure 3b).

2.27 The Subgroup agreed that the development of alternative methods of calibration was an important aspect of using krill fishing vessels to provide information on the distribution and abundance of Antarctic krill.

2.28 The Subgroup agreed that the seabed  $S_v$  along known or repeated transects has the potential to confirm system performance and provide inter-vessel comparisons, including between calibrated and uncalibrated vessels. Data available from the acoustic transects and calibration sites in Figure 2 could be examined for variability in seabed  $S_v$  and the Subgroup encouraged Members to undertake such investigations. Furthermore, the Subgroup encouraged the collection of data from these transects and calibration sites by vessels with and without standard sphere calibrated echosounders to provide a means to establish the uncertainty in this method.

2.29 Dr X. Wang (China) presented a segment of flat seabed data at 38 kHz collected on board the *Fu Rong Hai* using a Simrad EK60 echosounder. The seabed  $S_v$  was integrated over a grid size of 20 pings, and from the software-detected bottom line to 10 m below. The seabed  $S_v$  over ~2 000 pings showed a unimodal distribution ranging from -35.9 to -17.8 dB.

2.30 Dr Cox presented an analysis of seabed  $S_v$  from 2 km of calibrated 38 kHz EK60 line transect data exported on a 10-ping by 2 m grid. The echo integration results comprised of 477 cells that fell within the isolated seabed region. The cells had a range of -65.7 to -5.5 dB re  $1 \text{ m}^{-1}$  and had a bimodal distribution (Appendix E).

2.31 Dr Fielding presented the empirical cumulative distribution function (CDF) of seabed  $S_v$  (surface to 4 m below) from all of transect 3.1 of the British Antarctic Survey western core box (transect T5 in Figure 2c) time series from 2012, 2013 and 2014 (Figure 4), and there was a difference between the distributions.

2.32 Dr Skaret presented the preliminary results from a trial carried out by the fishing vessel *Juvel* in 2012. A 2 n mile section of relatively flat bottom close to the main fishing ground north of the South Orkney Islands was crossed three times repeatedly at ca. 10 knots even speed using a ping rate of  $2.5 \text{ sec}^{-1}$ . Bottom integration from detected bottom down to 5 m below the bottom was compared at frequencies of 38, 70 and 120 kHz from three repeated runs and indicated close agreement on all frequencies (Figure 5).

2.33 The Subgroup thanked those scientists who presented analyses on seabed  $S_v$  and agreed that this approach showed substantial potential and encouraged further development, including sensitivity analyses of each technique, including, inter alia, examining data from repeat transects, seabed topography (e.g. slope, flat area) and type, and integration grid dimensions.

2.34 Dr Cox also presented an analysis technique enabling the comparison of seabed acoustic returns from two vessels that may facilitate inter-vessel calibration. The technique maps the empirical cumulative distribution function from each vessel so that mean  $S_v$  values can be standardised between vessels and is based on the technique presented in Cox et al. (2010). The Subgroup agreed that this presented a promising method to inter-calibrate two vessels once a suitable seabed analysis method was identified and agreed that this process would be facilitated by vessels undertaking these transects with the parameter settings (e.g. power setting and pulse duration specific) as described in Appendix F.

2.35 The Subgroup recommended that the role of seabed as external reference target for calibration be the focus of intersessional work leading to the SG-ASAM meeting in 2015.

## Acoustic data analysis protocols

### Noise removal algorithms

2.36 The Subgroup recalled the previous discussion on removing interference from other acoustic instrumentation (SC-CAMLR-XXXI, Annex 4, paragraph 2.28). However, it was recognised that there may be operational requirements which prevent noise sources from being removed or switched off. Therefore, the development of noise removal algorithms is important to ensure the maximum utility of the acoustic data collected.

2.37 Dr Wang presented work on noise reduction on acoustic recordings from the fishing vessel *Fu Rong Hai*, which had severe interference noise from other acoustic instruments. Different noise reduction algorithms from the software package Echoview were used in combination for noise removal in several steps, including  $S_v$  thresholding and use of erosion, dilation and median filters. Noise occurring in several consecutive pings was particularly difficult to filter out. Dr Wang had further investigated the effect of  $S_v$  thresholding on echo integration by looking at the sensitivity in the CCAMLR  $S_v$  dB difference method for krill identification to varying  $S_v$  thresholds. While no effect was seen when using a low threshold, a higher threshold had an effect but only on the weak targets.

2.38 The Subgroup thanked Dr Wang for this interesting presentation, and Dr Cox suggested that delineation and isolation of swarms as regions in Echoview could be used to exclude the areas where noise was still present. It was also suggested that once templates for noise reduction have been established, it could be possible to work directly with manufacturers of acoustic software to implement general procedures for noise removal.

## Data processing software

2.39 Dr Skaret summarised SG-ASAM-14/02 Rev. 1, which evaluated the suitability of LSSS for inspection and processing of data from krill fishing vessels. The software is designed for efficient processing of large quantities of acoustic data and may therefore be a useful tool for handling acoustic data from the krill fishing fleet.

2.40 The Subgroup noted that an efficient tool for display and easy extraction of relevant parts of a dataset would be required in future CCAMLR work on acoustic data from the fisheries. It was acknowledged that different Members are likely to use different software systems and that the comparison of these systems using common datasets should be undertaken.

2.41 The Subgroup agreed that there is a need to develop standard data analysis protocols and that this has been identified as part of the future work of the Subgroup (Figure 1).

## Acoustic data from fishing vessels

2.42 Dr K. Abe (Japan) presented an analysis of the acoustic data from the Japanese-flagged fishing vessel *Fukuei Maru* during krill fishing operations in Subarea 48.1 in 2011/12 (SG-ASAM-14/03 Rev. 1). The vessel was operating a 38 kHz Simrad ES60 echosounder and data were collected for more than two months in that subarea.

2.43 The Subgroup noted that this work provided important insight into fishing activities, including movement patterns of a fishing vessel between different fishing locations (Figure 6). The Subgroup agreed that the provision of such data could potentially be used to define transects which link different fishing grounds and which could be undertaken as standard transects.

## Recommendations to the Scientific Committee

3.1 The Subgroup recognised that any vessel with a functioning echosounder had the potential to collect acoustic data and associated metadata required to provide information on the distribution and abundance of krill. The Subgroup further recognised that the level of confidence that could be attached to the products derived from that data will depend on the calibration of the echosounder and the survey design used. The Subgroup agreed that vessels with calibrated echosounders conducting appropriately designed surveys and with appropriate analysis protocols provided the greatest accuracy and precision in biomass estimates, however, these surveys were typically conducted over a short time period relative to the fishery. Therefore, while the data collected from fishing vessels may be of lower precision, it may be available over greater spatial and temporal scales.

3.2 Specific advice to the Scientific Committee is summarised below, and the body of the report leading to these paragraphs should also be considered:

- proof of concept (paragraph 2.5)
- protocols for data collection (paragraph 2.9)
- echosounder performance (paragraph 2.35).

## **Adoption of report**

4.1 The report of the meeting was adopted.

## **Close of the meeting**

5.1 In closing the meeting, the Co-conveners thanked all participants for their contributions to the work of SG-ASAM and for the detailed discussions which had resulted in the further development of protocols for using fishing-vessel-based acoustic data. Dr Watkins also thanked Dr Zhao and Dr X. Jin (Director General, YSFRI) for the excellent meeting facilities and their generous hospitality. The Subgroup thanked Drs Watkins and Zhao for co-convening the meeting.

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Table 1: Echosounder make and frequency, and fishing activity (to March 2014) of vessels notified to fish in the krill fishery in Subareas 48.1, 48.2, 48.3 and 48.4 in 2013/14. Participation in SG-ASAM's proof of concept and submission of acoustic data or echograms is indicated.

Notified vessel		Echosounder make	Frequency (kHz)	Activity this season (to March)	SG-ASAM proof-of-concept submission
Member	Vessel name				
Chile	<i>Betanzos</i>	Simrad ES60	38	Fishing	Data provided
	<i>Cabo de Hornos</i>	-		No activity reported	-
	<i>Diego Ramírez</i>	-		No activity reported	-
	<i>Ila</i>	-		No activity reported	-
China	<i>An Xing Hai</i>	Furuno FCV1200L*		Not licensed in 2013/14	-
	<i>Fu Rong Hai</i>	Simrad EK60	38, 70, 120	Fishing	Data provided
	<i>Kai Li</i>	Furuno FCV-140, MU101-C*		Fishing	-
	<i>Kai Yu</i>	Simrad ES60	38, 120	Fishing	-
	<i>Lian Xing Hai</i>	Furuno FCV1200L*		Not licensed in 2013/14	-
	<i>Long Teng</i>	Furuno FCV1200L*		Fishing	-
Korea, Republic of	<i>Adventure</i>	Simrad ES60	38	Replaced by <i>Sejong</i>	Data provided (2012/13)
	<i>Sejong</i>	Simrad ES70	38, 200	Fishing	Data provided
	<i>Insung Ho</i>	JRC JFV-130, Furuno FCV-161ET**	28, 50	Fishing	-
	<i>Kwang Ja Ho</i>	Simrad ES70	38, 120	Fishing	Data provided
	<i>Antarctic Sea</i>	Simrad ES60	38, 120	Fishing	-
Norway	<i>Juvel</i>	Simrad ES60	38, 70, 120	Fishing	Data provided
	<i>Saga Sea</i>	Simrad ES60	38, 120	Fishing	Data provided
	<i>Alina</i>	-		No activity reported	-
Poland	<i>Sirius</i>	-		No activity reported	-
	<i>More Sodruzhestva</i>	Simrad ES70	70	No activity reported	Echogram provided (2012/13)

\* Data storage not available. \*\* Data storage not available, Simrad echosounder expected to be installed in 2014/15.

Table 2: Positions (dd mm.00) of the start and end of acoustic transects in Subareas 48.1, 48.2 and 48.3. See also Figure 2.

Subarea	Transect	Start position		End position	
		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

Table 3: Additional instrument information required at the time of submitting the annual fishery notification.

<b>Vessel name</b>	
<b>Vessel call sign</b>	
<b>Transducer information</b>	
Frequency	
Type	
Serial number	
Transducer depth	
Diagram/photograph of transducer arrangement	
Manufacturer's calibration sheet	
<b>Logging system information</b>	
EK60/ES60/ES70 software version	

Table 4: Metadata required when running specified transects.

<b>Vessel name</b>						
<b>Vessel call sign</b>						
<b>Instructions</b>						
Set logging system to UTC						
Set instrument settings according to vessel-specific table						
Turn off all other acoustic instruments where possible						
Do not vary any parameters during a transect						
Ship speed stable around 10 knots						
<b>Transect number</b>	<b>Start date/time (UTC)</b>	<b>End date/time (UTC)</b>	<b>CCAMLR transect identifier</b>	<b>Sea state at start of transect</b>	<b>Wind direction at start of transect</b>	<b>Other remarks</b>

Table 5: Instrument setting for running specified transects.

<b>Vessel name</b>					
<b>Vessel call sign</b>					
<b>Settings to use for running specified transects</b>					
Frequency:	kHz:	38	70	120	200
Power settings*	W	* Will change dependent on beam width			
Pulse duration	microsecond	1024	1024	1024	1024
Ping interval	second	2	2	2	2
Data collection range (min.–max.)	m	0–1000	0–1000	0–1000	0–1000
Bottom detection range (min.–max.)	m	5–1000	5–1000	5–1000	5–1000
Display range (min.–max.)	m	0–1000	0–1000	0–1000	0–1000

Table 6: At-sea processes for determining echosounder performance. Grey shading denotes that further work and specification of the method is required.

	Internal validation			External validation	
	Transceiver system test	Transducer impedance measurement	Single target detection distribution	Calibration using bottom integration	Calibration using standard sphere
Purpose	To monitor basic system performance			To calibrate against known standard	
Method	Using internal test signal available in some Simrad echosounders	Development required by Subgroup	Distribution of single targets within beam used to assess transducer functionality	Vessel calibration either stationary or under way using seabed volume backscattering strength as derived standard	Stationary vessel using suspended target spheres as known calibration standard
How often	Minimum of beginning and end of fishing season			At least once each season	When possible, required for designed surveys
References	Simrad manual, Appendix D		See paragraph 2.26	See paragraphs 2.28 to 2.35	Foote et al., 1987

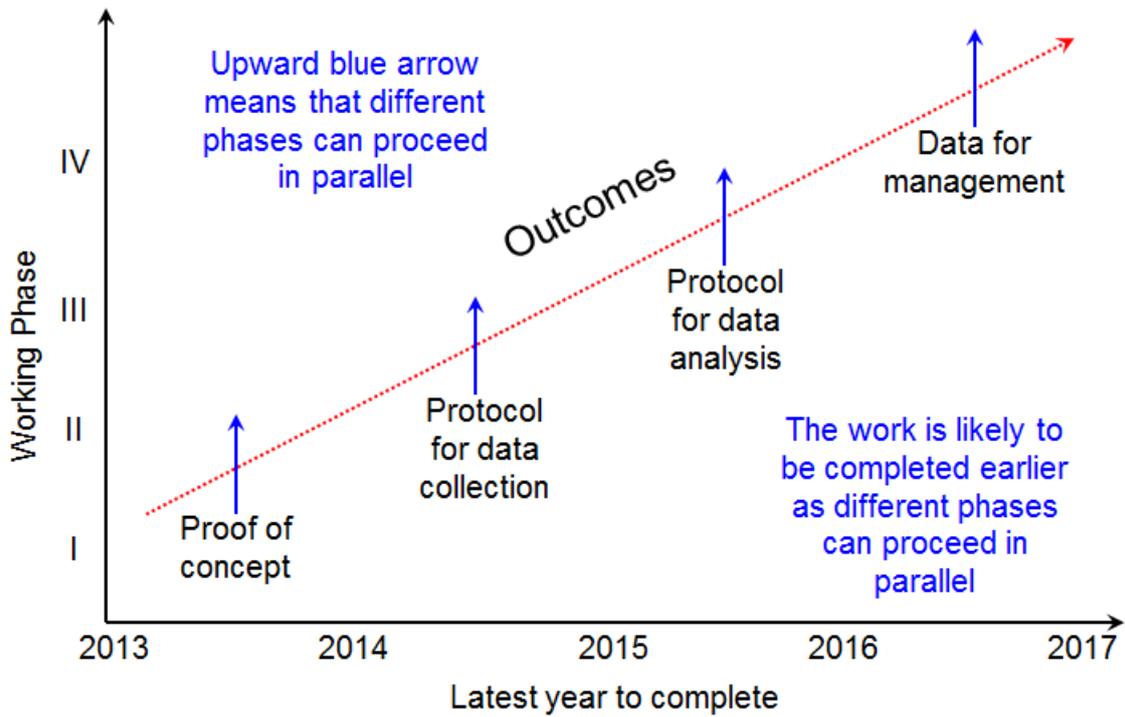


Figure 1: Road map towards the full utilisation of acoustic data collected from fishing vessels.

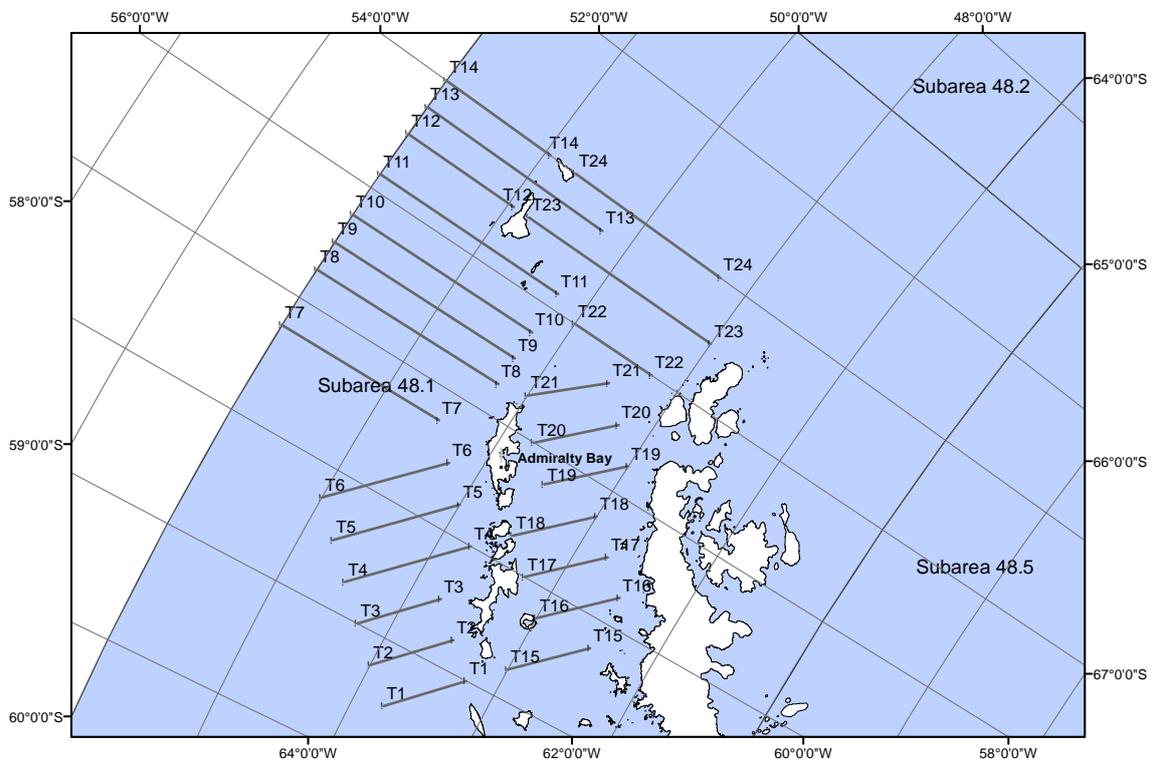


Figure 2(a): Location of acoustic transects (T1 to T24) and the calibration site (Admiralty Bay) at the South Shetland Islands (Subarea 48.1). The positions of the start and end of the transects are listed in Table 1.

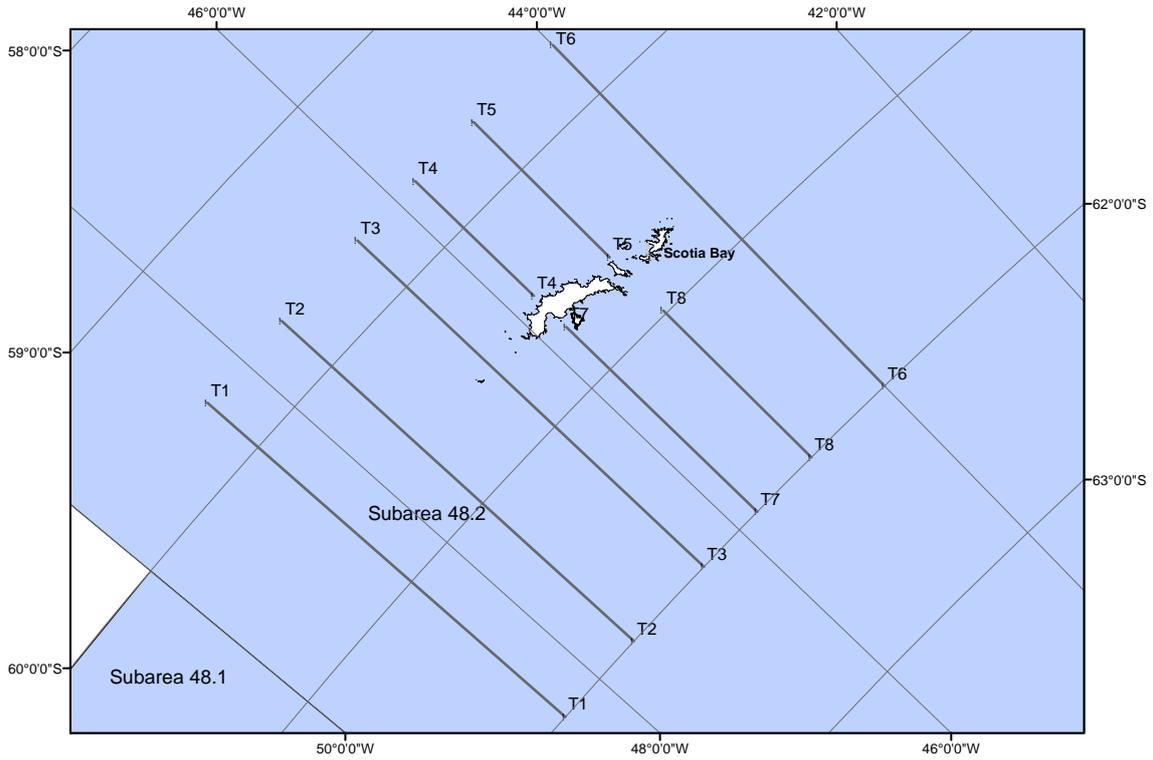


Figure 2(b): Location of acoustic transects (T1 to T8) and the calibration site (Scotia Bay) at the South Orkney Islands (Subarea 48.2). The positions of the start and end of the transects are listed in Table 1.

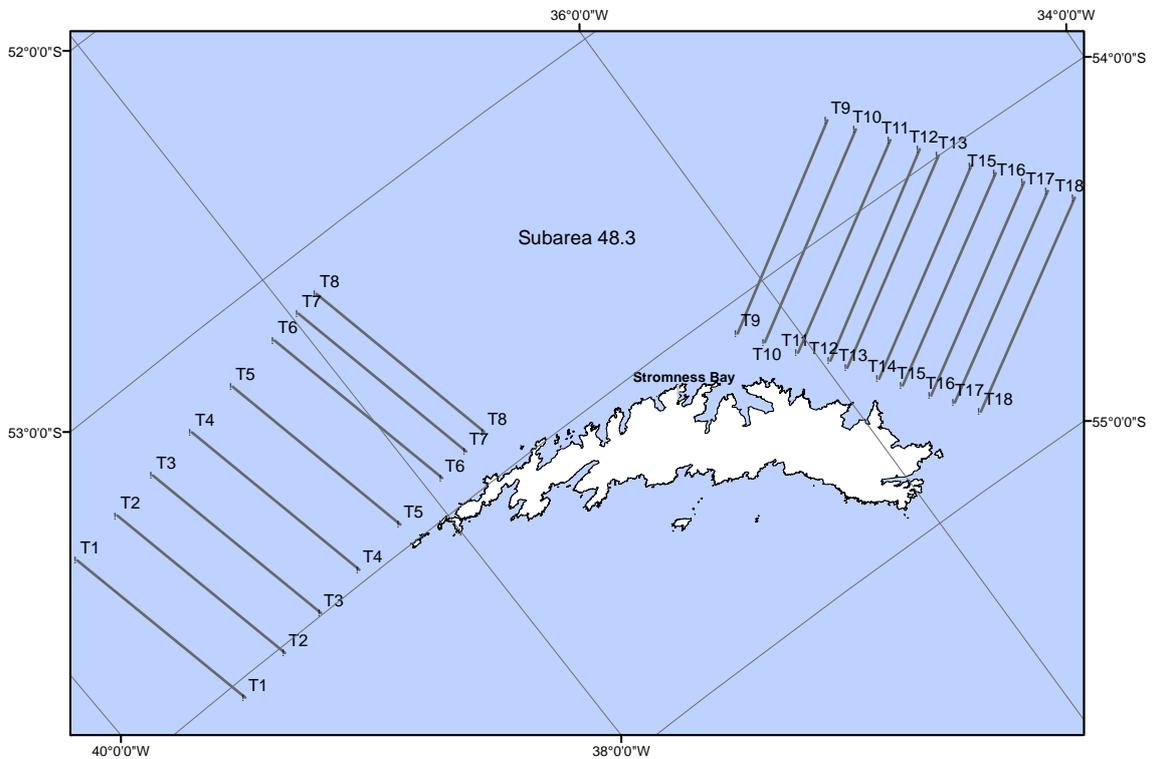


Figure 2(c): Location of acoustic transects (T1 to T18) and the calibration site (Stromness Bay) at South Georgia (Subarea 48.3). The positions of the start and end of the transects are listed in Table 1.

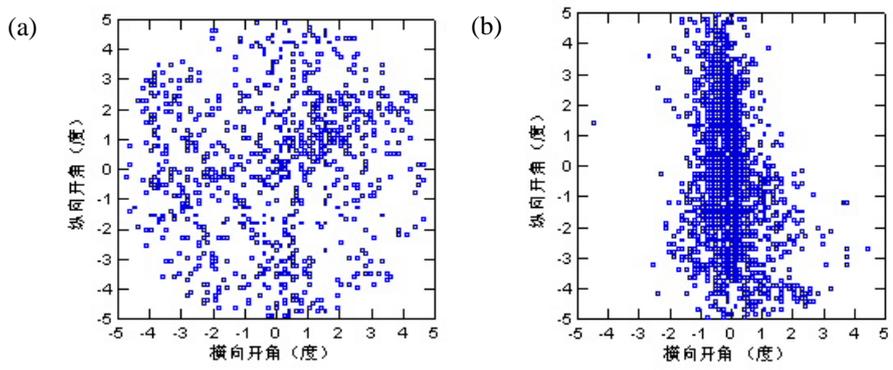


Figure 3: Distribution of detected single targets in the acoustic beam. X-axis: athwartship off-axis angle ( $^{\circ}$ ); y-axis: alongship off-axis angle ( $^{\circ}$ ); (a): from a properly functioning transducer, (b): from a malfunctioning transducer.

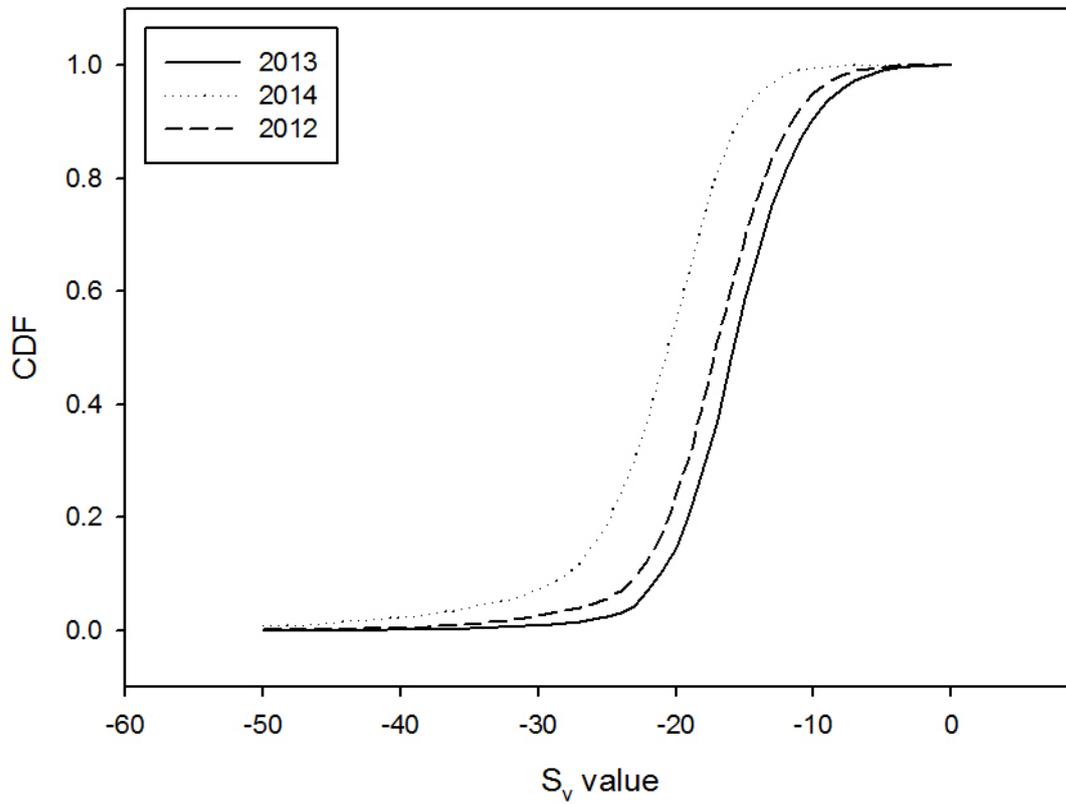


Figure 4: Cumulative distribution function of seabed  $S_v$  (dB) from Transect 3.1 of the British Antarctic Survey western core box (transect T5 in Figure 2c) time series (2012, 2013, 2014).

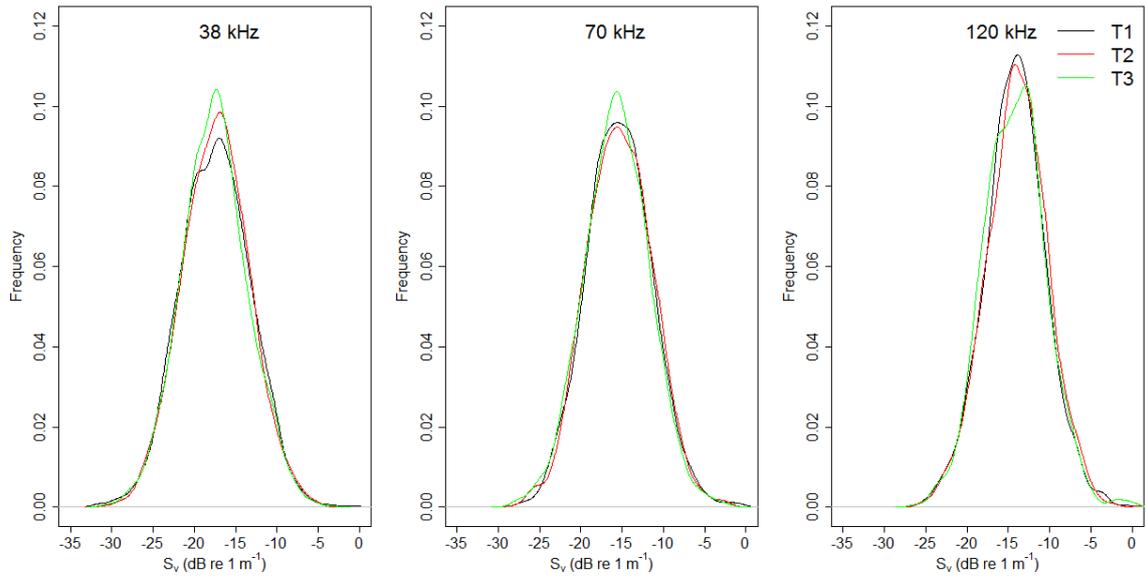


Figure 5: Distribution of acoustic volume backscattering strength ( $S_v$ ) from bottom integration using repeat transect data from the fishing vessel *Juvel* running three frequencies (38, 70 and 120 kHz). The PDF plots are based on single pings ( $N \sim 1700$ ) and three repetitions (T1, T2 and T3) of a ca. 2 n mile transect over a relatively flat bottom.

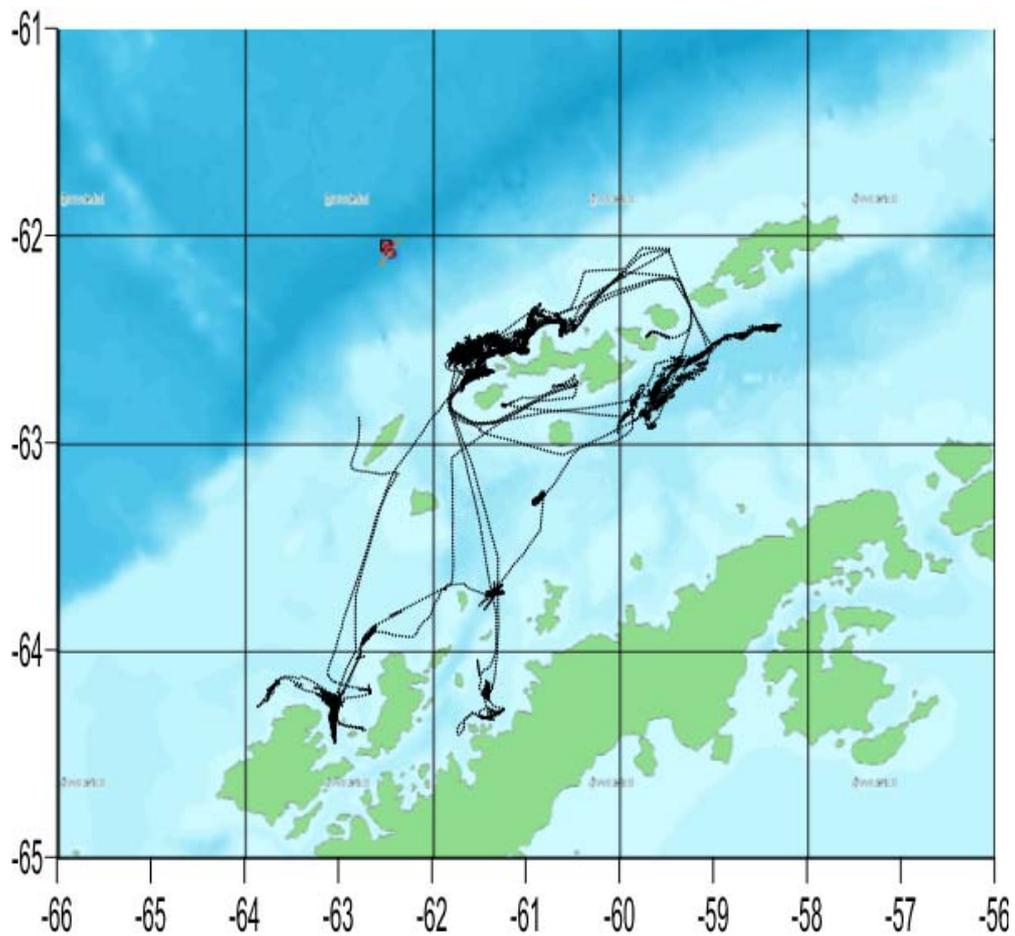


Figure 6: Location of the fishing vessel *Fukuei Maru* during krill fishing and collection of acoustic data in Subarea 48.1 in 2011/12.

## List of Participants

Subgroup on Acoustic Survey and Analysis Methods  
(Qingdao, People's Republic of China, 8 to 11 April 2014)

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## Agenda

Meeting of the Subgroup on Acoustic Survey and Analysis Methods  
(Qingdao, People's Republic of China, 8 to 11 April 2014)

1. Introduction
2. The scientific use of acoustic data collected on fishing vessels targeting krill
  - 2.1 Review acoustic data submitted from fishing vessels as part of the Proof of Concept
    - 2.1.1 What data have been submitted? – recalling the request for digital data geo-referenced and time-referenced with associated instrument metadata suitable for evaluation of data quality
  - 2.2 Development of protocols for data screening and analysis of acoustic data collected from fishing vessels
    - 2.2.1 Comparison of noise removal algorithms
    - 2.2.2 Degree of specification and standardisation required in noise removal and other processing steps
    - 2.2.3 What acoustic analysis protocols are needed to be put in place?
    - 2.2.4 Consider, and develop if required, a standard protocol (templates) for packages such as Echoview and LSSS (are there open-source options?)
    - 2.2.5 Survey statistics
  - 2.3 Routine data analysis, management and storage (CCAMLR, SONA, IMOS)
3. Assessment of the effectiveness of current CCAMLR acoustic analysis protocol
  - 3.1 How well is this working, is it being applied consistently and correctly?
  - 3.2 Is there a need for any updates or modifications?
4. Consideration of new methods or procedures submitted to SG-ASAM
5. Recommendations to the Scientific Committee
6. Adoption of report
7. Close of meeting.

**List of Documents**

Subgroup on Acoustic Survey and Analysis Methods  
(Qingdao, People's Republic of China, 8 to 11 April 2014)

- |                      |   |
|----------------------|---|
| SG-ASAM-14/01        | Collection, processing and potential use of sonar data from krill fishing vessels<br>G. Skaret (Norway) and M.J. Cox (Australia)  |
| SG-ASAM-14/02 Rev. 1 | Background for evaluation of the suitability of the software suite Large Scale Survey System (LSSS) for inspection and processing of acoustic data from krill fishing vessels<br>G. Skaret and R.J. Korneliussen (Norway) |
| SG-ASAM-14/03 Rev. 1 | Report of acoustic survey of Antarctic krill using FV <i>FUKUEI-MARU</i><br>K. Abe, Y. Takao and T. Ichii (Japan)   |

## Draft instruction documentation on instrument setup Simrad ES60 Open-ocean data logging

This set of instructions describes how to set up the Simrad ES60 38 kHz 7° beamwidth echosounder to record data during acoustic transects.

### System requirements

- Simrad ES60 running software versions 1.4.xx or higher
- USB external hard drive
- Keyboard with Windows button  (only very old keyboards would not have this key)
- Mouse attached to ES60 PC
- GPS connected to the ES60

### System settings

- Set data to log to a folder on the external USB hard drive
- Set power to 2 000 W; Pulse length to 1.024 ms
- Set display range: 0–1 000 m
- Set bottom detection range from 5 to 1 000 m
- Set ES60 PC clock to UTC and reset against GPS time source
- Log data from port to port

If you are unsure how to adjust any of these settings, details on how to set them up are given below in steps 1 to 6.

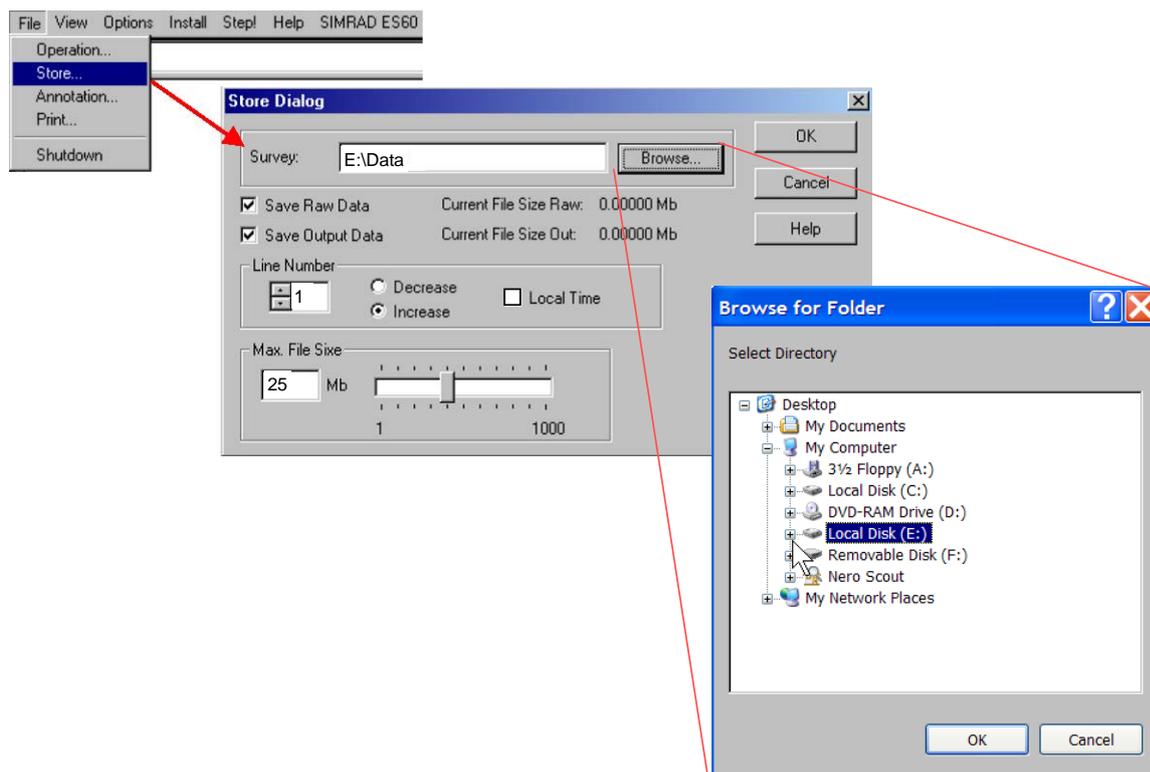
### A word of thanks

The areas that fishing vessels work in, and the transits to get there, give a unique opportunity to collect data. The information collected is forming part of a valuable dataset that is helping us to better understand the krill fishery.

Thank you for taking the time to record this data.

#### 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 button 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 button. This will take you back to the ES60 software.

\* For ES70 and EK60 recommend that the vessel use the call sign as file suffix to the recorded data.

## 2. Set Echosounder power and pulse duration

On the top of the ES60 screen, right click on the text '38 kHz' to bring up the transceiver settings dialog. Set the power to **2 000 W** and the pulse length to **1 024 microseconds** and click OK.

## 3. Set display range

Set the display range from 0 to 1 000 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 1 000 m. Note: if this reading is needed for navigational purposes, the depth setting should be reset.

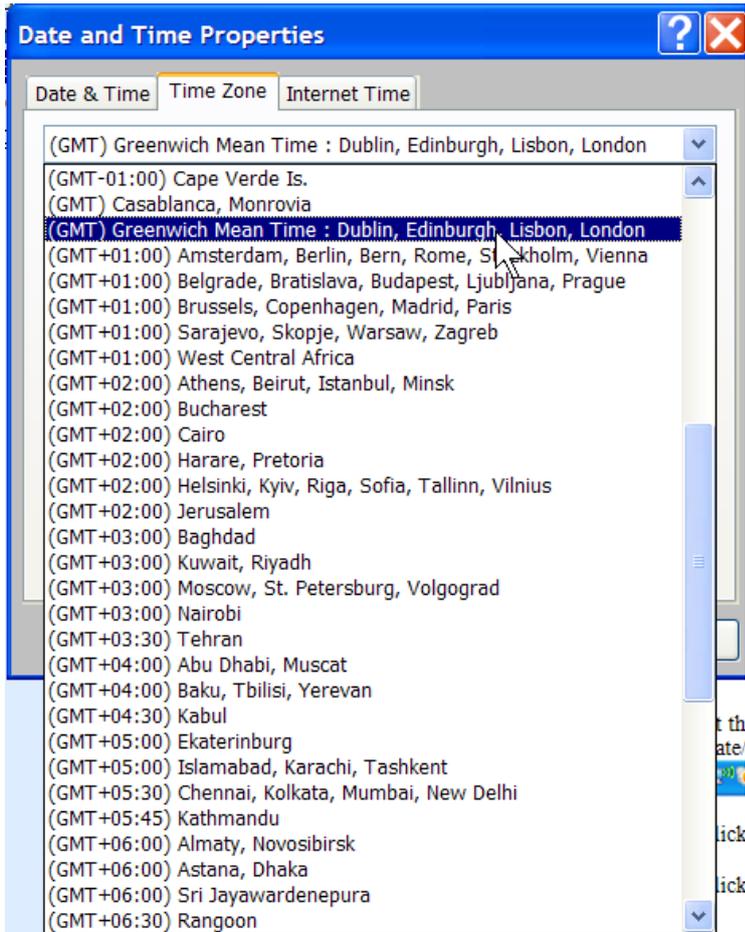
5. Set the ES60 PC clock to UTC

Hold the Windows button (  ) and press M to get to the ES60 PC's desktop.

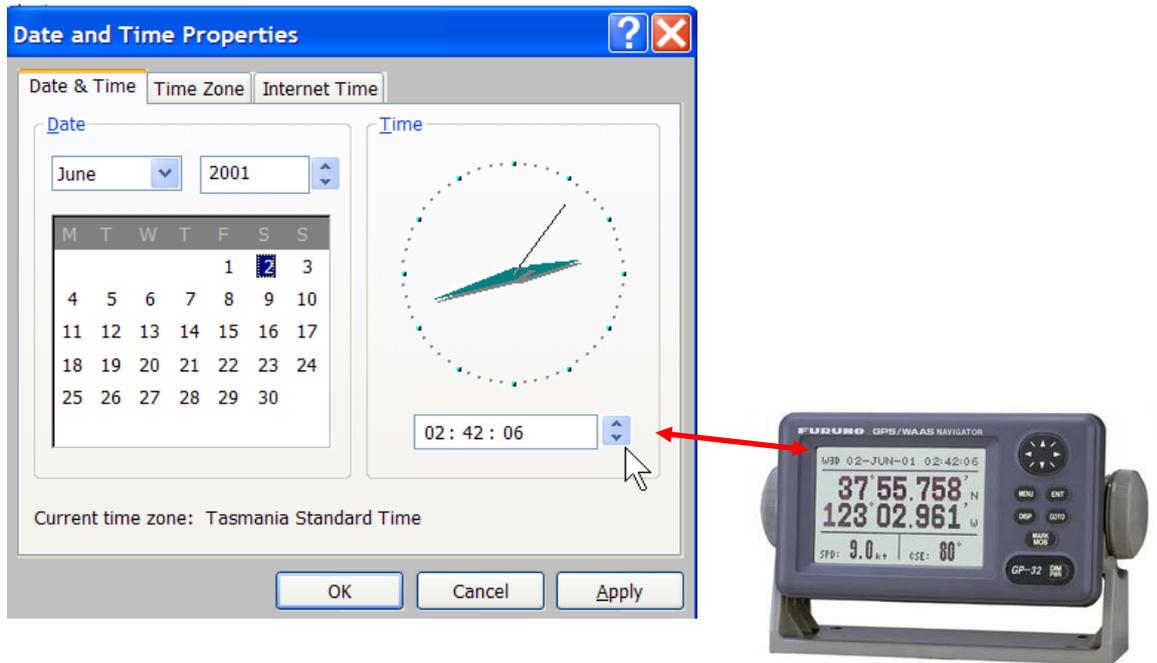
At the bottom right-hand side of the screen, double click on the time readout to bring up the Date/Time dialog.



Click on the Time Zone tab. Select GMT from the pick list and click OK.

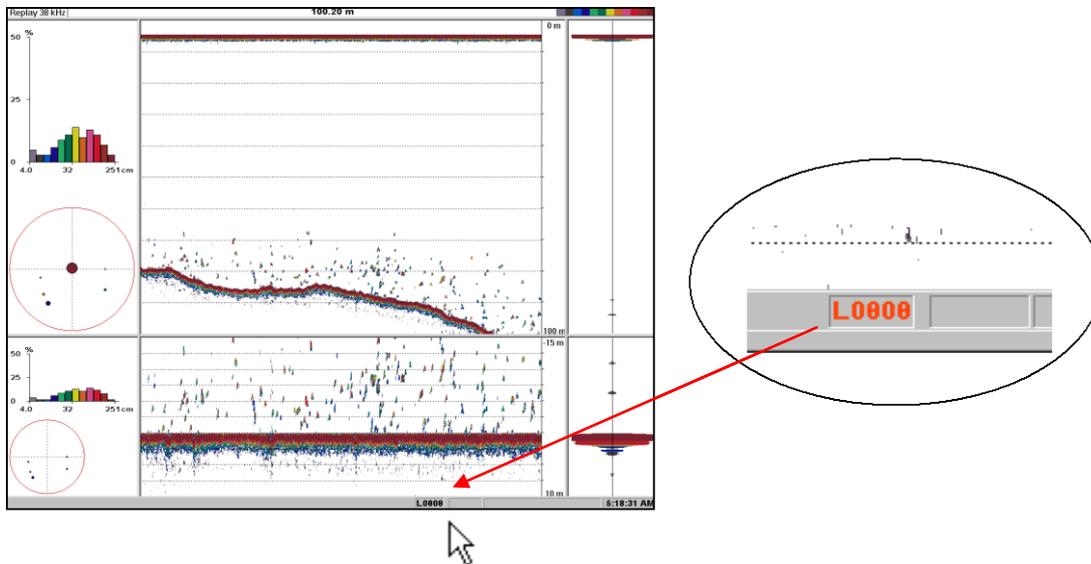


Click on the Date & Time tab. Reset the time to match the UTC time from a GPS readout.



## 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.



Turn off other sounders when logging in transects to avoid unwanted interference.

Tip: Log from port to port. This avoids the risk of forgetting to turn logging on when reaching deep water.

### An example of determining echosounder system performance by seabed comparison

When the seabed falls within the echosounder sampling range, seabed mean volume backscattering strength can be determined ( $S_v$ , UNITS: dB re  $1 \text{ m}^{-1}$ ). In Figure A1, an integration grid has been set up with 10 ping along transect and 2 m vertical cell dimensions. The ‘maximum  $S_v$  line pick’ in Echoview v5.4 (Myriax, Australia) was used to find the seabed boundary (Figure E1, seabed line) and offset a second line by 10 m from the seabed boundary line (Figure E1, offset seabed line). The integration grid was referenced to the seabed boundary line.

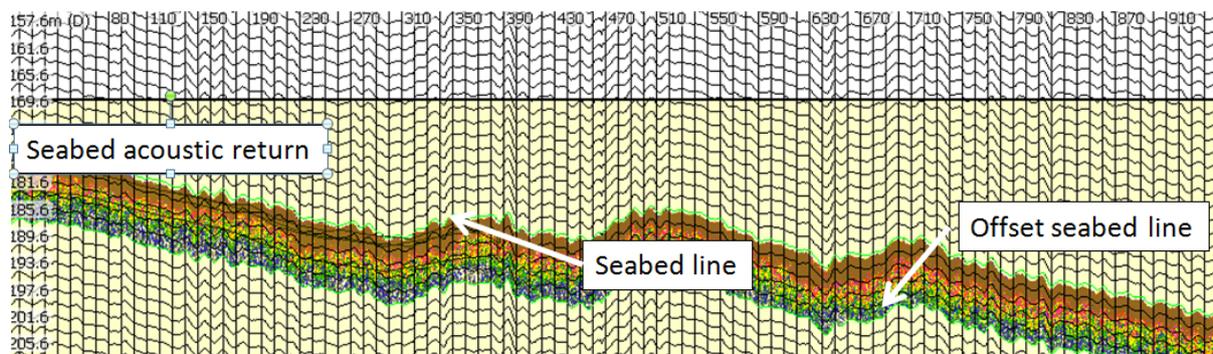


Figure E1: Example seabed echogram from a calibrated EK60 scientific echosounder operating at 38 kHz with a 10 ping by 2 m grid referenced to the seabed line. The echogram display threshold was  $-80 \text{ dB re } 1 \text{ m}^{-1}$ .

The echo integration results comprised of 477 cells that fell within the isolated seabed region. The cells had a range of  $-65.7$  to  $-5.5 \text{ dB re } 1 \text{ m}^{-1}$  and had a bimodal distribution (Figure E2).

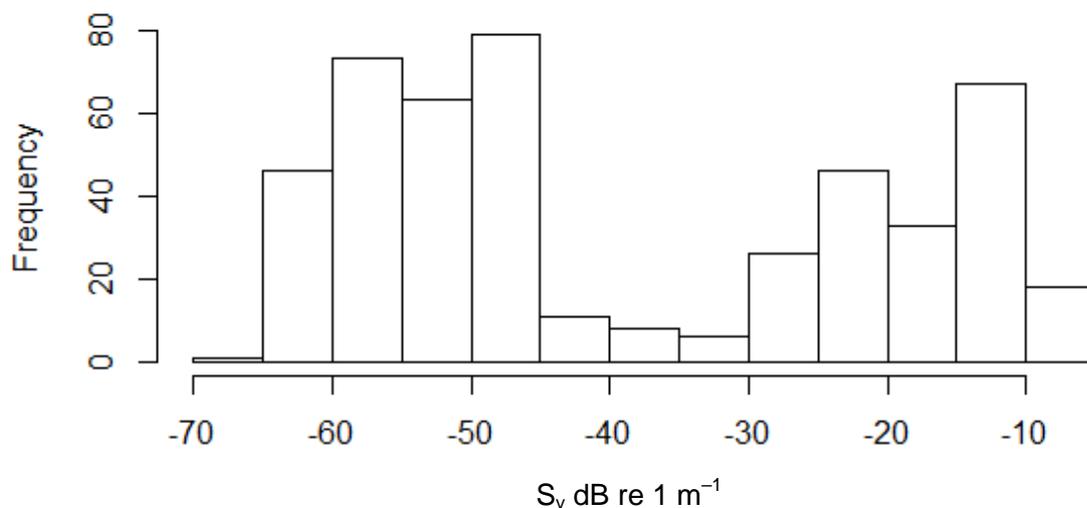


Figure E2: Echo integration results that fell in the seabed region in Figure A1.

As a preliminary investigation into the effect of integration cell size on the distribution of  $S_v$  values, the seabed was re-exported, using a 20 ping by 2 m grid. There was no significant difference between the 10 and 20 ping integration intervals (two-sample Kolmogorov-Smirnov test,  $D = 0.02$ ,  $p\text{-value} = 0.9$ ).

### Inter-vessel comparison

The seabed returns from two vessels can be compared by mapping each vessel's cumulative frequency distributions onto one another. To illustrate this technique, simulated  $S_v$  data have been taken from two vessels (Figure F1). The simulated values were drawn from a normal distribution, with the simulated data from vessel x having mean =  $-70$  dB re  $1 \text{ m}^{-1}$  and standard deviation  $5$  dB re  $1 \text{ m}^{-1}$ , and vessel y having mean =  $-50$  dB re  $1 \text{ m}^{-1}$  and standard deviation  $10$  dB re  $1 \text{ m}^{-1}$ . The 100 random sample histograms in the top row of Figure F1 are the simulated data from each vessel, and the bottom row is the empirical cumulative distribution (ECDF) for the simulated seabed  $S_v$  data for each vessel.

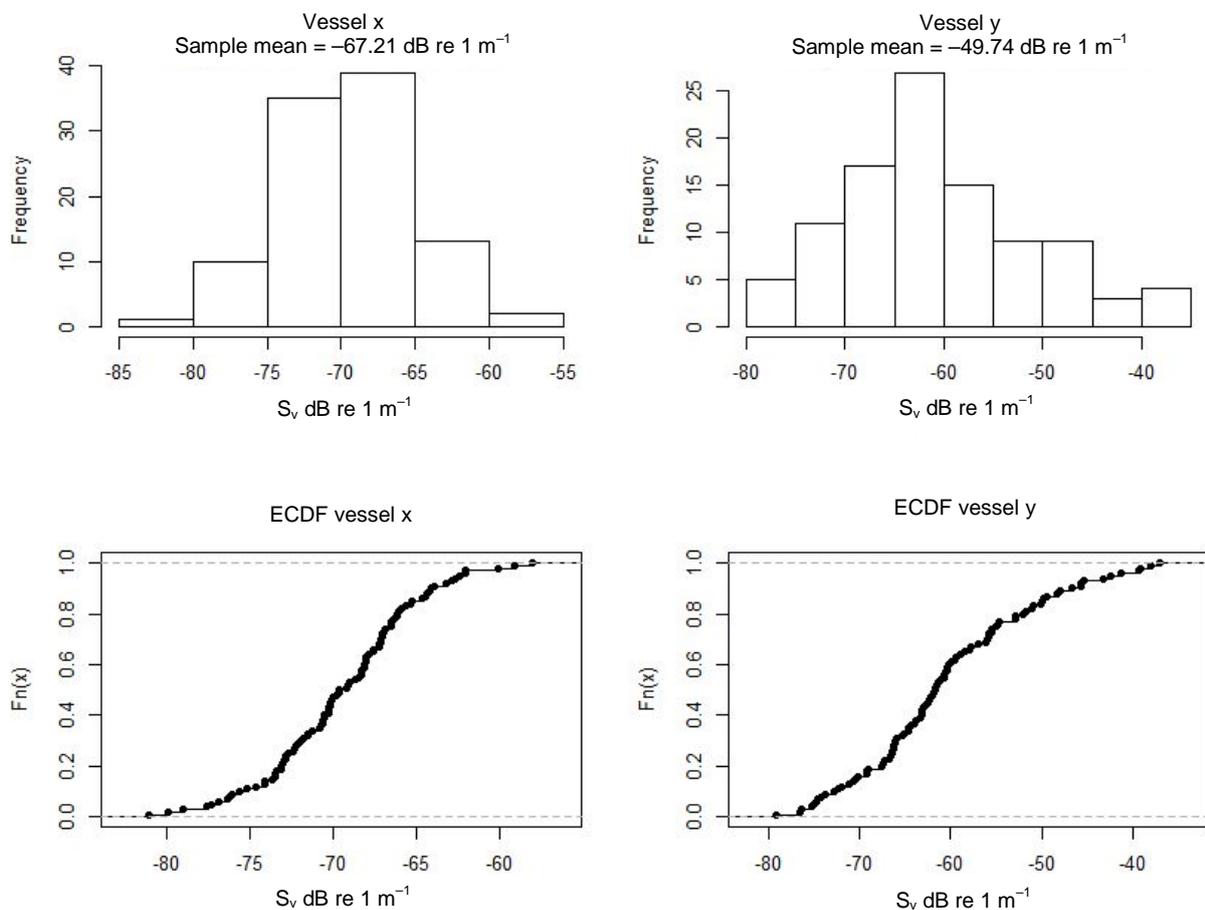


Figure F1: Inter-vessel comparison using seabed returns. Top row is the distribution of simulated  $S_v$  data from two vessels and the bottom row is empirical cumulative distribution function for each vessel.

ECDFs for each vessel are then mapped onto one another (solid black line, Figure F2). This mapped line can then be used to transfer  $S_v$  values between vessels. This procedure broadly follows that of Cox et al. (2010). Once mapped, the curve can be used to transfer  $S_v$  values between vessels. In Figure F2,  $S_v = -70$  dB re  $1 \text{ m}^{-1}$  from vessel x is transferred to vessel y, resulting in transferred  $S_v = -63$  dB re  $1 \text{ m}^{-1}$ . Uncertainty in the ECDF mapping can be

represented by resampling the  $S_v$  values from each vessel. In Figure F2, the simulated  $S_v$  data has been resampled (with replacement) 100 times and the ECDF mapping repeated for each resample (grey lines Figure F2).

The R code to carry out the ECDF mapping has been posted on the SG-ASAM e-group.

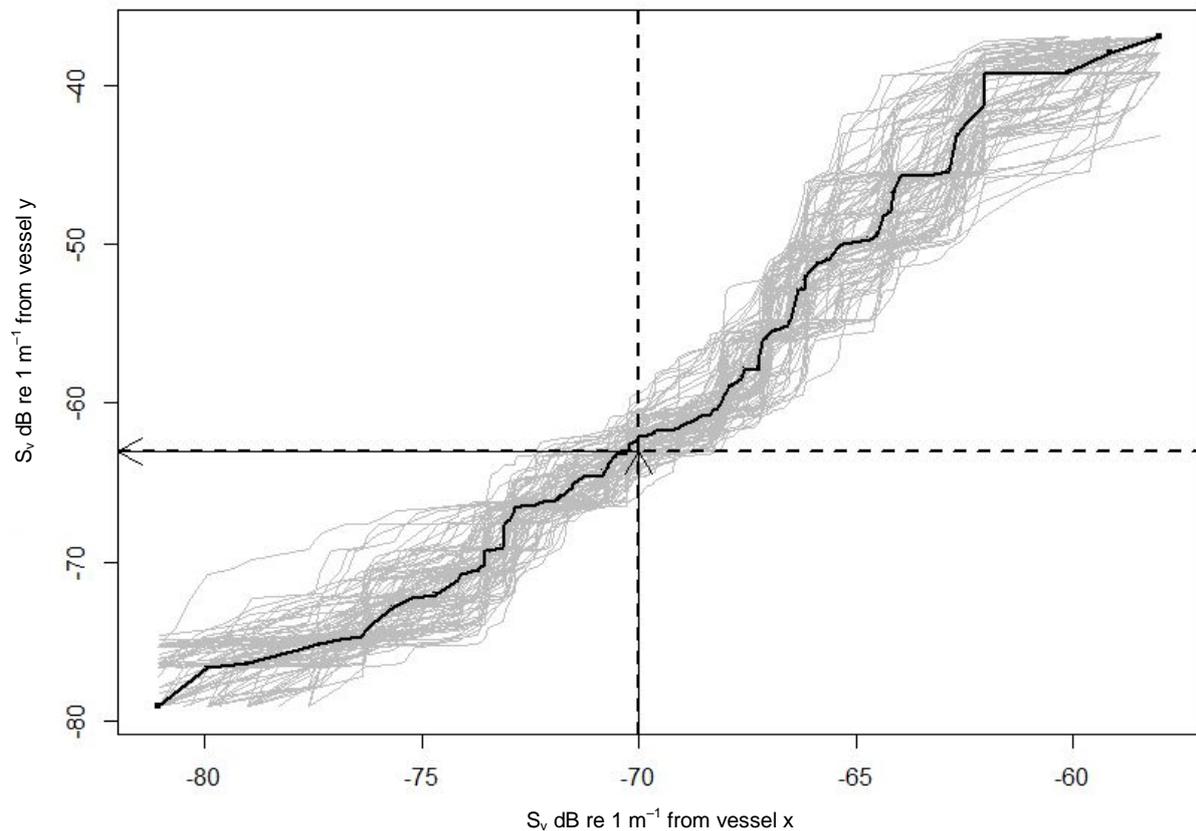


Figure F2: An example of empirical cumulative distribution function mapping. The mapped ECDFs are shown as a solid black line. The dashed lines and arrows illustrate the mapping of  $S_v = -70$  dB re  $1 \text{ m}^{-1}$  from vessel x to vessel y. The grey lines are the results of mapping ECDF based on resampling the  $S_v$  data 100 times.



**Report of the Working Group on  
Statistics, Assessments and Modelling**  
(Punta Arenas, Chile, 30 June to 4 July 2014)



## Contents

	Page
<b>Opening of the meeting</b> .....	153
Adoption of the agenda and organisation of the meeting .....	153
<b>A review of progress towards updated integrated assessments of toothfish</b> .....	153
Subarea 48.3 .....	153
Division 58.5.2 .....	154
Subarea 88.2 .....	154
Division 58.4.4 .....	156
A review of stock assessment methodologies used in CCAMLR's integrated toothfish assessments .....	158
Software version controls .....	158
External review .....	158
Seabed area calculations .....	159
Tag selection .....	159
Priority assessment methodology issues .....	160
Developments in integrated stock assessment methodologies for krill .....	161
<b>Evaluation of research plans from Members notifying to fish in new and exploratory fisheries in Subareas 48.6 and 58.4</b> .....	162
General .....	162
Subarea 48.6 .....	163
Divisions 58.4.1 and 58.4.2 .....	165
Division 58.4.3a .....	166
<b>Research proposals in other areas (closed areas, areas with zero catch limits, Subareas 88.1 and 88.2)</b> .....	168
Subarea 48.2 .....	168
Subarea 48.5 .....	169
Division 58.4.4 .....	170
Ross Sea region – SSRUs 882A–B .....	171
Ross Sea region – toothfish sub-adult survey .....	172
Subareas 48.1 and 48.2 .....	173
<b>Other business</b> .....	174
Fishery capacity .....	174
Fishery Reports .....	174
Stock assessment course .....	175
Translation of CM 33-03 .....	175
<b>Advice to the Scientific Committee</b> .....	175
<b>Adoption of the report and close of the meeting</b> .....	176
<b>References</b> .....	176

<b>Appendix A:</b>	List of Participants .....	178
<b>Appendix B:</b>	Agenda .....	182
<b>Appendix C:</b>	List of Documents .....	183

**Report of the Working Group on  
Statistics, Assessments and Modelling**  
(Punta Arenas, Chile, 30 June to 4 July 2014)

### **Opening of the meeting**

1.1 The 2014 meeting of WG-SAM was held at the Laboratorio Berguño, Chilean Antarctic Institute (Instituto Antártico Chileno – INACH), Punta Arenas, Chile, from 30 June to 4 July 2014. The meeting was convened by Dr S. Hanchet (New Zealand) and local arrangements were coordinated by Dr J. Arata (Chile) with support from INACH.

1.2 Dr Hanchet welcomed participants (Appendix A) and outlined the large workload that had been directed to WG-SAM and recalled that the role of the Working Group was to advise on quantitative and related issues relevant to the work of the Scientific Committee and its other working groups.

#### Adoption of the agenda and organisation of the meeting

1.3 The agenda was adopted (Appendix B).

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

1.5 In this report, paragraphs that provide advice to the Scientific Committee and its other working groups have been highlighted. A list of these paragraphs is provided in Item 6.

1.6 The report was prepared by Drs M. Belchier (UK; WG-FSA Convener), C. Darby (UK), C. Jones (USA; Chair of the Scientific Committee), S. Mormede and S. Parker (New Zealand), D. Ramm and K. Reid (Secretariat), Mr R. Scott (UK), Drs B. Sharp (New Zealand), D. Welsford and P. Ziegler (Australia).

### **A review of progress towards updated integrated assessments of toothfish**

#### Subarea 48.3

2.1 WG-SAM-14/35 described analyses of nine years of data derived from tagged and recaptured toothfish in Subarea 48.3, including movement, growth, tag shedding and maturation rates. The Working Group noted that comparable tag characterisations would be useful for all fisheries, and summary data, including numbers of fish tagged, released and recaptured, tag-overlap statistics, tag shedding, post-tagging mortality estimates and spatial distribution of tags would be useful to include in the Fishery Reports. The Working Group requested that the Secretariat examine the potential for providing such summaries for consideration at WG-FSA-14. It also welcomed the plan by UK scientists to conduct further

analysis of reproductive biology and the spatial dynamics of toothfish in Subarea 48.3. The Working Group noted that the mean tag overlap statistic for length frequencies had increased through time, from around 65% between 2004 and 2006 to around 85% between 2010 and 2013.

#### Division 58.5.2

2.2 WG-SAM-14/23 Rev. 1 described progress towards an updated assessment for toothfish in Division 58.5.2, including ageing otoliths collected from recent surveys and commercial fishing, re-estimation of the growth function taking account of selectivity, and proposed revised weightings of the survey time series. The authors noted that CASAL version 2.30-2012-03-21 rev 4648 will be used to conduct the revised assessment.

2.3 The Working Group noted that currently the assessment assumes the trawl survey has a  $q = 1$ . It recommended that tests of the sensitivity of the assessment to  $q$  be conducted, as well as estimating  $q$  within the assessment. It noted that the survey estimate of biomass on the main trawl ground could be compared to biomass estimates calculated from the tag recaptures in the surveys to create a prior for  $q$ .

2.4 The Working Group recommended that ageing toothfish from the most recent surveys should be a priority, to enable improved estimates of year-class strength (YCS) and ageing of samples from the commercial longline fishery, to enable better estimation of fishery selectivity and growth of male and female fish above twenty years old. It also recommended sensitivity testing of the age set for the plus group based on the distribution of ages observed in the fishery and investigation of the trends in survey length frequency.

2.5 The Working Group agreed that tag releases and recaptures from the longline fishery could be used to provide an index of abundance for adult toothfish. The Working Group noted that, because toothfish movements and spatial patterns of fishing effort can generate bias in tag-based biomass estimates, actual fishing effort patterns and apparent fish movements in this area should be considered in any such application of tag data to the assessment.

2.6 Dr Ziegler presented a map illustrating the historical concentration of tag releases in a small number of spatially restricted trawl grounds and the patchy distribution of longline effort around the slope through time in Division 58.5.2. The Working Group noted that methods to account for this bias were currently being investigated, including developing movement and fleet dynamics models to reduce any bias that would be introduced by including these data in their entirety in an integrated assessment. It also noted that tag-based abundance estimates could be calculated external to CASAL using subsets of data that better meet model assumptions and that such analyses may provide a useful context in interpreting the revised assessment.

#### Subarea 88.2

2.7 The Working Group noted work to progress an assessment of toothfish in Subarea 88.2, including: consideration of stock structure (WG-SAM-14/26), otolith microchemistry analyses (WG-SAM-14/33), a spatial description of the fishery and biomass

estimation on individual seamounts and the use of tag data to estimate abundance (WG-SAM-14/08 and 14/27), a proposed CASAL assessment (WG-SAM-14/29) and options for improving the amount and quality of information for the SSRUs 882C–G portion of the subarea (WG-SAM-14/28).

2.8 WG-SAM-14/26 presented a stock structure hypothesis in Subareas 88.1, 88.2 and 88.3 comprising two spawning components with some potential mixing between the two in the juvenile stage. The Working Group noted the preliminary results of otolith microchemistry analyses (WG-SAM-14/33) which indicated that adult fish in SSRUs 881C and 882H may have occupied different habitats as juveniles. The Working Group considered that, whilst there was some evidence that identified separate population units in Subareas 88.1 and 88.2, there was insufficient evidence to conclude that there is a clear stock separation between the two areas. The Working Group agreed that the most precautionary approach would be to consider toothfish in Subareas 88.1 and 88.2 as separate management units as is currently assumed in the existing management approach and that additional research would be useful to further test or develop the hypothesis.

2.9 The Working Group noted the additional information that can be obtained from the use of satellite tags and considered that a multinational collaborative program would be a useful approach.

2.10 During the meeting, analysis of decay rates of tag recaptures showed an ability to monitor the decline of cohorts of tags over a period of three to four years. Furthermore, the decay rates had steeper gradients in the most recent years, indicating increasing exploitation rates over time and potential localised depletion consistent with the results of WG-SAM-14/27. The Working Group recommended that revised estimates of abundance, including seamount-specific estimates, be calculated using tag-recapture information for one, two and three years at liberty using both the Petersen and Chapman methods and that this matter be referred to WG-FSA for further consideration. The Working Group further considered that updated stock assessments in this area should evaluate the use of tagging data up to three years at liberty as well as the estimation of emigration rates.

2.11 The Working Group recalled the previous analyses of Agnew et al. (2006) and Welsford and Ziegler (2013) and noted the potential for bias in abundance estimates derived from spatially clumped tag-release and -recapture data. The analysis in WG-SAM-14/27 suggested that actual fishing effort in SSRU 882H is spread across all fishable habitat and that fishing patterns are relatively consistent between years, indicating that the effects of spatial bias are likely to be low. Dr Constable informed the Working Group of preliminary analyses to investigate the potential bias in total population estimates derived from localised tag recaptures around seamounts. The Working Group considered this to be a useful and important analysis and recommended this be submitted for consideration by WG-FSA.

2.12 The Working Group recalled the advice of the Scientific Committee in 2013 (SC-CAMLR-XXXII, paragraphs 3.165 to 3.167) that to date the majority of tags had been recaptured from the northern area and that fishing in the south had been conducted on an intermittent basis and not in spatially consistent locations. The Working Group considered a number of options for the estimation of toothfish biomass in Subarea 88.2, including integrated assessments using CASAL and biomass estimates based on tag recaptures for both the northern and southern areas.

2.13 The Working Group identified the following options that should be presented to WG-FSA for further consideration:

- (i) a CASAL-based assessment for SSRU 882H
- (ii) a CASAL-based assessment for the whole of Subarea 88.2 that excludes tag-recapture data for the southern area
- (iii) tag-based abundance estimates calculated using recaptures of tagged fish up to three years at liberty.

2.14 The Working Group considered that in SSRUs 882C–G obtaining tag-based estimates of abundance should be a priority. The Working Group agreed that options for the spatial management of fishing effort within SSRUs 882C–G should be presented to WG-FSA in order to better facilitate abundance estimation from the tagging program.

2.15 The Working Group discussed what percentage value should be used as an appropriate exploitation level when determining catch limits from estimates of total stock abundance. The Working Group recalled the previous work of Welsford (2011) and de la Mare et al. (1998) and noted that a value of 4% is currently used within research blocks in data-poor fisheries. The Working Group noted that the 4% value had been determined from analyses on Patagonian toothfish (*Dissostichus eleginoides*) and recommended that a revised analysis for Antarctic toothfish (*D. mawsoni*) should be conducted for consideration by WG-FSA.

2.16 The Working Group noted that any proposal to change the method by which exploitation rates are determined must have a strong scientific foundation and identified the following options by which an appropriate value might be determined:

- (i) use of the GYM to estimate an appropriate gamma value
- (ii) a fishing-mortality-based strategy informed by catch curves and tag-cohort analyses
- (iii) an approach similar to that currently used for icefish.

2.17 The Working Group noted that in the context of determining appropriate catch limits, it is important to distinguish between estimates of local biomass obtained from within research blocks and estimates of abundance of the whole stock derived from analytical assessments to which the CCAMLR harvest control rules are applied.

#### Division 58.4.4

2.18 Two CASAL assessments were presented for toothfish in Division 58.4.4.

2.19 WG-SAM-14/15 presented a revised assessment for *D. eleginoides* in research block C of Division 58.4.4 that explored the potential for the inclusion of additional information in the assessment model, including catch-at-length and age information, the use of annual age-length keys (ALKs) and revised maturity estimates. The maximum of the posterior density (MPD) results of several comparative assessments using the revised data showed generally

consistent estimates of initial and current biomass and fairly good fits to age composition and tag data. However, some large differences were evident between the MPD estimates and median values of the Markov Chain Monte Carlo (MCMC) analyses.

2.20 The Working Group noted the highly structured nature of fishing under the research plan and considered that good progress was being made towards the development of an assessment for this area. The Working Group further noted that although there was general consistency in the MPD results of the assessments, they were all characterised by high uncertainty and that MCMC analyses continue to show poor convergence.

2.21 Dr K. Taki (Japan) noted the high incidence of IUU fishing in this area and the Working Group recommended that an analysis of IUU fishing scenarios would be useful for further consideration by WG-FSA.

2.22 WG-SAM-14/18 presented further developments of a CASAL assessment for toothfish in Division 58.4.4 that explored a number of potential IUU fishing scenarios and compared the results of those assessments to estimates of abundance derived from Petersen tag-based approaches. The Working Group noted that estimates of IUU fishing based on sightings data have not been calculated for the recent period. The Working Group encouraged further analyses to estimate levels of IUU fishing, including within the CASAL framework.

2.23 The Working Group commended the progress made by France (WG-SAM-14/18) and Japan (WG-SAM-14/15) towards the development of the assessment but noted some differences in the input data between the two sets of input files and recommended that closer collaboration on the calculation of these data would lead to more consistent results between the two approaches. The Working Group made a number of recommendations regarding the standardisation of input data, including the use of consistent estimates of natural mortality, maturity and growth and alternative priors for initial biomass estimates. The Working Group noted that age data are available and could be included in the assessment.

2.24 The Working Group recommended that further development of the assessment in Division 58.4.4 should consider the following:

- (i) estimation of YCS
- (ii) data weighting
- (iii) estimation of IUU catches using fixed selection patterns (possibly based on expert knowledge of likely selection patterns)
- (iv) use of CCAMLR harvest control rules to calculate future yield options.

2.25 The research programs for Division 58.4.4 are further discussed in paragraphs 4.13 to 4.15 and comments on the difficulties encountered when undertaking multiple research programs in the same area are given in paragraphs 3.4 and 3.5.

## A review of stock assessment methodologies used in CCAMLR's integrated toothfish assessments

### Software version controls

2.26 WG-SAM-14/32 presented a protocol for version control of stock assessment software within CCAMLR, with the specific example of the CASAL program. It was proposed that the latest version approved by CCAMLR of any stock assessment software submitted to CCAMLR should be used by default to conduct assessments, unless a newer update or development version was regarded as necessary, in which case it was considered the responsibility of the software user to demonstrate that the latest development version performed as expected.

2.27 The Working Group considered the process of software validation, version control and usage within CCAMLR, noting that this was a CCAMLR responsibility and that processes for new software had previously been agreed by WG-SAM in 2007 (SC-CAMLR-XXVI, Annex 7, paragraph 6.3) and has been reiterated on a number of occasions (e.g. SC-CAMLR-XXVIII, Annex 6, paragraph 5.11). In the past it was considered that the introduction of new software for review requires:

- (i) the method, procedure or approach be submitted to WG-SAM with sufficient information to enable replication of the model. This includes, but is not limited to, the software package or code and the input data
- (ii) the method, procedure or approach be tested against previously documented and appropriate scenarios, simulated data or other ecological models
- (iii) the realism and suitability of the method, procedure or approach be reviewed by the relevant working group (WG-EMM, WG-FSA or WG-IMAF).

2.28 The Working Group considered a process for version control and agreed that a CCAMLR e-group<sup>1</sup> (led by Dr Darby) be established to further develop and recommend a protocol that will include a process for validating and approving software updates and present a paper to WG-FSA-14.

2.29 The Working Group further recommended that CASAL version 2.30-2012-03-21 rev 4648 be considered the current approved CCAMLR version until a process is agreed for validating and approving updated software. This version was provided at the meeting and is to be posted on the CCAMLR website. The use of newer versions of CASAL would need to be reviewed by WG-SAM and would require documentation and sufficient justification.

2.30 The Working Group noted that the R library associated with version 2.30-2012-03-21 rev 4648 of CASAL is compatible with R 2.x versions only and this should be noted on the CCAMLR website, and should be considered by the e-group (paragraph 2.28).

### External review

2.31 WG-SAM-14/16 presented the ICES Benchmark Protocol, which is a review process for evaluating the data and analyses that form the basis of ICES management advice for a

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<sup>1</sup> CCAMLR e-groups can be accessed from the [CCAMLR homepage](#) and are available to authorised users.

stock. A full stock review is conducted every three to five years for each stock in turn and protocols for the assessment data and model structure specified. Assessments are conducted following the benchmark-agreed protocol with the only update being the addition of new data each year. ICES benchmark meetings review the stock structure, fishery characteristics, biological and assessment data, stock assessment and projection methodology. The review includes experts from outside of the ICES community and stakeholders to broaden knowledge and enhance credibility. The paper noted that ICES science was strongly independent of the political process and majority decisions were the norm. It also noted that introducing benchmarking of CCAMLR assessments would be expected to provide greater transparency, quality control and stability to WG-FSA and the Scientific Committee management advice and to improve communication between scientists, the industry, stakeholders and administrators. The ICES stock annexes, equivalent to CCAMLR Fishery Reports, and the ICES advisory sheets were also presented to WG-SAM for illustration.

2.32 The Working Group recalled that the Scientific Committee had agreed that independent expert reviews of CCAMLR stock assessments would be valuable and should be facilitated (SC-CAMLR-XXXII, paragraph 3.66). The Working Group agreed that external reviewers would assist in making CCAMLR stock assessment reviews more transparent and robust and that their contributions to assessment review meetings, or even as contributors to WG-SAM during assessment years, could be valuable, although this would have obvious budget implications.

2.33 Recalling Scientific Committee agreement (SC-CAMLR-XXXII, paragraph 3.66), the Working Group recommended a process by which a detailed review of a selected stock assessment could be conducted in the year prior to an assessment year. Independent reviewers would be appointed by the Scientific Committee and the chair of that panel be appointed to manage the meeting and the provision of a report of the review. The review could be conducted in the country of the Member conducting the assessment and would be open to other Members. The review would be facilitated by the Secretariat and would likely require a week to complete. The independent reviewers would present a report of their evaluation of the assessment to WG-SAM and to the Scientific Committee. The Working Group considered that identifying one assessment per assessment cycle would be an appropriate workload detailed in a multiyear work plan.

#### Seabed area calculations

2.34 The Working Group noted that seabed areas had been recalculated by the Secretariat for subareas, SSRUs and research blocks and that these are now available in the *Statistical Bulletin*.

#### Tag selection

2.35 The Working Group recalled that decisions about how to use tagging data of varying quality in a stock assessment are critical in tag-based stock assessments. The Scientific Committee agreed in 2012 that the approach described in Mormede and Dunn (2013) using pairwise tagging performance metrics indicative of tag-detection rates, should be further developed for use in stock assessments (SC-CAMLR-XXXI, paragraph 3.167). The method

described in WG-SAM-14/30 calculates relative indices of effective tagging mortality and effective tag detection for each vessel and weights the contribution of each vessel's tagging data in the assessment based on each index independently, thus allowing all of the tagging data to be used.

2.36 The Working Group agreed that the revised method provided an appropriate approach to weighting tag data for stock assessments.

2.37 The Working Group agreed that the method should be used in the Ross Sea stock assessment and could also be considered for use in all other areas where tagging data are used in stock assessments.

2.38 Dr A. Petrov (Russia) made the following statement:

'Some Members have stated doubt about the necessity of the use of the presented method for the stock assessment of SSRUs 882C–H in 2014, because of a small representativeness of the data. I suggest to continue work on the presented method on more statistical material.'

2.39 WG-SAM-14/31 presented an updated spatial population model (SPM) for the Ross Sea region. Changes resulted in better fits to maturity, age composition, tagging information and in the estimated residence times in the northern area. The model can now be run at a fine scale (population distributed among 446 cells) and is intended to be used to test different hypotheses of fish distribution patterns within the Ross Sea and as a management strategy evaluation tool, for example, calculating the potential for stock assessment bias due to spatial changes in the toothfish tagging program, or the estimation of local exploitation rates. Further, spatial population models are useful research planning tools and can be used to identify critical information gaps.

#### Priority assessment methodology issues

2.40 The Working Group discussed a framework by which high-priority assessment methodology issues could be progressed within CCAMLR. Several longstanding issues were discussed and placed into a priority list for future work. The Working Group recommended that over the next few years, the most important issues to progress in order of priority were:

- (i) The development of standard diagnostic tools for integrated stock assessments. These include data characterisation and summary diagnostics prior to conducting an assessment, diagnostics associated with assessing model performance and convergence and diagnostics associated with MCMC interpretation. This would also include the estimation and characterisation of cryptic biomass.
- (ii) Developing recommended data weighting and screening procedures.
- (iii) Refinement of a standardised process for local biomass estimation and the subsequent development of advice on catch limits considering precautionary exploitation rates in data-poor fisheries, consistent with previous advice (SC-CAMLR-XXXII, paragraphs 3.170, 3.171 and 3.183).

- (iv) Analysis and management strategy evaluation of CCAMLR harvest decision rules.
- (v) Comparison of MCMC and covariance resampling methods.
- (vi) Methods to determine the influence of spatial patterns of tag releases and fishing effort on estimates of stock dynamics determined from tag-based analyses, e.g. on seamounts (paragraph 2.12).

2.41 The Working Group considered that the highest priority was the development of standard diagnostic tools for integrated assessments. To progress this item, the Working Group recommended that papers describing common diagnostic information needs that are common to all integrated stock assessments in CCAMLR be identified and submitted to WG-FSA. In addition, papers are requested that review integrated stock assessments used in other regions and identify useful diagnostic methods that could be used within CCAMLR to also be submitted to WG-FSA-14. The Working Group requested WG-FSA review and integrate these results to identify an agreed set of diagnostic procedures that could be further developed into an R library and made available through the Secretariat via a software repository. The Working Group considered that development of a CCAMLR e-group led by Dr Ziegler would be a useful way to progress this issue in the short term.

2.42 The Working Group recalled the work by Ziegler (2013) which showed that a low tag-overlap statistic can introduce bias into tag-based assessments. The Working Group recommended that methods to account for potential bias in assessments resulting from low tag overlap, e.g. inverse weighting of cohorts of tags, be investigated. It also recommended that a spatial overlap statistic be developed to reflect the fact that fish movement and fleet dynamics may result in changes to the number of tags that are available for recapture.

#### Developments in integrated stock assessment methodologies for krill

2.43 WG-SAM-14/20 described an integrated stock assessment model for krill that combines an age-structured cohort model with survey observations. This is a single-area population model that uses survey data collected by Germany (RMT8 net sampling), the USA (IKMT net samples and hydroacoustic transects) and Peru (IKMT sampling) that is organised into different temporal aggregations (annual, seasonal or monthly).

2.44 The Working Group noted the substantive progress in developing an integrated assessment for krill since the last paper (WG-EMM-12/27) that represented four areas and attempted to estimate movement between them. A single-area model approach was adopted since the four areas were close together and estimating movement proved to be difficult due to paucity of data.

2.45 The Working Group discussed the krill population biomass estimated by the different model scenarios. Estimating population biomass was sensitive to the level of survey aggregation that was used in different scenarios. Biomass was estimated, together with natural mortality and other parameters, such as steepness of the stock-recruitment relationship, without a scaling factor or bounds. High estimates of natural mortality equal to, or greater than, 1 resulted in good model fits to the data, but also led to high ratios of total biomass compared to spawning stock biomass (i.e. large numbers of young krill). The Working Group

suggested that age- or length-specific natural mortality may be explored. The structure of the model meant that the area over which the biomass was estimated was unconstrained; the biomass estimates could represent not only the survey area itself, but also a wider, yet unknown, area outside of this. The overall biomass estimates were in the range of the estimates from the CCAMLR-2000 Survey when scaled up to the entire Scotia Sea, although estimates based on different temporal aggregations of the data varied widely. The Working Group encouraged evaluating and including environmental correlates with biomass in the model to allow for future projection of biomass.

2.46 Dr Petrov made the following statement:

‘Total abundance of krill-dependent predators is currently not known, which means that the total krill consumption by predators cannot be determined at present. Influence of predators on krill stock cannot be estimated also. At the same time, available data show that annual krill consumption by predators will be significantly higher than the annual catch. Therefore, integrated models may be insufficient for adequate modelling of the population dynamic of krill in Subarea 48.1. According to the work of Steve Nicol to be presented at the ARK workshop in Punta Arenas, Chile, the total krill consumption by predators is 48 million tonnes, and the total catch is approximately 200 000 tonnes, i.e. catch equals 0.4% of the total krill consumption by predators.’

## **Evaluation of research plans from Members notifying to fish in new and exploratory fisheries in Subareas 48.6 and 58.4**

### General

3.1 The Working Group commended the high standard of the research plans, which has improved substantially over the last few years. It acknowledged the improvement in the research proposals, the analysis and presentation of the results and the effort of Members to start ageing otoliths. The Working Group followed the established process to review the design and methodology in research proposals and noted that WG-FSA would review the catch limits. This process is described in SC-CAMLR-XXXII, paragraphs 3.170, 3.171 and 3.183.

3.2 The Working Group noted that the reviews of progress in developing assessments based on research proposals did not include all the data available, as some data from the current season were not available at the time of the analysis. The Working Group recommended that the table generated at WG-FSA-13 (SC-CAMLR-XXXII, Table 3) for assessing research proposals be used as a template to be updated by the Secretariat in advance of WG-SAM and WG-FSA each year. It further recommended that three columns be added with data from the most recent season: actual catch to date, expected tags recovered given that catch, and actual tags recovered.

3.3 The Working Group recommended that available data in the CCAMLR database could be used by the Secretariat to start developing circumpolar habitat modelling of toothfish. It further noted that an in-depth review of all research should be undertaken at the end of the initial three years and would be useful to evaluate how Members had addressed their planned objectives. However, it also noted that in many areas the approved research plans have not yet been implemented.

3.4 The Working Group noted that in most cases two or more Members were carrying out research fishing under CMs 21-02 or 24-01 in the same parts of the Convention Area. The Working Group discussed approaches for harmonising this research, including operational aspects of the fishing by vessels, data analysis and otolith age determination, as well as the development of stock assessments.

3.5 The Working Group recognised that there were practical difficulties in collaboration and coordination and encouraged the Scientific Committee to consider mechanisms that could be put in place to help Members to work together more effectively to deliver multi-Member research proposals to meet the needs of CCAMLR.

#### Subarea 48.6

3.6 The Working Group considered WG-SAM-14/01, 14/10, 14/11 and 14/21.

3.7 WG-SAM-14/10 reported on research fishing undertaken by Japan and South Africa in Subarea 48.6 in 2012/13 and the first two months of the 2013/14 season. The Working Group noted that to date there have been 31 recaptures of tagged fish, although nearly half of these have been within season. The Working Group suggested that the high level of within-season tag recapture was a result of spatial aggregation of fishing within the subarea. With these numbers of returns it was thought likely that the development of an integrated stock assessment in this subarea could be achieved as soon as 2015.

3.8 The Working Group noted that the use of higher-resolution bathymetry for maps of fishing locations would assist with the visualisation of fishing patterns and could help in refining the spatial extent of research blocks. The Working Group encouraged the gathering of bathymetric data from fishing vessels to develop more accurate depth data. It was noted that bathymetry data for the whole CCAMLR region is available via the CCAMLR-GIS and high-resolution data could be added.

3.9 Members undertaking research noted evidence of increasing IUU fishing activity in Subarea 48.6. The Working Group expressed concern about the potential for high levels of unreported fish mortality through IUU fishing, which increases the uncertainty associated with assessments.

3.10 The Working Group thanked Japan and South Africa for the progress made on their research within Subarea 48.6, which demonstrated how close and effective collaboration could lead to considerable progress towards the development of an assessment.

3.11 WG-SAM-14/01 presented a revised research plan for Subarea 48.6 for 2014/15 by Japan. A number of revisions to the existing research plan were noted by the Working Group, including:

- (i) a request for increased flexibility under adverse ice conditions
- (ii) an increase in catch limit from 50 to 100 tonnes in research block 486\_3
- (iii) improvements to age-determination capacity by increasing access to reference sets.

3.12 The Working Group noted that estimated local exploitation rates associated with the proposed increased catch in research block 486\_3 remain lower than 4%, consistent with the agreed process for assessing appropriate catch limits.

3.13 The Working Group considered two suggestions by Japan aimed at improving operational flexibility in circumstances when difficult sea-ice conditions made it impossible for the vessel to deploy fishing gear in the designated research blocks. Japan requested that:

- (i) if both the buffer zone and extended buffer zone are inaccessible in heavy sea-ice, a vessel shall notify the Secretariat, and may attempt to set research lines in the nearest fishable area reasonably close to the original research block. In such a case the catch will be counted against the catch limit for the original research block
- (ii) when a vessel attempting to survey cannot find the nearest fishable area, the whole catch limit in that research block for the fishing season be carried over to the following season. The carried-over catch limit will be effective for the following season only.

3.14 The Working Group recalled previous substantive discussion around previous requests to move beyond the designated research blocks when sea-ice was problematic (SC-CAMLR-XXXII, paragraphs 3.177 to 3.181). The Working Group recalled that the primary aim of the research blocks is to ensure that fishing effort is located in areas where there is a high likelihood of recapturing tags and spatial overlap of fishing effort between years is maximised. Fishing outside the research block was unlikely to lead to the recapture of tagged fish and, therefore, would provide limited information to assist with the development of stock assessments. The Working Group was unable to provide further advice on this operational issue and recommended that it was given further consideration by the Scientific Committee.

3.15 The Working Group discussed Japan's request to carry over catch limits for a year within research blocks when heavy sea-ice made fishing impossible. Some participants expressed concern that this approach was not precautionary and could potentially lead to high fishing mortality on specific cohorts. However, it was noted that it was desirable to ensure that sufficient tags were available for recapture to progress the development of stock assessments and this may be facilitated by carrying the catch limits over for one year.

3.16 It was recalled that simulations (SC-CAMLR-XXVI, Annex 7, paragraph 6.13) had shown that inadvertent doubling of catches in a single year was unlikely to have any long-term impact on toothfish stock abundance and it was long-term average catches that were considered most important. However, it was noted that these analyses were applied to a single assessed stock and their findings may not be valid for data-poor fisheries.

3.17 The Working Group recommended that natural mortality should be considered and discounted from the following year's catch limit within a research block if the catch is carried forward. The Working Group requested that the issue of catch carry-over be further considered by WG-FSA.

3.18 The Working Group discussed the allocation of catches between years in the context of multiyear research plans. It was noted that in order to obtain sufficient data on which to base a stock assessment in a shorter time period, it may be beneficial to have higher tagging

rates within the first year of a research program with lower catches, and then increased efforts to recapture tagged fish with increased catches in subsequent years. Such a strategy may help overcome difficulties in tagging programs when there is a need for operational flexibility in areas subject to heavy ice years.

3.19 Concern was expressed that high tagging rates per tonne of fish caught could lead to a reduction in data quality due to operational constraints on vessels. Whilst there was general agreement that increasing tag availability at the start of a research program was likely to expedite the development of a stock assessment, each particular research program should be assessed on an individual basis.

3.20 The Working Group recommended that WG-FSA consider methods by which the effect of the tagging rate on data quality might be evaluated and by which the tagging rate of fish could be increased without impacting upon data quality.

3.21 Dr Taki informed the Working Group that Japan had started to develop an Antarctic toothfish ageing program and had been working with the Secretariat to obtain reference sets of otoliths. Issues had arisen with the distribution and availability of these sets, which had the potential to constrain the development of the program.

3.22 The Working Group requested that Members develop reference collections of digital images of otoliths to provide a useful additional resource to assist in the development of Members' otoliths ageing programs (SC-CAMLR-XXXI, Annex 7, paragraphs 10.1 to 10.19). It noted that these reference collections could be available from the Secretariat.

3.23 Details of the third year of South Africa's planned research in Subarea 48.6 were provided in WG-SAM-14/11. The Working Group noted that the research plan was the same as that undertaken in 2013/14, with no increase in catch requested.

3.24 WG-SAM-14/21 outlined research planned by the Republic of Korea in Subarea 48.6 and discussion on the research plan is provided in paragraph 3.27.

#### Divisions 58.4.1 and 58.4.2

3.25 Japan, the Republic of Korea and Spain had all proposed research fishing in Divisions 58.4.1 and 58.4.2 in 2014/15 as reported in WG-SAM-14/02, 14/03, 14/09, 14/12 Rev. 1 and 14/21. Only Spain fished this season and encountered some difficulties in conducting research fishing due to sea-ice conditions and also reported encountering an IUU fishing vessel and gillnet gear.

3.26 The Working Group considered the research reports and plan by Japan in WG-SAM-14/02 and 14/03 and noted no fishing was able to be conducted in 2013/14. Japan requested operational flexibility in case of sea-ice conditions for all its proposals (paragraphs 3.13 to 3.15). The updated catch limits where data were available were similar to those agreed in 2012/13, and the proposal was to continue the research as agreed in 2013/14.

3.27 The Working Group considered the research plan developed by the Republic of Korea in WG-SAM-14/21, which presented an integrated research program, including age and length composition, diet, reproductive biology, food-web structure including plankton

sampling, the routine use of conductivity temperature depth probes (CTDs) on longlines and the use of pop-up satellite tags in Subarea 48.6 and Divisions 58.4.1 and 58.4.2. It also included the routine use of CTDs by Korean vessels fishing in Subareas 88.1 and 88.2. The Working Group noted that the plan was comprehensive but ambitious and recommended prioritisation of objectives might be necessary, particularly in light of the benefits of focusing effort and the variable accessibility of some areas. The Working Group also noted the initial results from an otolith ageing program and encouraged Korea to submit a paper to WG-FSA describing its program and the results.

3.28 Regarding the Spanish depletion experiment and ongoing research plan in WG-SAM-14/09 and 14/12 Rev. 1, the authors noted that the experimental catch of 42 tonnes had been exceeded once in one SSRU in the first two years of the experiment and this may jeopardise the experiment in areas with high fish densities. The Working Group requested that the CV of the de Lury estimates of local biomass be provided to WG-FSA to be used to consider appropriate catch levels in the experiment and the value of such experiments relative to other methods for estimating biomass for use in stock assessments. It also recommended the survey area be stratified in areas of high and low catch rates and biomass be calculated accordingly.

3.29 The Working Group noted that there is a need to identify the area to which the biomass estimate would be applied and recommended that this be considered by WG-FSA. It noted that one possible method might be to use areal attraction and effective area, which could be calculated using an approach similar to that used to assess lithodid crab densities in Subarea 48.3 (Collins et al., 2002).

3.30 The Working Group noted that tags had been recaptured and recommended Petersen estimates be calculated where suitable. It also noted that the biomass calculation extrapolated to the scale of entire SSRUs assumed all areas had a high catch rate as observed in the location of the depletion experiment, when actually some exploratory locations had catch rates too low to run a depletion experiment.

3.31 Spain proposed that the experiment be carried out for another four years, to revisit the areas already fished and to carry on prospecting as much as possible, increasing the catch limit from 42 to 50 tonnes, with an expectation of a stock assessment by the end of 2017/18. The Working Group recommended that a full review of all the results be considered by WG-SAM-15 before a decision is made to extend the survey.

#### Division 58.4.3a

3.32 The Working Group noted that France and Japan had proposed to continue research in this division in 2013/14. The *Saint André* caught a total of 16 tonnes of toothfish and recaptured 22 tags, but the *Shinsei Maru No. 3* had not yet carried out its research. The Working Group further noted that France and Japan proposed to continue research in this division in 2014/15, as described in WG-SAM-14/04 (Japan) and 14/17 (France). The Working Group noted that the proposal was a very good example of international collaboration and should be commended.

3.33 The Working Group noted with concern that the concentration of effort and the large number of tags recovered out of a small catch (22 recaptured for 16 tonnes catch when 11

were expected for a total catch of 32 tonnes) indicated a high risk of localised depletion and unsustainable exploitation in the west, with no other known areas of high catch-per-unit-effort (CPUE) across the bank.

3.34 The Working Group noted that there had been an error in translation in the French version of CM 33-03 that had led to the by-catch move-on rule being triggered at lower levels of by-catch than in the English version (see also paragraph 5.9). This caused the French-flagged vessel to move to areas of lower macrourid by-catch which in turn caused greater spatial aggregation of longline sets.

3.35 The Working Group expressed concern that within the French catch, high levels of skate by-catch were observed in the west and macrourid by-catch in the east, and questioned the viability of fishing in this region with a gear type that has high by-catch rates. However, the Working Group noted that 94% of skates were released alive this season. It noted that in the previous year, fishing with trotline gear had not experienced this problem. It also noted that this was an opportunity to compare gear types and recommended an analysis of the differences between the gear types be carried out to better understand tag-recapture and by-catch rates. The Working Group noted that only five sets were carried out in the eastern area, as it was limited by high macrourid by-catch.

3.36 The Working Group noted that although CPUE was used as a basis for the catch limit in the proposal in WG-SAM-14/04, 11 tags were recaptured last year and 22 so far this season. These tag-recapture rates indicate that local exploitation rates may be substantially higher than the agreed limit of 4% applied for other data-poor fishery research plans. It further noted that the CPUE-based biomass estimate was likely to be biased high, because catch data used in the calculation all derived from a single location at which catch rates were high, but these were extrapolated over the entire area, including to areas in which catch rates are known to be much lower. The Working Group noted that a CASAL stock assessment was in development for this region which will help to address these issues.

3.37 The Working Group recommended France and Japan consider how to refine the research consistent with the agreed framework for research plans in data-poor fisheries (SC-CAMLR-XXXII, Figure 10). The Working Group recommended that a research block should be defined around the location in the western Elan Bank in which tags have been released. Petersen biomass estimates should be used to define a catch limit inside the research block with an appropriate local exploitation rate (i.e. not greater than 4%). Outside the research block (i.e. in the prospecting phase), in order to ensure spread of the effort, the Working Group recommended that a grid survey, similar to that used in Division 58.4.4, be implemented following the conclusion of this year's program.

3.38 The Working Group noted the ongoing research undertaken by France to investigate skate condition and mortality rate and recommended that an analysis of skate by-catch be carried out and presented at WG-FSA, including species-specific spatial analyses and investigating alternative functional forms of the relationship between catch and depth.

**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-14/13 and 14/22, which described a proposed research program by Ukraine to undertake a longline survey of toothfish in Subarea 48.2. The Working Group noted that the proposed survey design in 2014 remains largely unchanged from that initially proposed in 2013 (WG-SAM-13/15). The Working Group recalled that following WG-FSA in 2013 (during the meeting of the Scientific Committee and Commission), several participants of WG-FSA and the Secretariat had worked closely with Ukrainian scientists to modify the proposed research plan in accordance with working group advice (see SC-CAMLR-XXXII, Annex 4, paragraphs 3.14 to 3.21; SC-CAMLR-XXXII, Annex 6, paragraphs 6.70 to 6.79). Some Members noted that the 2014 proposal did not incorporate these modifications. The Working Group recommended that Ukrainian scientists consider incorporating these modifications prior to re-submission of this research plan for consideration by WG-FSA. Specific recommendations include:

- (i) improved stratification of the proposed survey stations by depth
- (ii) reduced distance between stations, for reasons of operational feasibility as well as to more accurately map patterns of toothfish distribution and abundance
- (iii) focusing the research on a smaller region of Subarea 48.2
- (iv) including some consideration of historical harvest and research activities in this area.

4.2 The Working Group recalled conservation measure (CM) 25-02, paragraph 5, in which daytime setting of longlines is prohibited in order to minimise risks of incidental seabird capture. The Working Group expressed concern that the proposed research would involve daytime setting during summer in a location with potentially vulnerable seabird populations, and using a gear type (Spanish line) known to pose considerable risk to seabirds. The Working Group recommended that the proposal be modified to minimise the risk of incidental seabird captures.

4.3 The Working Group noted that two of the proposed survey stations were located inside the South Orkney Islands MPA (CM 91-03) such that research within the MPA should be designed and considered in the context of the MPA research and monitoring plan, with consideration of potential effects of the proposed research activities on the objectives of the MPA in the location of the proposed survey stations. The Working Group recommended that these matters should be referred to WG-EMM.

4.4 The Working Group recalled the agreed framework for research plans in data-poor fisheries (SC-CAMLR-XXXII, paragraphs 3.170, 3.171 and 3.183 and Figure 1). It noted that the proposed research in Subarea 48.2 does not include a plan or likely schedule by which the research will progress to the biomass estimation phase leading to a stock assessment. The Working Group recommended that the proposal be modified so that it is consistent with the advice contained in the data-poor fisheries framework and diagram agreed last year (SC-CAMLR-XXXII, Figure 1).

4.5 The Working Group recalled the concerns of the Scientific Committee in 2013 regarding the effects of the low tag-overlap statistic achieved by the vessel listed in this proposal in the past (SC-CAMLR-XXXII, paragraphs 3.211 and Annex 6, paragraph 5.4) and encouraged the proponents to include in their proposal a commitment to achieving tag-overlap statistics substantially higher than the minimum level (i.e. 60%) required in exploratory fisheries.

#### Subarea 48.5

4.6 The Working Group reviewed a report on year 2 of an ongoing multiyear toothfish research program by Russia in the Weddell Sea in 2014 (WG-SAM-14/05) and considered a proposal to continue that research program in 2015 (WG-SAM-14/07). The Working Group noted that the objectives of this research are consistent with the framework for research in data-poor fisheries leading to stock assessments as agreed in 2013 and recommended that the research continue in 2014/15. The Working Group agreed that the proposed research design for options 1 and 2 was appropriate to achieve the objectives of the research, however, some Members expressed concern that ice conditions in the area of option 3 (i.e. western Weddell Sea) were sufficiently adverse that multiyear research to recover tagged fish in a consistent location may not be possible. The Working Group requested that Russia update the proposal for consideration by WG-FSA.

4.7 The Working Group thanked Russia for the thorough and detailed report of biological sampling and analyses and planned academic publications arising from this research. The Working Group noted interesting characteristics of toothfish diets in relation to by-catch reported in this area. Daggertooth (*Anotopterus pharao*) is unusual in toothfish diets because it is a pelagic fish, whereas blue antimora (*Antimora rostrata*) was notable by its absence in by-catch. The Working Group also noted that catch rates of by-catch species in this location were variable between years, and that by-catch rates were low compared with other toothfish fisheries elsewhere in the CCAMLR area. It encouraged Russian scientists to collaborate with other research in the area to better understand the potentially unique oceanographic and biological characteristics of this location.

4.8 The Working Group noted that the survey design that was implemented in 2013/14 was similar to what had been proposed last year under option 1, except that unfavourable ice conditions had blocked access to about 50% of the predefined research block in which tags were thought to be available for recapture (i.e. biomass estimation phase), and ice conditions also caused other sets outside the research block (i.e. prospecting phase) to be closer together than the originally planned 5 n miles separation distance. The Working Group recommended that the proponents report the level of catch that was taken from inside the research block in 2014 and calculate the number of expected tag recaptures associated with this level of catch, based on local biomass estimates and corresponding local exploitation rates. No tags were recaptured in 2014.

4.9 The Working Group further noted that the following changes may be consistent with the agreed framework for research plans in data-poor fisheries: (i) the research block in option 1 be redrawn to encompass the full extent of the area that had been surveyed in 2013/14 to take account of where tags are now thought to be available for recapture; (ii) the corresponding catch limit inside the research block be adjusted consistent with the decision

criteria for data-poor fisheries research plans (i.e. local exploitation rate not exceeding 4%); and (iii) the corresponding number of tag recaptures expected in 2014/15 be calculated based on updated estimates of local biomass. The Working Group recommended the proponents consider these points and forward the proposal to WG-FSA for further consideration. The Working Group agreed that returning to the research block in option 1 to recover tagged fish was the highest priority for this research.

4.10 The Working Group noted the proposed modification to the spatial design of the research under option 2 to include prospecting phase sets on two nearby seamounts and requested a map of the total area showing all the proposed research areas. The Working Group recommended that the revised proposal be considered by WG-FSA.

4.11 The Working Group agreed that participation by other Members in this research as part of a multi-Member, multi-vessel research program would provide valuable information regarding possible vessel effects and would facilitate more rapid development of a stock assessment (paragraphs 3.4 and 3.5).

4.12 The Working Group also requested that the Scientific Committee consider, consistent with the CCAMLR regulatory framework, whether fishing for *Dissostichus* spp. in Subarea 48.5 be considered an exploratory fishery under CM 21-02.

#### Division 58.4.4

4.13 WG-SAM-14/14 described a research plan for a longline survey of toothfish in Division 58.4.4 by Japan in 2014/15. WG-SAM-14/18 described a proposal from France to also undertake a research survey in Division 58.4.4. The Working Group endorsed the designs in the proposals and recommended that they be forwarded to WG-FSA for consideration. The Working Group agreed that it would be greatly beneficial for Japan and France to collaborate on this research.

4.14 The Working Group noted that in SSRU 5844D, research to date had not resulted in any tag recaptures, and consequently stock abundance had been estimated using the ‘CPUE seabed area analogy’ method. Some Members noted that, where CPUE-based estimates are derived from a single vessel, the order and timing of fishing relative to other vessels conducting research fishing could result in increased uncertainty in those CPUE-based estimates. However, the Working Group also noted that IUU fishing is known to occur in this area and may have the same effect.

4.15 Other Members recalled that in the example of research activities in Division 58.4.3a, tag-recapture rates had increased after France commenced research in the area and felt that the involvement of multiple vessels in the research programs where only one vessel has been operating, such as in Division 58.4.4, may accelerate the development of tag-based estimates of abundance. The Working Group noted that the increased tag-recapture rate associated with the French vessel’s initiating research in Division 58.4.3a is likely to be because the vessel fished in a spatially constrained location. The Working Group agreed that tag-based estimates are likely to be more robust than those based solely on CPUE.

## Ross Sea region – SSRUs 882A–B

4.16 The Working Group reviewed separate proposals for new research plans in SSRUs 882A–B (WG-SAM-14/06 and 14/34).

4.17 WG-SAM-14/06 presented a proposal by Russia for a multiyear research program on the slope of SSRU 882A. The Working Group recalled that in 2013 the Scientific Committee endorsed the importance of research in this area as a high priority to investigate toothfish distribution and movements and potential implications for stock structure and stock assessment (SC-CAMLR-XXXII, paragraph 3.76iv). The Working Group agreed that the research design proposed in WG-SAM-14/06 was appropriate to address these objectives and was a useful project to implement in the coming year. The Working Group requested that the proposal be forwarded to WG-FSA.

4.18 WG-SAM-14/34 presented a multiyear, multi-Member proposal by New Zealand, Norway and the UK for research in the north of SSRUs 882A–B. The Working Group recalled that in 2013 the Scientific Committee endorsed the importance of research in this area as a high priority to further parameterise the toothfish SPM and reduce potential bias in stock assessment (SC-CAMLR-XXXII, paragraph 3.76iv) and to better understand toothfish spawning dynamics (SC-CAMLR-IM-I, paragraphs 2.31(vii) and 2.32). The Working Group agreed that the research design proposed in WG-SAM-14/34 was appropriate to address these objectives and was a useful project to implement in the coming year.

4.19 In relation to the proposal in WG-SAM-14/34, the Working Group:

- (i) agreed that the proposed cluster design with a minimum inter-cluster separation distance and a maximum number of hooks per cluster was a useful design to deliver adequate spatial coverage of the survey in an area where fishable bathymetry has not yet been mapped
- (ii) questioned whether the option to set very long lines could diminish the statistical power of subsequent analyses (in instances where data is not aggregated into SPM cells)
- (iii) suggested that a shorter maximum line length within clusters be considered by the proponents
- (iv) suggested that the proponents consider adding limited sampling in adjacent areas of SSRU 881C (an area open to fishing within which commercial data is available) using the standardised survey gear to enable calibration between research catch rates in the survey area and adjacent commercial fishery data
- (v) requested that a revised proposal be submitted to WG-FSA
- (vi) discussed the proposed tagging rate of 3 fish per tonne and noted that because the primary research objective is to map fishable habitat and characterise the distribution, abundance and population characteristics of the toothfish population in new locations, tagging is a secondary priority, and returning to recapture tags in the same location in subsequent years may be of lesser priority than

continuing to map fishable habitats across all survey strata. However, releasing tagged fish in these areas can be expected to generate improved knowledge of toothfish movements and stock structure

(vii) noted that in this area where the average fish size is expected to be large, 3 fish per tonne implies tagging approximately every 10th fish. The maximum achievable tagging rate without compromising tagging performance (i.e. potentially resulting in increased tagging mortality and associated stock assessment bias, see also paragraph 3.18) is unknown, and may be variable in different contexts

(viii) recommended that an appropriate tagging rate should be considered by WG-FSA.

4.20 The Working Group noted that proposals set out in WG-SAM-14/06 and 14/34 would benefit from collaboration between New Zealand, Norway, Russia and the UK. The Working Group recommended that these Members work together to further harmonise the two proposals, to the extent possible, in advance of WG-FSA-14, and continue their collaboration in the implementation and analysis stages of both research plans. Specifically, the Working Group recommended that proponents consider working together to ensure: (i) gear standardisation between vessels; (ii) collection of a consistent suite of biological data and specimens for further analysis; (iii) collection of improved bathymetric data of the survey areas; and (iv) adequate spatial spread of fishing effort across the survey areas.

4.21 The Working Group noted that fish in SSRUs 882A–B are considered to be part of the Ross Sea region stock, for which a stock assessment and precautionary catch limits currently exist. Therefore, while some aspects of these research designs are similar to those prescribed under the framework for data-poor fisheries, the objectives of the research proposals described in WG-SAM-14/06 and 14/34 are different from those in data-poor areas.

4.22 The Working Group recalled previous advice that SSRU 882A could potentially be opened and managed as part of the Ross Sea fishery (SC-CAMLR-XXXI, paragraph 9.30) and that the boundaries of CM 41-09 should be revised so that catches in Subarea 88.1 and SSRUs 882A–B are managed under a single conservation measure commensurate with the Ross Sea fishery stock assessment (SC-CAMLR-XXXII, paragraph 3.160). On this basis, the Working Group requested that WG-FSA consider an appropriate mechanism to account for the catches required in these research plans.

4.23 The Working Group noted that new information collected under these research plans would be useful to parameterise the toothfish SPM in locations for which data are currently unavailable, thus improving current understanding of toothfish life cycle dynamics in the Ross Sea region with implications for improved stock assessment and management (WG-SAM-14/31).

#### Ross Sea region – toothfish sub-adult survey

4.24 The Working Group reviewed the results of the third year of a standardised survey for sub-adult toothfish on the southern Ross Sea shelf (WG-SAM-14/24) and a proposal by New

Zealand to continue that survey for a fourth year (WG-SAM-14/25). The Working Group agreed that the proposed survey design for 2015 was consistent with these objectives and recommended that the survey be implemented in accordance with this design.

4.25 The Working Group noted that peak cohorts in the plotted age frequencies from the first three years' surveys appear to shift by one year annually, suggesting that the survey is potentially able to track YCS and could provide information on recruitment variability. The Working Group discussed to what extent analysis of commercial fishery data could be adequate for the same purpose. The Working Group recalled that this analysis had been attempted when the sub-adult survey was first proposed, and at that time there was no interpretable signal apparent in the commercial fishery data, probably due to inconsistent spatio-temporal fishing patterns and/or variable gear selectivities between vessels. The Working Group agreed that repeating this analysis now, to enable comparison with the results obtained from the first three years of survey data, would be useful, and the results of this analysis will enable evaluation of the ongoing utility of this survey.

4.26 The Working Group noted that the purpose of the 'exploratory' (non-core) survey strata is to explore new areas in order to identify potential locations with high abundances of sub-adult toothfish, which may be considered as additional core survey strata in future. However, secondary research objectives may also be achieved incidentally by sampling toothfish in particular locations of interest. For example, the exploratory stratum in the extreme southwest Ross Sea in 2013 did not reveal high densities of sub-adult toothfish, but did reveal considerable numbers of larger toothfish in McMurdo Sound, an area in which toothfish population dynamics have been the subject of considerable interest. The Working Group agreed that, while monitoring larger toothfish is not the primary objective of the sub-adult survey, continued limited monitoring in this location may be of considerable value, especially in concert with new research and monitoring of potential toothfish predators in the same area (i.e. see WG-EMM-14/52).

4.27 The Working Group noted that one potential future exploratory stratum is located in the south of SSRU 882A, near the survey location proposed in WG-SAM-14/06. The Working Group noted that if it were possible to standardise gear deployments between vessels, vessels conducting research on the shelf and slope of SSRU 882A could productively contribute also to the sub-adult survey in the future.

#### Subareas 48.1 and 48.2

4.28 Dr Arata informed the Working Group that Chile intends to undertake a trawl survey for demersal finfish in Subareas 48.1 and 48.2 to monitor the recovery of fish stocks such as *Champscephalus gunnari* and *Notothenia rossii* during 2014/15. The Working Group noted that this proposal had been reviewed by both WG-SAM and WG-FSA in 2013 (WG-SAM-13/14 and WG-FSA-13/10 respectively), and that due to logistical difficulties, the survey could not be undertaken in 2013/14, but would instead be conducted in 2014/15 using a different vessel. The Working Group recommended that the proposal to undertake the survey be updated and submitted for consideration by WG-FSA.

## Other business

### Fishery capacity

5.1 An analysis of capacity-related issues, using information derived from the CCAMLR C2 catch-and-effort data from the Ross Sea toothfish fishery was presented in WG-SAM-14/19. The analysis provided a series of metrics that CCAMLR could use to assess and monitor capacity and capacity utilisation.

5.2 The Working Group agreed that there was no evidence of overcapacity in the metrics presented but noted that no target capacity has been defined against which to assess fishery performance. The Secretariat was requested to provide annual reports of the metrics of capacity and capacity utilisation in order to monitor trends in capacity in exploratory toothfish fisheries. In addition, the Secretariat was also asked to include a measure of potential daily fishing capacity as a function of the catch limit for an area in order to identify situations where the catch limit could potentially be taken before any data are available with which to forecast the closure of that fishery (SC-CAMLR-XXXII, Annex 4, paragraphs 4.28 and 4.29).

5.3 The Working Group recognised that such simplified indices which summarise complex interactions need to be interpreted in the context of specific knowledge of the region and/or fishery in question and recommended that work to determine additional metrics of capacity be continued.

5.4 Dr Petrov made the following statement:

‘The document (WG-SAM-14/19), submitted by the EU, does not include any proposals on toothfish fishery area expansion for research purposes and opening of fishing grounds closed for the time being.

Simulated conditions, in particular closed small-scale research units (SSRUs), are among the fundamental reasons of fleet concentration in the CCAMLR fishing grounds. Discussing the question of overcapacities in the CCAMLR zone, Russian scientists concur that all closed SSRUs should be opened, as we announced during the meetings of the Scientific Committee and Commission previously (SC-CAMLR-IM-I/03; SC-CAMLR-IM-I/04; SC-CAMLR-IM-I/05; SC-CAMLR-IM-I/06; WG-FSA-13/12; WG-FSA-13/13; SC-CAMLR-XXXII/06). After they recommend to analyse fishing conditions for studying a risk of overcapacity there.

We consider that the recommendations on overcapacity given by the EU are eligible when analysis of fishing capacities covering entire area without closed SSRUs is carried out. It is certain that new results will suspend a question of fishing capacities in the years.’

### Fishery Reports

5.5 The Working Group recognised the important role of the Fishery Reports as a central source of reference material for scientists engaged in the work of the Scientific Committee. It agreed that a consistent format for the Fishery Reports that presented the key pieces of information for a fishery should include a general description and background information on the fishery, details of current management advice and details of the assessment or progress in

research designed to lead to an assessment. The Working Group also noted that, apart from the routine update of the tables and figures by the Secretariat, the bulk of the Fishery Report should remain largely unchanged between years. It also noted this would reduce the workload associated with the translation of the reports (CCAMLR-XXXII, Annex 7).

5.6 In considering the content and format of the Fishery Reports, the Working Group also agreed that an executive summary of each Fishery Report would be a useful addition to the more detailed presentation of the reports itself.

5.7 The presentation of the details of the assessment and/or progress in research could be used to produce a 'fishery data dashboard' on the CCAMLR website that provided agreed fishery indicators and a summary of the status, assessment and catch limits in place for each fishery.

#### Stock assessment course

5.8 The Working Group noted the suggestion from WG-FSA on the desirability of broadening the knowledge base of CCAMLR's approach to assessments and in particular in the use of CASAL software (SC-CAMLR-XXXII, Annex 6, paragraphs 11.1 and 11.2). The Working Group welcomed the offer from New Zealand to run a CASAL training course at the CCAMLR Secretariat immediately prior to WG-FSA-14. New Zealand scientists agreed to provide an SC CIRC outlining the content of the course and inviting participation from Members.

#### Translation of CM 33-03

5.9 Noting that discussion of the potential for triggering a closure in an SSRU as a result of macrourid by-catch in the decisions on fishing location in Division 58.4.3a, Mrs A. Relot (France) informed the Secretariat of an inconsistency in the different language versions of CM 33-03. Specifically, the English version of CM 33-03, paragraph 6, referred to 'each' of the two 10-day periods, whereas the French language version referred to 'one' of the 10-day periods. The Secretariat apologised for this mistranslation and confirmed that the French-language version had now been revised and was consistent with the English version (paragraph 3.34).

### **Advice to the Scientific Committee**

6.1 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) version control (paragraph 2.29)
  - (b) external review (paragraph 2.33)
  - (c) future work (paragraph 2.41).

- (ii) Research plans for exploratory fisheries for toothfish in Subareas 48.6 and 58.4 –
  - (a) general (paragraphs 3.2, 3.3 and 3.5)
  - (b) Subarea 48.6 (paragraphs 3.14, 3.17, 3.20 and 3.22)
  - (c) Divisions 58.4.1 and 58.4.2 (paragraph 3.31).
- (iii) Scientific research proposals for toothfish in other areas –
  - (a) Subarea 48.2 (paragraph 4.3)
  - (b) Subarea 48.5 (paragraph 4.12)
  - (c) Ross Sea region (paragraph 4.22).
- (iv) Other matters –
  - (a) Fishery capacity (paragraph 5.2).

### **Adoption of the report and close of the meeting**

7.1 The report of the meeting of WG-SAM was adopted.

7.2 In closing the meeting, Dr Hanchet thanked the participants for their contributions to the meeting and their work during the intersessional period, the subgroup coordinators for facilitating discussions, the rapporteurs for preparing the report and the Secretariat for its support. Dr Hanchet also thanked INACH for hosting the meeting and Dr Arata and colleagues for their kind hospitality and assistance during the meeting. Dr Hanchet's term as Convener of WG-SAM ended with this meeting.

7.3 Dr Constable, on behalf of the Working Group, thanked Dr Hanchet for his outstanding role as convener of WG-SAM. The Working Group was very thankful to Dr Hanchet for taking this role and for his significant contribution to the work of WG-SAM, the Scientific Committee and the Commission.

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(Punta Arenas, Chile, 30 June to 4 July 2014)

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## Agenda

Working Group on Statistics, Assessments and Modelling  
(Punta Arenas, Chile, 30 June to 4 July 2014)

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 toothfish assessments
  - 2.3 A review of mechanisms by which CCAMLR decision rules are implemented
  - 2.4 Developments in integrated stock assessment methodologies for krill
  - 2.5 Other work
3. Evaluation of research plans from Members notifying to fish in new and 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. Advice to the Scientific Committee
  - 6.1 WG-FSA
  - 6.2 General
7. Adoption of report and close of meeting.

### List of Documents

Working Group on Statistics, Assessments and Modelling  
(Punta Arenas, Chile, 30 June to 4 July 2014)

- |              |   |
|--------------|---|
| WG-SAM-14/01 | Research plan for the exploratory fisheries for <i>Dissostichus</i> spp. in Subarea 48.6 in 2014/15<br>Delegation of Japan  |
| WG-SAM-14/02 | Research plan for the exploratory fisheries for <i>Dissostichus</i> spp. in Division 58.4.1 in 2014/15<br>Delegation of Japan   |
| WG-SAM-14/03 | Research plan for the exploratory fisheries for <i>Dissostichus</i> spp. in Division 58.4.2 in 2014/15<br>Delegation of Japan   |
| WG-SAM-14/04 | Research plan for the exploratory fisheries for <i>Dissostichus</i> spp. in Division 58.4.3a in 2014/15<br>Delegation of Japan  |
| WG-SAM-14/05 | Progress report on the Weddell Sea Research Program Stage II<br>A.F. Petrov, I.I. Gordeev, S.V. Pianova and E.F. Uryupova<br>(Russia)                                     |
| WG-SAM-14/06 | Research program on resource potential and life cycle of <i>Dissostichus</i> species from the Subarea 88.2 A in 2014–2017<br>Delegation of the Russian Federation         |
| WG-SAM-14/07 | Plan of research program of the Russian Federation in Subarea 48.5 (Weddell Sea) in season 2014/2015<br>Delegation of the Russian Federation                              |
| WG-SAM-14/08 | Stock assessment and proposed TAC for Antarctic toothfish (TOA) in the Subarea 88.2 H in the season 2014–2015<br>S.M. Goncharov and A.F. Petrov (Russia)                  |
| WG-SAM-14/09 | Continuation in the 2014/15 season of the research plan initiated in 2012/13 for stocks of <i>Dissostichus</i> spp. in Divisions 58.4.1 and 58.4.2<br>Delegation of Spain |

WG-SAM-14/10	Progress report on the research fishery for <i>Dissostichus</i> spp. in Subarea 48.6 being jointly undertaken by Japan and South Africa: 2012/13 and 2013/14 R. Leslie (South Africa), K. Taki, T. Ichii (Japan) and S. Somhlaba (South Africa)
WG-SAM-14/11	Revised South African work plan for 2014/15 for the joint Japan/South Africa research on <i>Dissostichus</i> spp. in Subarea 48.6. Delegation of South Africa
WG-SAM-14/12 Rev. 1	Results of the Spanish exploratory longline fishery for <i>Dissostichus</i> spp. in Divisions 58.4.1 and 58.4.2 in the 2013/14 season R. Sarralde, L.J. López-Abellán and S. Barreiro (Spain)
WG-SAM-14/13	Format for reporting finfish research proposals of the Ukraine in Subarea 48.2 in 2015 Delegation of Ukraine
WG-SAM-14/14	Research plan for toothfish in Division 58.4.4b by <i>Shinsei maru</i> No. 3 in 2014/15 Delegation of Japan
WG-SAM-14/15	Revised assessment models for Patagonian toothfish in research block C of Division 58.4.4, Ob & Lena Banks for the years 1989/1990 to 2012/13 K. Taki (Japan)
WG-SAM-14/16	The ICES Benchmark Protocol C. Darby (United Kingdom)
WG-SAM-14/17	Research plan for the exploratory longline fishery for <i>Dissostichus</i> spp. in 2014/15 in Division 58.4.3a Delegation of France
WG-SAM-14/18	Proposal for a research plan for the exploratory longline fishery for <i>Dissostichus</i> spp. in 2014/15 in Division 58.4.4 Delegation of France
WG-SAM-14/19	European Union – Measurement of capacity in CCAMLR exploratory fisheries in Subareas 88.1 and 88.2 Delegation of the European Union
WG-SAM-14/20	Integrated models for Antarctic krill ( <i>Euphausia superba</i> ) using survey data from 1981–2014 in Subarea 48.1 D. Kinzey, G.M. Watters and C.S. Reiss (USA)

- WG-SAM-14/21 Research plan for the exploratory longline fishery for *Dissostichus* spp. in Divisions 58.4.1, 58.4.2 and Subarea 48.6 in 2014/2015 (including CTD data in 88.1, 88.2)  
Delegation of the Republic of Korea
- WG-SAM-14/22 Plan of research program of the Ukraine in Subarea 48.2 in 2015  
Delegation of Ukraine
- WG-SAM-14/23 Rev. 1 Data and approach for the revised stock assessment for the Heard Island and the McDonald Islands Patagonian toothfish (*Dissostichus eleginoides*) fishery (Division 58.5.2)  
P. Ziegler and D. Welsford (Australia)
- WG-SAM-14/24 Preliminary results of the third CCAMLR sponsored research survey to monitor abundance of subadult Antarctic toothfish in the southern Ross Sea, February 2014  
S. Mormede, S.J. Parker, S.M. Hanchet, A. Dunn (New Zealand) and S. Gregory (United Kingdom)
- WG-SAM-14/25 Proposal to continue the time series of CCAMLR-sponsored research surveys to monitor abundance of subadult Antarctic toothfish in the southern Ross Sea in 2015  
S.M. Hanchet, S.J. Parker and S. Mormede (New Zealand)
- WG-SAM-14/26 Stock structure of Antarctic toothfish in Statistical Area 88 and implications for assessment and management  
S.J. Parker, S.M. Hanchet and P.L. Horn (New Zealand)
- WG-SAM-14/27 Analysis of seamount-specific catch and tagging data in the Amundsen Sea, SSRU 88.2H  
S.J. Parker (New Zealand)
- WG-SAM-14/28 Towards the development of an assessment of stock abundance for Subarea 88.2 SSRUs 88.2C–G – a discussion paper  
S.M. Hanchet and S.J. Parker (New Zealand)
- WG-SAM-14/29 Further investigations in the assessment of Antarctic toothfish (*Dissostichus mawsoni*) in Subarea 88.2 SSRUs 88.2C–H for the years 2002–03 to 2012–13  
S. Mormede, A. Dunn and S.M. Hanchet (New Zealand)
- WG-SAM-14/30 Calculating effective releases and recaptures for stock assessments based on tag detection and tagging mortality indices  
S. Mormede (New Zealand)

- WG-SAM-14/31 An updated spatially explicit population dynamics operating model for Antarctic toothfish in the habitable depths of the Ross Sea region  
S. Mormede, A. Dunn, S. Parker and S. Hanchet (New Zealand)
- WG-SAM-14/32 A proposed process for the management of model updates and software versions for stock assessment used within CCAMLR with the example of the CASAL software  
S. Mormede and A. Dunn (New Zealand)
- WG-SAM-14/33 Preliminary examination of otolith microchemistry to determine stock structure in Antarctic toothfish (*Dissostichus mawsoni*) between SSRU 88.1C and 88.2H  
R. Tana, B.J. Hicks, C. Pilditch and S.M. Hanchet (New Zealand)
- WG-SAM-14/34 Proposal for a longline survey of toothfish in the northern Ross Sea region (SSRUs 88.2 A and B)  
Delegations of New Zealand, Norway and the United Kingdom
- WG-SAM-14/35 Nine years of tag-recapture in CCAMLR Statistical Subarea 48.3 – Part I: General data characterisation and analysis  
M. Soeffker, C. Darby and R.D. Scott (United Kingdom)

**Report of the Working Group on  
Ecosystem Monitoring and Management  
(Punta Arenas, Chile, 7 to 18 July 2014)**



## Contents

	Page
<b>Introduction</b> .....	191
Opening of the meeting .....	191
Adoption of the agenda and organisation of the meeting .....	191
<b>The krill-centric ecosystem and issues related to management of the krill fishery</b> .....	192
Issues for the present .....	192
Fishing activities .....	192
Krill Fishery Report .....	192
2012/13 season .....	194
Current season .....	195
Notifications for 2014/15 season .....	195
Krill catch reports .....	197
Scientific observation .....	199
Fish by-catch .....	199
Revision to Conservation Measure 51-06 .....	200
Krill biology, ecology and management .....	201
Current ecosystem monitoring .....	205
Analyses of CEMP monitoring data .....	205
Estimates of penguin population .....	206
Role of fish in the ecosystem .....	209
Feedback management strategy .....	212
Introduction .....	212
Overlap .....	213
Simple feedback .....	214
Structured fishing and reference areas .....	219
Stage 1 of FBM and Conservation Measure 51-07 .....	220
Advancement to stage 2 of FBM .....	220
Conservation Measure 51-07 .....	221
Future ecosystem monitoring .....	222
Predator abundance and reproductive success .....	222
Predator foraging distribution .....	224
CEMP Site locations .....	226
Biogeochemical cycling .....	226
Oceanographic modelling .....	227
Integrated assessment model .....	227
Fishing vessel surveys .....	229
SG-ASAM .....	230
ARK workshop .....	231
<b>Spatial management</b> .....	232
Weddell Sea (Domains 3 and 4) .....	232
Western Antarctic Peninsula and southern Scotia Sea (Domain 1) .....	235
East Antarctica (Domain 7) .....	238
South Orkney Islands (Domain 1) .....	239

MPA Reports .....	243
General procedures for establishing MPAs .....	243
<b>Advice to the Scientific Committee and its working groups</b> .....	244
<b>Future work</b> .....	245
2015/16 multinational investigation of the krill-based ecosystem .....	245
Interactions with ICED .....	247
Interactions with SOOS .....	250
SG-ASAM .....	250
Modelling .....	250
Activities of mutual interest with the IWC SC .....	251
<b>Other business</b> .....	252
CEMP Fund .....	252
The CCAMLR Scientific Scholarship Scheme .....	252
<b>Adoption of the report and close of the meeting</b> .....	255
<b>References</b> .....	255
<b>Tables</b> .....	257
<b>Appendix A:</b> List of Participants .....	259
<b>Appendix B:</b> Agenda .....	264
<b>Appendix C:</b> List of Documents .....	265
<b>Appendix D:</b> Pro forma for submission of stage 2 feedback management ideas ..	273

**Report of the Working Group on  
Ecosystem Monitoring and Management  
(Punta Arenas, Chile, 7 to 18 July 2014)**

## **Introduction**

### Opening of the meeting

1.1 The 2014 meeting of WG-EMM was held in the Cruz Roja Auditorium, Punta Arenas, Chile, from 7 to 18 July 2014. The meeting was convened by Dr S. Kawaguchi (Australia) and local arrangements were coordinated by Dr J. Arata from the Chilean Antarctic Institute (Instituto Antártico Chileno – INACH). The meeting was opened by Dr J. Retamales, Director of INACH, who welcomed all participants and highlighted the strong historical and contemporary linkages between Punta Arenas and the Antarctic.

1.2 Dr Kawaguchi welcomed participants (Appendix A), including participants from Peru (Acceding State). Dr Kawaguchi reviewed the current work of WG-EMM and outlined the meeting's agenda which 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. The agenda was adopted without change (Appendix B). Subgroups were formed to address detailed aspects of the agenda. The Working Group did not receive any new notifications of VMEs and Agenda Item 3.2 was not considered.

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 Dr Arata, Prof. T. Brey (Germany), Drs A. Constable (Australia), C. Darby (UK), O.R. Godø (Norway), S. Grant and S. Hill (UK), J. Hinke (USA), B. Krafft (Norway), D. Ramm and K. Reid (Secretariat), C. Reiss (USA), Lic. M. Santos (Argentina), Drs P. Trathan and J. Watkins (UK), G. Watters (USA) and D. Welsford (Australia).

## **The krill-centric ecosystem and issues related to management of the krill fishery**

Issues for the present

Fishing activities

Krill Fishery Report

2.1 In response to the request from WG-EMM in 2013 (SC-CAMLR-XXXII, Annex 5, paragraph 2.9), the Secretariat prepared a draft Krill Fishery Report (WG-EMM-14/58) for consideration by WG-EMM. As requested by WG-EMM, it included a description of the history of the krill fishery, reported catches, catch-distribution maps, information on krill length frequency, finfish by-catch and seabird and marine mammal by-catch estimations from the CCAMLR Scheme of International Scientific Observation (SISO), as well as current methodology for advising on catch limits and the background to the parameters used in this process.

2.2 The Working Group thanked the Secretariat for the draft Krill Fishery Report and provided specific recommendations for further developing the contents of the Fishery Report and agreed that the Krill Fishery Report should include:

- (i) background to the development of the fishery, as well as an annual update providing a description (including catch-distribution maps) of the activity of the fishery in the current season and the season for which there is complete data
- (ii) presentation of the data collected through the SISO, including the length-frequency distribution of krill, fish by-catch and incidental mortality of marine mammals and seabirds
- (iii) a description of the approach taken by CCAMLR in the management of the krill fishery, including the setting of catch limits and the background to the data/science used in the conservation measures relating to this krill fishery
- (iv) a description of how CCAMLR includes the broader ecosystem aspects of krill, krill predators and the krill fishery in its consideration of the krill fishery.

2.3 The Working Group noted that although the length-frequency distributions of krill by subarea and month followed the outcomes of discussion in SC-CAMLR-XXXI, Annex 6, paragraphs 2.38 to 2.40, the interpretation of these data could benefit from a more detailed analysis of the effects of gear type on the length frequency of krill from individual vessels.

2.4 The Working Group acknowledged the important role of scientific observers in collecting valuable information for the understanding of the krill fishery and the footprints in the ecosystems. The Working Group also acknowledged that there is already a remarkable amount of information that has not been utilised in full in the context of the fishery management and encouraged Members to undertake and present analyses in the context of FBM.

2.5 During the discussion of the potential role and content of the Krill Fishery Report, the Working Group noted that it would be useful to develop a synthesis of knowledge on key

questions often discussed by the Scientific Committee and the Commission on the krill fishery, krill populations, ecology and dynamics, krill predators, incidental mortality in krill fisheries and management of the krill fishery. It also noted that summary information on the status of models and assessment procedures relating to krill would also be useful. This synthesis would be expected to be developed according to discussions and papers submitted to WG-EMM. Some of this information is expected to be available in the Krill Fishery Report, while other information is often discussed, but not summarised in a single place, within the reports of the Scientific Committee or its working groups.

2.6 The Working Group noted that the following questions could form the basis for developing synthesis of knowledge, though these may not be the only questions to be developed:

1. The fishery –
  - (i) What is the trend in the fishery?
  - (ii) What is the total mortality of krill from the fishery?
  - (iii) What parts of the stock are being exploited and are these predictable (space, time, depth, age/size selectivity)?
  - (iv) What are the preferences of the fishery?
    - (a) Do fishers prefer high concentrations of krill (similar to predators)?
    - (b) What factors influence choice of the types of krill to be exploited?
  - (v) What are the main economic drivers of the fishery that may influence changes within a year and between years?
2. Krill –
  - (i) What is the trend in the krill population?
  - (ii) What are the dynamics and variability of the krill population and the key drivers?
  - (iii) What escapement of the stock is there from the fishery (space, time, depth, age/size)?
  - (iv) How is the krill habitat changing?
  - (v) What data-limited methods might be used to manage krill stocks and the fishery?
3. Krill predators –
  - (i) Where are the krill predators found?
  - (ii) What is the total mortality of krill from the predators?
  - (iii) How dependent are the predators on krill for their success?

- (iv) What are the dynamics and variability of the krill predators and the key drivers?
  - (v) What factors are changing in the long term that might impact on predators?
  - (vi) What effects might the fishery have on krill predators?
    - (a) What parts of the krill stock are being exploited by the predators (space, time, depth, age/size)?
    - (b) What is the degree of overlap between the fishery and the foraging requirements of predators?
    - (c) What direct or indirect effects of the fishery have been detected on krill predators?
4. Incidental mortality –
- (i) What effects is the fishery having on Antarctic marine living resources other than krill and krill predators?
    - (a) fish larvae and consequences for commercial species
    - (b) birds
    - (c) seals.
5. Models and analytical methods –
- (i) assessment models (e.g. GYM)
  - (ii) ecosystem models (e.g. FOOSA).
6. Management –
- (i) decision rules for deciding on catch limits
  - (ii) trigger level and its spatial division
  - (iii) small-scale management units.

2.7 The Working Group noted that there were elements of the above list that would be included in the Krill Fishery Report. It also noted the similarities between this list of questions and the work undertaken by Dr K.-H. Kock (Germany) in the early 1990s on *CCAMLR's Approach to Management*. It was agreed that a review of the material included in *CCAMLR's Approach to Management*, based on the questions above, would be very valuable, particularly if this material was developed for inclusion on the CCAMLR website. Drs Constable, Reid and Jones undertook to formulate a proposal for the Scientific Committee to consider this year that could lead to this synthesis being developed for publication on the CCAMLR website.

#### 2012/13 season

2.8 A total of 217 357 tonnes of krill were caught in 2012/13, most of which came from Subarea 48.1 (153 830 tonnes), particularly from Bransfield Strait West (SSMU APBSW)

(110 426 tonnes). The interim catch limit for krill in Subarea 48.1 (155 000 tonnes) was reached in June 2013 and that subarea was closed for the remainder of the season. The total catch of krill in Subareas 48.2 and 48.3 was 31 306 tonnes and 32 221 tonnes respectively, and no fishing occurred in Subarea 48.4.

#### Current season

2.9 To date, 12 vessels from five CCAMLR Members have participated in the krill fishery in 2013/14 (WG-EMM-14/58). Total catch so far was 205 853 tonnes, 74% of which was taken from Subarea 48.1. This subarea reached 98% (152 402 tonnes) of its interim catch limit on 17 May 2014 and the subarea was closed. This closure was earlier than the previous two closures under similar circumstances (June 2013 and October 2010).

#### Notifications for 2014/15 season

2.10 Twenty-one vessels from six Members had notified of their intent to fish for krill in 2014/15 (WG-EMM-14/58), and the total notified expected level of krill catches was 611 000 tonnes. This year, the Secretariat implemented a new online notification system and most of the information for notifications was uploaded directly on the CCAMLR website. Associated diagrams of fishing nets and marine mammal exclusion devices were submitted as meeting papers (WG-EMM-14/01, 14/18, 14/33, 14/34, 14/45 Rev. 1 and 14/46).

2.11 The Working Group recalled that in 2013/14, 19 vessels had notified to fish and as of June 2014, only 12 vessels had fished. This situation had also occurred in previous seasons (i.e. the number of notified vessels was larger than the number of vessels which subsequently fished).

2.12 The Working Group reviewed the krill fishery notifications for 2014/15. All vessels complied with the information required in Conservation Measure (CM) 21-03. However, the Working Group requested that some notifying Members clarify the details of acoustic equipment used on board vessels (echosounder model/type and/or frequency used; Table 1).

2.13 In relation to the acoustic equipment on board the vessels, the Working Group noted the variety in echosounder models and frequencies used (i.e. SIMRAD vs FURUNO and 28, 38, 50, 68, 70, 120 and 200 kHz frequencies), which may make the work of SG-ASAM challenging. The Working Group also noted that some vessels used a single echosounder frequency, typically 38 kHz, while other vessels used two and three frequencies. The Working Group agreed that having more than one frequency would be useful to distinguish krill from other species. This may become more relevant if captures of species other than krill, such as icefish of which two vessels captured several tonnes recently by mistake (i.e. misidentification of krill swarms), become common.

2.14 The Working Group also noted several items in the notifications which WG-EMM was not able to fully evaluate, such as the echosounder type and model or the onboard procedures for estimating the green weight of krill caught. Such specifications are significant for the work of SG-ASAM and WG-EMM, and the Working Group requested that scientific observers, when on board the vessels, confirm the notified details.

2.15 Although vessels notified the methods used for estimating the green weight of krill caught based on CM 21-03, Annex B, the notifications did not provide details on how each vessel would actually conduct the estimation measurements on board. The Working Group also noted the large variability in volume-to-mass conversion factors used between vessels in 2013/14 for the same green-weight estimation method (WG-EMM-14/29, see also paragraph 2.17). As a way forward, the Working Group agreed to review the observers' reports at its next meeting in order to understand the implementation of green-weight estimation methods on board each vessel. In addition, the Working Group recommended that, where possible, vessels undertake a comparison of two methods for estimating green weight, in order to assess each method's performance.

2.16 WG-EMM-14/01, 14/18, 14/33, 14/34, 14/45 Rev. 1 and 14/46 presented notified information on net diagrams and seal exclusion devices. All notifications met the data requirements outlined in CM 21-03. The Working Group agreed that the codend mesh size should be notified as a parameter in the main online notification form, as this parameter may influence krill catch selectivity.

2.17 The Working Group noted the high variability in the estimates of the 'density of the sample' parameter (see Annex 21-03/B) reported by fishing vessels in 2013/14 (WG-EMM-14/29), which seems to be due to differences in gear configuration and product processes on each vessel. The Working Group recommended that the parameter defined as 'density of the sample' in Annex 21-03/B be renamed to 'volume-to-mass conversion factor', in order to emphasise that this parameter reflects the mass of krill in a sample taken from the container or equipment from which the total volume, including seawater, is derived. The Working Group also recommended increasing the frequency requirement for estimating the volume-to-mass conversion factor, currently required 'every month' (Annex 21-03/B), in order to improve the estimate of the variability of this measurement.

2.18 Dr Arata indicated that the Working Group also noted that the krill fishing vessel *Betanzos* is applying an alternative version of the flow-meter method for estimating green weight, which is explained in detail in CCAMLR-XXXII/05 Rev. 1. This alternative method was required because the location of the vessel's flow meters precluded using the formula in Annex 21-03/B. The alternative method uses two flow meters to estimate the volume of krill product (ground krill paste) and the volume of water added to the process. These volumes are measured for each 6-hour period. The volume-to-mass conversion factor is determined from 20-litre samples of krill product taken each week. The green weight of krill caught ( $M_{gw}$ , in kg) is estimated as

$$M_{gw} = (V * \rho) - L$$

where

V = total volume of krill product (litre)

L = amount of water added to the process (litre, converted to kg)

$\rho$  = volume-to-mass conversion factor (kg/litre).

2.19 The Working Group agreed that there are still some unknown variables with the method used by the *Betanzos* that would need further consideration. Particularly, the volume-to-mass proportion of krill and water that feeds the grinder should be estimated and used for

correcting  $M_{gw}$ . Further, the Working Group encouraged the vessel operator to compare this method with another method for estimating green weight (e.g. the codend method) and to present the results of such comparison at WG-EMM-15.

2.20 The Working Group recommended that this alternative method be added to CM 21-03, Annex B.

### Krill catch reports

2.21 The Working Group considered a possible change to the catch and effort reporting system for the krill fishery. This reporting system (CM 23-06, paragraphs 3 to 5) is a dual system which currently requires monthly reporting of catch and effort while the total catch is less than 50–80% of the trigger level, and then five-day reporting when catches exceed 50–80%. The Working Group noted that the dual reporting system does not provide timely information to the Secretariat on catch and effort while the monthly reporting applies, because catch and effort is only reported month by month, and the deadline for submitting these reports is the end of the following month (CM 23-03). As a result, there may be up to a two-month time lag in determining total catches from the fishery. In addition, the Working Group noted that the switch from monthly to five-day reporting during a fishing season may be difficult to implement and may require several reporting periods before the five-day reporting period is established across all vessels in the fishery.

2.22 The Working Group noted that the Secretariat had indicated that the use of a single five-day reporting system for the entire season is a preferable option for the purpose of monitoring the krill fishery. The Working Group recommended that this matter be referred to the Scientific Committee for further consideration.

2.23 Dr Krafft presented results on escape mortality experiments on krill caught in trawl nets (WG-EMM-14/14). The escape mortality from nets was difficult to estimate but had a relatively low rate (1–6%). Factors affecting escape mortality were krill size, tow depth and duration and amount of catch in the net. Variability in the results suggested that there are still unaccounted variables in the experimental design. Although direct mortality seems low, impacted animals may potentially become easier prey for predators. A behaviour comparison experiment of impacted and unharmed krill is proposed. The Working Group emphasised the importance of focusing future experiments on mechanisms for estimating escape mortality rates, in order to determine the overall impact of the fishery on krill.

2.24 The Working Group encouraged further work on escape mortality and noted the proposed further development of the method based on these experiments. Future work may include the use of video cameras inside and outside the trawl net at selected areas to further understand krill behaviour, swimming speed and direction and the angle of krill impact on the trawl panels. Work to quantify gear avoidance by krill in the trawl mouth, and to observe escapement processes, was also proposed.

2.25 Dr Ramm presented a preliminary analysis on the estimation of green weight caught based on data provided by fishing vessels in 2013/14 (WG-EMM-14/29). This is the second year that green-weight estimates have been requested in accordance with Annex 21-03/B. The Working Group noted that there is still variability in the way vessels estimate green weight

and that some vessels did not provide some parameter estimates at the frequency required to estimate variability. The Working Group also noted that some vessels reported estimated green weight at approximately 3–5 tonnes resolution, which introduced further uncertainty in overall catch estimates and closure forecasts.

2.26 The Working Group agreed that scientific observers may provide guidance to assist crew in obtaining parameter measurements required for estimating the green weight of krill caught. However, the Working Group emphasised that it was the responsibility of Flag States to provide these data in the C1 form, and that at the moment there is not 100% observer coverage on all vessels. The Working Group agreed that observers could provide a clear description on green-weight estimation methods used by the vessels and provide independent estimates of green-weight parameters.

2.27 Dr S. Kasatkina (Russia) presented an analysis of the spatial–temporal variability of CPUE and fishing efforts in Subareas 48.1 and 48.2 for traditional trawling and continuous krill fishing methods (WG-EMM-14/21 and 14/22). The traditional trawl fleet, as well as the fleet using the continuous pumping method, showed a considerable variability in fishing locations by year and month in Subarea 48.1, but within the Bransfield Strait all fleets were aggregated. In contrast, in Subarea 48.2 all vessels, without reference to fishing methods, nationality or year, used consistent areas within South Orkney West (SSMU SOW). The author noted that the historical Soviet/Russian fleet did not fish the Bransfield Strait but was concentrated near Elephant Island (SSMU APEI) in Subarea 48.1. The historic fleet also concentrated to the northwest of Coronation Island (SSMU SOW) from year to year, in a manner similar to the current situation.

2.28 Dr Kasatkina also indicated that CPUE values based on traditional fishing methods were significantly higher compared to the continuous fishing method. This was traced by month and year in each SSMU. Moreover, significant variability in CPUE among traditional trawlers which operated simultaneously in the same fishing grounds was revealed. In general, the analysis identified a shift in CPUE regime from 2006 onwards compared with the previous years. These papers provided additional evidence that the ‘high CPUE regime’ from 2006 onwards is not associated with changes in fishing methods but may be a result of the influence of a changing environment on krill distribution patterns. The authors suggested that understanding fishery strategy and performance requires better knowledge of krill distribution, with special attention to krill aggregation patterns, as this factor influences fishing catchability. This information could be provided through acoustic surveys and observations on board krill fishing vessels.

2.29 The Working Group discussed the potential use of CPUE in understanding the krill fishery and assessing krill stocks. The Working Group noted that time spent searching for krill aggregations should be considered when estimating CPUE indices, as well as the type of product that the vessel is targeting.

2.30 WG-EMM-14/11 analysed the relationship between fishing distribution and seasonal sea-ice coverage. The fishery consistently used very constrained fishing grounds in Subareas 48.2 and 48.3. By contrast, fishing grounds in Subarea 48.1 are more variable, and include increased use of the Bransfield Strait from 2008 onwards, reaching as far south as Gerlache Strait. Further use of kernel density analysis, as presented in this paper, would be beneficial for clarifying the overlap between fishing grounds and predator foraging grounds (e.g. WG-EMM-14/02).

## Scientific observation

2.31 Dr Welsford provided the Working Group with a brief description of the SISO review that took place in 2013 and outlined the process for implementing the outcomes of the review (SC CIRC 14/14). He described the use of the Scheme of International Scientific Observation e-group<sup>1</sup> to progress the range of recommendations from the review, some of which were relevant to WG-EMM. He encouraged all Working Group participants with an interest in the SISO to join the e-group and to provide input not limited to discussions at working group meetings.

2.32 In response to a specific recommendation of the SISO review, the Secretariat outlined draft revisions of the krill observer logbook which were described in WG-EMM-14/28 and had been placed on the e-group for comment.

2.33 The Working Group welcomed the revision to the krill observer logbook and noted the general principle of not requiring observers to duplicate data that are reported elsewhere (such as details about the vessel, e.g. vessel length and tonnage that are already provided in the notification and licencing information). This principle also motivated the suggestion to remove the requirement for observers to report catch, in recognition that it is not possible for observers to provide a vessel-independent record of catch for each haul. The Working Group noted that the inclusion of these data in the observer logbooks may create an unrealistic expectation that a verification of the catch data submitted by the vessel was being provided by the observer.

2.34 The Working Group noted a proposal to remove those logbook forms/parts of forms that were functionally redundant, where little or no data had ever been submitted and there now existed more practical ways to access the information. For example, the 'reasons for changing fishing grounds' form had been removed as there was almost no information provided through this form and feedback from observers indicated that it was not practical to gather the information. The Working Group noted that this form was designed to help understand the operation of the fishery and that direct engagement with vessel captains, such as discussions and presentations in the recent ARK workshop (5 and 6 July 2014, Punta Arenas, Chile) (paragraphs 2.201 to 2.204), was a more effective means of gaining an understanding of the fishing strategy of individual vessels.

2.35 The Working Group welcomed the revisions to the krill observer logbook, noting that comments had already been provided to the Secretariat and encouraged all CCAMLR scientists with an interest in the data from observers on krill fishing vessels to provide input using the e-group.

## Fish by-catch

2.36 WG-EMM-14/31 Rev. 1 reported on the frequency of occurrence, proportion by mass and length-frequency distribution of the fish taxa recorded in fish by-catch sampling as part of the CCAMLR SISO from 9 303 hauls collected on 60 cruises involving 18 different vessels over the period 2010–2014. The frequency of occurrence of fish ranged from 10 to 98%

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<sup>1</sup> CCAMLR e-groups can be accessed from the [CCAMLR homepage](#) and are available to authorised users.

between vessels and there were 14 taxa for which the frequency of occurrence was >1% in any subarea (of which seven were Channichthids) and the modal size of fish was between 5 and 10 cm.

2.37 The Working Group noted that fish by-catch is not being reported consistently by fishing vessels using the C1 data and there may be some confusion over the role of observers and vessels' respective reporting requirements. The Working Group recognised that the reporting of fish by-catch was complicated by the difficulties in identifying fish, and there was an important role for observers, when present, in assisting with identification. However, 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 commercial catch (C1) data.

2.38 The Working Group welcomed the increased provision of data on fish by-catch in the krill fishery and the improvement in the identification of fish, which had been assisted by the development of identification material (SC-CAMLR-XXXI, Annex 6, paragraph 2.44), evident in the fish taxa reported being largely consistent with the known ecology of those taxa that might be expected to occur in pelagic krill catches.

2.39 The Working Group agreed that, while the provision of data on fish by-catch is improving, there is still uncertainty on the frequency of fish by-catch in the krill fishery and, therefore, it is not possible to provide a definitive view on whether the krill fishery could have a role in the recovery of previously over-exploited stocks and on the potential interactions with currently fished stocks (e.g. icefish). The Working Group recognised that molecular techniques could assist with the identification of fish taxa and that other chemical analyses (e.g. detecting wax esters) could be used to indicate the presence of fish in products derived from the krill fishery.

2.40 The Working Group noted that data from fish by-catch in the krill fishery could provide a potentially important source of information on krill-associated pelagic fish, for which very little (or no) routine sampling occurs. The Working Group encouraged the Scientific Committee to ensure that this issue is appropriately reviewed by WG-EMM and WG-FSA.

#### Revision to Conservation Measure 51-06

2.41 While there was a general desire to increase the level of observer coverage, the Working Group noted that for some Members there were specific reasons that a mandatory level of 100% would be problematic. The Working Group recognised that identifying specific impediments to increasing levels of observer coverage would assist in finding appropriate solutions to these issues. Some Members supported the aspiration for 100% coverage but noted that this could be logistically challenging because of the long periods of time that vessels are at sea (compared to other vessels in CCAMLR fisheries).

2.42 The Working Group agreed that 100% observer coverage was scientifically desirable but that any decision on a mandatory level required in the fishery was a decision for the Commission. The Working Group agreed that the most important consideration in respect of

the data derived from the SISO was ensuring that the data are of the highest quality possible and most informative for the work of WG-EMM, rather than focusing on the level of observer coverage alone.

2.43 The Working Group agreed that a key aspect of improving data quality is to improve the training for scientific observers, including the availability of resources from the Secretariat. The Working Group also agreed that the krill fishery was a diverse fishery and that observers were expected to have a broad level of expertise. The Working Group suggested that a review (possibly by the ad hoc Technical Group for At-Sea Operations (TASO)) to examine observer training in the krill fishery was necessary.

2.44 The Working Group recommended that the elements of CM 51-06 be retained for the 2014/15 season.

#### Krill biology, ecology and management

2.45 WG-EMM-14/13 described the winter distribution and condition of Antarctic krill (*Euphausia superba*) in relation to sea-ice and water-column production in the South Shetland Islands during the 2013 austral winter. IKMT net samples from 88 stations show that Antarctic krill were concentrated in the southwestern Bransfield Strait. These krill were approximately 33 mm in length, which was a similar size to those sampled in the previous summer, suggesting that no growth occurred between summer 2013 and winter 2013. In contrast, krill found in winter 2012 (i.e. one year earlier) were 10 mm smaller than those found in winter 2013, suggesting that growth had occurred over this longer period. Some large krill (>50 mm) were found in the Elephant Island region but were not abundant. A series of 11 net hauls between 170 and 650 m depth did not indicate any increase in krill at greater depth compared to summer.

2.46 At-sea predator observations collected during this cruise show that many species (including crabeater (*Lobodon carcinophagus*), Antarctic fur (*Arctocephalus gazella*) and leopard (*Hydrurga leptonyx*) seal and Adélie penguins (*Pygoscelis antarctica*)) were found in the southwestern Bransfield Strait, associated with the high concentrations of krill. This is also an area that has been targeted by the krill fishery in recent years. The high abundance of predators and their prey, together with the concurrent fishery, suggests that the overlap between predators and the fishery exists outside the breeding season of these predators.

2.47 The Working Group agreed that this study was important in demonstrating that overlap between predators and the fishery could exist even when the predators are not constrained to return regularly to their breeding sites as happens during the breeding season. There was general agreement that tracking predators during the winter period is important, but more difficult than during the summer, as penguins moult and therefore shed some instruments. Smaller leg-mounted instruments that would not be lost during moulting are often of low accuracy (~180 to 200 km). However, understanding the degree of winter dispersal and what may constrain their distribution in this period is very important as over-winter survival and/or winter feeding conditions can have significant impacts on recruitment to breeding populations in the following summer. It was noted that over-winter distributions of predators from tracking studies carried out by the US AMLR program had been summarised and presented to WG-EMM.

2.48 WG-EMM-14/15 described the results from a series of scientific observations undertaken on the Norwegian-flagged krill fishing vessel *Saga Sea* while carrying out commercial fishing between January and March 2009 in a krill hotspot on the northwest side of the South Orkney Islands. Regular krill samples were taken from the pumped supply from continuously fished commercial trawls with 16 mm meshed trawls (same mesh size throughout the net). Two-frequency acoustic data were logged but no calibration was undertaken during the cruise although calibration later in the year confirmed that the system operated according to specifications. Environmental data were collected from a conductivity temperature depth probe (CTD) mounted on the net and surface water samples were taken.

2.49 Length-frequency and maturity-stage data of krill taken from the catches show that a decrease in the proportion of immature or subadult males was reflected to some degree in an increase in mature adult males. At the same time, there was a change in the proportion of males in the sampled population from 0.8 to 0.3 that may have been due to immigration or emigration of krill through the hotspot.

2.50 The acoustic data collected from this study show that there was a clear diurnal vertical migration with deeper and more vertically compact swarms during the day than during the night, however, there were large differences in this general pattern. It was also noted that, although fishing was carried out during the entire period of the study, there was no obvious change in the acoustic backscatter (NASC) recorded during the study, suggesting that the overall density of krill was not changing during this period.

2.51 The Working Group noted that such studies, particularly time series that sample the same area repeatedly over a period of weeks, provided key information on the vertical distribution of krill and the potential overlap with the vertical foraging ranges of different predators. It was recognised that the depth at which krill occur will affect the availability to predators as different species will be able to forage to different depths. However, it was also noted that the depth of krill aggregations can change rapidly and that krill may react to both the predators and fishery by altering their depth and their degree of aggregation. The Working Group agreed that, given such dynamic interactions between krill and their predators, it was important to be able to integrate these data over suitable temporal and spatial scales.

2.52 WG-EMM-14/37 described a study comparing the selectivity of three nets: Bongo, IKMT and a twin warp Engel commercial trawl were deployed from the Peruvian Antarctic Program's research vessel *BIC Humboldt*. Total length of samples was compared from up to 53 stations. The Bongo and IKMT had a common mesh size of 505 microns but were deployed to different maximum depths (300 m and ~180 m respectively). The Engel trawl had a 10 mm mesh codend and a mouth area of 594 m<sup>2</sup> (compared to ~0.3 and 3.2 m<sup>2</sup> mouth area for Bongo and IKMT respectively). The Bongo net caught the broadest range of krill lengths, while the Engel trawl caught the smallest range of krill lengths. There was a substantial overlap in krill sizes caught in the different nets. While the Bongo net and IKMT have the same size mesh, the Bongo caught smaller-sized krill; however, this could reflect a difference in the spatial coverage of the samples taken with these two nets. Although there was a greater proportion of large krill found in the Engel trawl compared to the other nets, there was only a small difference (5 mm) in the maximum size of krill caught in all three nets. The effect of these net differences on the use of length-frequency data in acoustic estimation has been illustrated by the calculation of conversion factors (used to scale backscatter to acoustic

density) and varies from 0.34 to 0.43 to 0.51. Overall, these differences could bias the acoustic estimates and the use of the larger nets could bias any assessments of recruitment and abundance of krill smaller than about 28 mm in length.

2.53 The Working Group noted that the work presented in WG-EMM-14/37 would not have been possible without the contribution of the Peruvian Antarctic Program and Instituto del Mar del Peru (IMARPE). The Working Group welcomed the excellent scientific engagement of Peru in the collaborative work of CCAMLR between Contracting Parties.

2.54 The Working Group also recognised that combining four separate surveys in the Antarctic Peninsula region from winter 2012 (USA), summer (Germany) and winter 2013 (USA) and summer 2014 (Peru) had considerable power in tracking the growth of the krill population through this period.

2.55 The Working Group noted that the length frequency based on proportion of catch for these nets would probably be more similar than comparisons based on the number of krill caught. In addition, the Working Group agreed that the spatial scale of making such net comparisons was important as krill were known to exhibit significant variability in length composition both between adjacent swarms and within layers.

2.56 The Working Group agreed that synthesis studies comparing selectivity between scientific and commercial nets as well as predators were important in developing selectivity functions that might be applied to standardise length-frequency distributions derived from different sources.

2.57 The Working Group noted that net sampling during the CCAMLR-2000 Survey used standardised RMT8 hauls, however, the regional national surveys, conducted in Subareas 48.1, 48.2 and 48.3, utilised different types of nets. To date, there has been no direct comparison between two commonly used scientific nets (IKMT and RMT8) and the Working Group encouraged such comparisons.

2.58 WG-EMM-14/60 described a study with samples taken from Admiralty Bay, King George Island, between December 2008 and March 2009. The occurrence and abundance of euphausiid species in the bay and associated inlets are described. The most abundant euphausiid at this time was bigeye krill (*Thysanoessa macrura*), which occurred at maximum densities of 873 individuals  $1\ 000\ m^{-3}$  in early January. *Euphausia superba* were found in low numbers generally (less than 10% of the total), although in some samples were a significant proportion of the catch (up to 30% in Ezcurra Inlet). A comparison of this study to earlier work in the region suggested that euphausiid numbers (*T. macrura*) are higher than in the early 1980s. The Working Group welcomed this paper which had been produced by the Polish CCAMLR scholar Dr A. Panasiuk-Chodnicka. Discussion was deferred until after the full presentation of this work, see also paragraphs 6.7 to 6.10.

2.59 WG-EMM-14/P04, now published in *ICES Journal of Marine Science*, described the interannual variability in krill density in the British Antarctic Survey (BAS) Western Core Box (WCB) at South Georgia from 1997 to 2013. Krill targets were identified in acoustic data using the approved CCAMLR protocol, using a multi-frequency identification window and converting to krill density using the stochastic distorted-wave Born approximation (SDWBA) target strength model. In most years, the mean krill density is driven by the relatively few very dense swarms. The mean krill density showed several years (1997–1998, 2001–2003,

2005–2007) of high density ( $>30 \text{ g m}^{-2}$ ) interspersed with years (1999–2000, 2004, 2009–2010) of low density ( $<30 \text{ g m}^{-2}$ ). This pattern showed three different periods, with fluctuations every four to five years. Cross-correlation analyses of variability in krill density with current and lagged indices of ocean (sea-surface temperature (SST)) and atmospheric variability (southern annular mode (SAM) and El Niño southern oscillation (ENSO)) found the highest correlation between krill density and winter SST (August SST) from the preceding year.

2.60 The Working Group noted that there was considerable information contained in the frequency distributions of krill density along the component transects, showing the structure at an aggregation scale (500 m) rather than at a transect scale (100 km). Such detailed information was not normally available in acoustic analyses presented to the Working Group.

2.61 WG-EMM-14/P04 also presented an additional table which utilised the annual krill density to derive the total krill biomass for the survey area and compared them with the commercial krill catches for SSMUs within Subarea 48.3. Commercial catches within South Georgia West (SGW) are very small in comparison to the biomass in the WCB, and even the total commercial catch in Subarea 48.3 is frequently less than 10% of the biomass within the survey area.

2.62 The Working Group noted that there was considerable value in developing methods to use these regular national surveys to scale the large basin-scale surveys such as the CCAMLR-2000 Survey. It was noted that there is a temporal offset in the timing of this regular scientific survey in Subarea 48.3 and the timing of the fishery. However, the Working Group noted that, as the present commercial catch in Subarea 48.3 is generally a small proportion of the biomass of krill observed in only a small part of the subarea, this should be considered as important management advice.

2.63 WG-EMM-14/P06 presented a series of risk maps for Antarctic krill under projected Southern Ocean acidification. This paper, now published in *Nature Climate Change*, showed that the embryonic development of Antarctic krill in elevated seawater  $\text{CO}_2$  levels and successful hatching is impaired at  $\text{CO}_2$  levels greater than  $1\,000 \mu\text{atm}$ . Exposure to elevated  $\text{CO}_2$  during the first three days of embryonic development significantly retards subsequent development, even if the embryos are transferred to seawater with current levels of  $\text{CO}_2$ . Krill embryos appear more vulnerable to ocean acidification than other pelagic crustaceans such as copepods.  $p\text{CO}_2$  in the Southern Ocean is predicted to rise to above  $1\,500 \mu\text{atm}$  in some parts of krill's depth range by the year 2100 unless emissions are mitigated. Risk maps, combining modelled hatch rates and the three-dimensional circumpolar projection of future  $p\text{CO}_2$ , predict that by 2100 the Weddell Sea and the waters to the east are the highest-risk areas for krill embryos. The entire Southern Ocean south of the Polar Front is predicted to be unsuitable for hatching by the year 2300, which would lead to the collapse of the krill population.

2.64 The Working Group noted that changes in  $p\text{CO}_2$  are already occurring in the Southern Ocean and the physiological cost to krill will rise and so krill vulnerability to stress will increase. Such changes highlight the need to think about future decision rules used for the management of the fishery. For instance, the present decision rules are based upon a pre-exploitation estimate of biomass ( $B_0$ ), however, under conditions of environmental change this may not be realistic and so alternative reference points may be required.

2.65 The Working Group recognised that determining how much habitat change had already occurred and might occur over the next 10 years would be useful and could provide a time frame for having to define future decision rules.

## Current ecosystem monitoring

### Analyses of CEMP monitoring data

2.66 WG-EMM-14/30 reported on the submission of CEMP data by eight Members for 12 CEMP parameters recorded at 15 sites for 2013/14. The Working Group welcomed the data submission from three new CEMP sites (Lions Rump, Galindez Island and Petermann Island) in the Antarctic Peninsula area by Poland and Ukraine. The Working Group noted that, although no data were received from CEMP sites in Area 88, the Secretariat had been advised that historical data from monitoring in this area may be made available in the near future and that the Italian monitoring program at Edmonson Point is under review and the collection of CEMP data may resume in the near future. Dr B. Sharp (New Zealand) also notified the Working Group that data from CEMP sites in the Ross Sea will be made available later this year.

2.67 The Working Group noted that time series of Adélie penguin populations from colonies at King George Island, showed a consistent pattern of interannual variation, whereas two CEMP sites in the South Orkney Islands (Signy and Laurie Islands) appeared to show contrasting patterns of interannual changes.

2.68 The Working Group noted that a number of Members currently undertake ‘CEMP-like’ monitoring activities in the Antarctic, but that they do not submit their data to the Secretariat. It therefore invited such Members to submit relevant monitoring data, including data that may not be collected in accordance with CEMP protocols, noting that such submissions should be accompanied by detailed descriptions of the methods used to collect the data.

2.69 WG-EMM-14/43 reported on an analysis of two penguin species monitored at three sites on King George Island/Isla 25 de Mayo, with all sites located within 30 km of one another. The study examined five indices, including counts (breeders and chicks), reproductive success (crèche rates) and chick growth (fledge weights). The study found strong positive correlations across sites for count data, implying that similar influences act at all three sites. However, the analyses also revealed evidence of site- and species-specific differences that highlight heterogeneity in indices of reproductive success at local scales; chick growth (fledgling mass) also varied but seemed to be an effect of different methods being used. The authors noted that heterogeneity at such small spatial scales suggests a need for CEMP monitoring to be distributed more widely than at present in order to encapsulate population responses to changing environments and fishing activity. Within the broad network of CEMP monitoring, the authors suggested that it would be useful to have several monitoring clusters, such as at King George Island, to help identify the relative importance of local environmental factors.

2.70 The Working Group thanked the authors, noting that this was an important contribution which provided considerable insight into monitoring penguin population processes. It recommended that the authors continue their analyses and provide updates to

future meetings of WG-EMM. It suggested that it may be valuable to exchange field personnel between sites to ensure that field methods were consistent. The Working Group recommended exploring the use of an integrative index in order to take account of the trends documented. It also recommended that the use of generalised linear model (GLM) or generalised additive model (GAM) analyses would be appropriate, as use of multivariate statistical methods in combination with appropriate environmental data might facilitate improved understanding of regional environmental forcing factors and local stochastic variability. The Working Group also suggested that it would be useful to extend the analyses by including data from other monitoring sites on King George Island.

2.71 The Working Group discussed whether it would be useful to extend the analysis described in WG-EMM-14/43 by including survival data. It noted, however, that survival data based on flipper banding can include impacts directly associated with the use of flipper bands themselves. The Working Group recognised that alternative methods of estimating survival, based on passive implantable transponders (PITs), may be feasible at some colonies but may require the use of automatic gateways to record the passage of PIT tags. The Working Group agreed that understanding spatial correlation in CEMP data between sites at varying distances from each other, such as described in WG-EMM-14/43, is likely to be an important part of monitoring associated with FBM of the krill fishery.

#### Estimates of penguin population

2.72 WG-EMM-14/54 described semi-automated software developed to count nesting Adélie penguins from aerial photographs. The software is written in MATLAB<sup>®</sup>, offers users a graphical user interface and is freely available. The authors indicated that the software could be used for penguin (or other species) monitoring projects utilising either aerial photography or satellite survey. The authors estimated that penguin colonies are able to be counted 25–50% quicker using this semi-automated software than using a manual approach.

2.73 The Working Group noted that such image analysis tools have the potential to be extremely important for CCAMLR management purposes; consequently it would be helpful for interested experts to collaborate, sharing ideas and software in this rapidly developing field, possibly through a CCAMLR e-group. The Working Group also noted that developing management advice based on the outputs of automated software, such as that described in WG-EMM-14/54, would necessitate that software routines were scrutinised and evaluated by appropriate experts, including by WG-SAM.

2.74 WG-EMM-14/56 provided an estimate of the breeding population of emperor penguins (*Aptenodytes forsteri*) on the south coast of Snow Hill Island, which constitutes the northernmost colony known in Antarctica. During the 2013 breeding season, the breeding population, estimated from an aerial survey, was 7 952 pairs. Visits by land showed a count of 3 700 chicks. The authors indicated that these estimates represent an increase since the last colony counts. The paper noted that direct observational counts, such as those presented in WG-EMM-14/56, are needed to validate estimates made by satellite.

2.75 The Working Group noted that increases in population size of emperor penguins at Snow Hill Island may be related to a number of factors and encouraged the collection of data to identify the causes of the population changes to determine if ecological drivers, such as climate change, are impacting the population.

2.76 WG-EMM-14/P05 provided an estimate for the global Adélie penguin breeding population using a combination of ground counts and satellite imagery; the authors estimated a global population of 3.79 million breeding pairs, including estimates for 11 previously unknown colonies.

2.77 The Working Group welcomed this paper, noting that global estimates of predator abundance are rare but useful for understanding long-term trends. Furthermore, regional estimates of predator abundance and demand are needed to support FBM. The Working Group noted that the methods provide an advance on previous studies but identified that some technical issues remain and should be addressed. For example, the Working Group noted that while satellite images of Adélie and chinstrap penguin (*P. antarctica*) colonies can often be distinguished based on their different breeding phenologies and spectral characteristics of the two species, gentoo penguins (*P. papua*) are particularly difficult to distinguish from Adélie penguins. Such complexities in image analysis may mean that Adélie penguin population estimates for the Antarctic Peninsula, where 21% of the population breeds, will require ground truthing via either field surveys or aerial surveys.

2.78 The Working Group also noted the following issues that would need to be addressed in the future:

- (i) the basis of the analysis presented in WG-EMM-14/P05 was a digital elevation model with a horizontal resolution of approximately 200 m at the Antarctic Peninsula, and about 400 m in sloped coastal regions. Such a resolution may be inappropriate for analysing mixed-species breeding aggregations where variability in terrain can be important
- (ii) the population estimates assume a constant density of nests within colonies, yet nesting density can vary depending upon terrain, particularly in mixed breeding aggregations
- (iii) population counts undertaken in East Antarctica by Australian researchers show contrasting population trajectories to those reported in WG-EMM-14/P05, suggesting that a greater degree of ground-truthing of satellite data may be needed in the different regions
- (iv) it was uncertain whether adjustments had been made for variability in breeding phenology or whether the population estimate was based on a single year or was developed across a number of years.

2.79 The Working Group invited the authors to standardise these methods further and work with scientists already engaged in the work of WG-EMM-STAPP in order that their results could be incorporated into the work of CCAMLR.

2.80 WG-EMM-14/17 reported a recent sighting of a young Magellanic penguin (*Spheniscus magellanicus*) at Vernadsky Station during annual surveys at the station. This is the southernmost sighting for the species. Vagrant species are regularly recorded at different locations in the Antarctic and sub-Antarctic. The Working Group noted that such extralimital records could indicate changes in distributions and range expansions by species present in other areas of the Southern Ocean that might be related to environmental change.

2.81 WG-EMM-14/53 reviewed the occurrence of diseases in penguin species in Antarctica. The authors recommended that CCAMLR establish a health/disease monitoring program (including designated control sites and compilation of disease datasets) for Adélie penguins in the western Antarctic Peninsula, the Ross Sea and coastal regions of East Antarctica. The authors also proposed that research groups establish baseline data collection and tracking of infectious diseases in Adélie penguins. The paper noted that further increases in human activity and continued environmental change in the Antarctic could mean an increase in disease occurrence.

2.82 The Working Group recommended that the authors also engage with CEP, SCAR (EGBAMM) and IAATO, given the broader application of the monitoring described in WG-EMM-14/53. It also noted that the proposed Joint SC-CAMLR–CEP Workshop in the near future is likely to include a monitoring theme.

2.83 WG-EMM-14/55 presented estimates of the abundance of south polar skuas (*Catharacta maccormicki*) at three Adélie penguin colonies on Ross Island, based on a distance-sampling approach. The relationship between these estimates and penguin colony sizes was then used to predict the number of skuas breeding in association with Adélie penguins for the entire Ross Sea region. The authors estimated that the number of skuas ranged between 141–152 individuals at Cape Royds and 4 054–4 892 individuals at Cape Crozier. Comparisons of abundance estimates of breeding birds with total skua abundance suggested that most of the skuas surveyed were breeding birds.

2.84 Based on the strong relationship found between the number of skuas and penguin breeding pairs, a total of 18 000 skuas (9 000 breeding pairs) was estimated for the western Ross Sea. These figures are 1.75–2.2 times higher than the numbers observed in 1980 and 1981. The authors suggested that an increased supply of silverfish may have led to recent population increases in skuas on Ross Island. Future research is proposed to revise the estimates and regression model presented in WG-EMM-14/55 and to validate the model by surveying skuas at a subset of Adélie penguin colonies of different sizes. In addition, the authors suggested resurveying sites where skuas have in the past bred in the absence of penguins and developing a standard method for sampling skuas at penguin colonies.

2.85 The Working Group noted that the focus in this paper on top-down (e.g. predator control) studies of avian species is less common than studies focused on bottom-up (e.g. food availability) processes. The Working Group suggested that data collected for this study could be used to assist in estimating breeding performance by land-based predators and that predation rates could also be estimated, providing more complete data from monitoring efforts. It also noted that studies on population changes in predators should consider both bottom-up and top-down processes.

2.86 The Working Group noted that in some locations in the Atlantic sector of the Southern Ocean, south polar skuas eat fish, principally silverfish, and recently, failures in reproduction and changes in diet have been documented, suggesting that bottom-up processes were important for populations in this region. It also noted the importance of comparative studies among areas to better understand the relative roles of top-down and bottom-up processes on avian species.

2.87 WG-EMM-14/39 presented the most recent data on Antarctic fur seal pup production in the South Shetland Islands from monitoring at Cape Shirreff, Livingston Island. The

authors noted the dramatic decline in pup production over the last eight years after increasing since near-extirpation in the 1800s. The authors also show that age-specific natality rate of fur seals has declined for prime-age breeders over time, while the population had aged, probably due to reduced recruitment. Much of the decline in fur seals has been attributed to increasing top-down predation by leopard seals but the authors suggested that bottom-up forcing has had an impact on fur seal pup production. The authors noted that relative impacts of bottom-up versus top-down processes will vary among species and at different times. They further suggested that the relative role of top-down and bottom-up processes to declining recruitment and first-year survival in other krill-dependent predators may be an important, but overlooked, source of mortality that may be increasing.

2.88 The Working Group also discussed whether the impacts of the krill fishery or environmental variability could be separated from the population production trend and, given the necessity for both short- and long-term indices for feedback management and the proximity of the breeding site at Cape Shirreff to the fishing areas, how these data could be used over the short or long term.

2.89 The Working Group also agreed that comprehensive data on the demography of land-based predators are rare. It considered that demographic data could be useful in parameterising ecosystem models for feedback management. Three possible ways to make the data available for use were noted. The first was directly using the data in models of the population dynamics. Second, the data could be placed in a repository for future studies of the Southern Ocean (e.g. Southern Ocean Observing System (SOOS)). Finally, the data could be used directly as indicators in FBM.

#### Role of fish in the ecosystem

2.90 WG-EMM-14/38 described the distribution of fish larvae collected in opportunistic tows taken during the late austral summer of 2013 in the southern and eastern Ross Sea. Over 99% of ichthyoplankton consisted of 0+ aged Antarctic silverfish (*Pleuragramma antarcticum*). A single tow in the Bay of Whales indicated spawning activity may take place there as well as in Terra Nova Bay. The Working Group welcomed these early results from an ongoing research program and looked forward to more papers being submitted to future meetings.

2.91 WG-EMM-14/44 described a comparison between ground-based counts of Weddell seals (*Leptonychotes weddelli*) in the southern Ross Sea from the 1950–1960s to satellite-based counts between 2006 and 2012. The authors concluded that seal numbers have declined and found no concurrent change in broad-scale sea-ice habitat, leading them to hypothesise a relationship between the decline in seals with development of the Ross Sea toothfish fishery. The authors recommended increased monitoring of Weddell seals in the region.

2.92 The Working Group noted that the data in WG-EMM-14/44 indicated that Weddell seal pup production at Erebus Bay had been stable over the longer period examined, and had increased over the period since 2004, indicating that a simple link between toothfish fishing and observed Weddell seal population dynamics was unlikely. It also noted that results from satellite surveys are likely to systematically underestimate Weddell seal abundance (La Rue et al., 2011).

2.93 Dr Sharp presented data from ongoing research that indicated that the number of seals hauled out on the ice (and therefore available to a census) is strongly related to diurnal and tidal cycles and that those cycles were correlated with blood cortisol levels, indicating that seals are most active during the time of highest tidal flow when fish are also likely to be most active.

2.94 The Working Group encouraged the authors of WG-EMM-14/44 to reanalyse the census data, incorporating multiple explanatory variables, including tidal state. The Working Group noted that developing accurate estimates of total abundance and interpreting population trends in Weddell seals will benefit from incorporating a larger proportion of the population rather than being based on a few selected areas.

2.95 WG-EMM-14/50 described stable isotope analyses of Antarctic toothfish (*Dissostichus mawsoni*) and the four most common by-catch taxa captured in Subarea 88.1 and SSRU 882H. The authors noted that patterns in nitrogen isotope enrichment indicate that the trophic level of *D. mawsoni* increases with size, while patterns in carbon enrichment varied strongly between Subarea 88.1 and SSRU 882H, indicating that the food web in the two regions differs and that toothfish do not routinely mix between the two areas. The relationship between the isotopic signatures of by-catch species on the slope and shelf indicated that they could account for the patterns observed in toothfish in these areas; however, fish captured on the northern seamounts apparently obtain most of their food elsewhere or are not resident in that area for more than a year.

2.96 The Working Group noted that, while the overall pattern in stable isotope composition supports current hypotheses regarding the diet and movement of toothfish, the large variability in individual isotopic signatures unrelated to fish size and location indicates that different toothfish, even in the same location, may be specialising in different prey types and this variability means that conclusions derived from smaller datasets may not apply, except in a local context. The Working Group also noted that other methods of characterising toothfish and by-catch species diet, such as DNA analyses and other biochemical trace analyses, would provide a useful validation of such stable isotope datasets.

2.97 WG-EMM-14/51 described the development of a spatially explicit minimum realistic model of demersal fish population dynamics, predator–prey interactions and fishery removals based on the spatial population model (SPM) for toothfish in the Ross Sea. The model includes *D. mawsoni* as well as macrourids and channichthyids, the two groups that make up ~50% of *D. mawsoni* prey. The model predicts that channichthyids are expected to substantially increase in abundance within fished locations as predation pressure by toothfish is decreased, particularly in SSRU 881H where historical fishery removals have been most concentrated.

2.98 The Working Group agreed that the model was a potentially useful approach to investigate multi-species interactions and ecosystem effects of fishing, and asked how the model could be validated. It noted that while full validation is difficult, model predictions are consistent with the following observations:

- (i) observed CPUE changes for icefish and macrourids are consistent with biomass changes predicted by the model

- (ii) predicted changes in toothfish diet, corresponding to changes in available prey biomass, are consistent with observed trends
- (iii) spatially variable toothfish consumption rates correlate with toothfish stomach fullness.

2.99 The Working Group encouraged further development of such models, including incorporating other prey or predator species interacting with toothfish and using different datasets and hypotheses to assist in understanding how the food-web dynamics in the Ross Sea are likely to change in response to fishing. It noted that a key uncertainty is the distribution and abundance of other higher predators in the Ross Sea and encouraged initiatives by Members to develop such datasets (see also paragraph 2.101). The Working Group noted that increased collection of toothfish diet data, and of the length and age distributions of channichthyids and macrourids, could be undertaken intermittently in SSRUs 881H and K to further validate model predictions and improve model structure.

2.100 The Working Group welcomed the development of minimum realistic modelling approaches in the Ross Sea, recalling that similar modelling approaches had been used in investigating krill, predator and fishery dynamics in Area 48, including developing the advice that underpins CM 51-07.

2.101 WG-EMM-14/52 described research on the ecology of Type C killer whales (*Orcinus orca*) in the southwestern Ross Sea involving aerial surveys and observations from the fast-ice edge in southwest McMurdo Sound. On several occasions, killer whales were observed eating large *D. mawsoni*. An analysis of the energy content of main fish prey species available in the area, relative to killer whale energetic requirements, suggested that, as toothfish are the only fish prey capable of meeting female killer whale energetic requirements during the calving and lactation period, a reduction in the availability of toothfish in preferred foraging locations during this time could reduce reproductive success of killer whale populations in the Ross Sea. The Working Group noted that further research would be valuable to understand the nature and spatio-temporal extent of this apparent trophic dependence.

2.102 Dr L. Pshenichnov (Ukraine) noted that there is no evidence that killer whales dive anywhere to depths of more than 500 m (but large toothfish inhabit the bottom of more than 700 m depth), and killer whales in the Southern Ocean are mainly feeding on whales and seals (on the basis of scientific reports of Soviet whaling expeditions).

2.103 The Working Group recalled the work of Berzin and Vladimirov (1983) in which they described an apparently distinct killer whale ecotype with a specialised diet of more than 95% fish; this ecotype has subsequently been labelled 'Type C' killer whales and comprises the majority of the Ross Sea killer whale population (Pitman and Ensor, 2003). The Working Group noted that killer whale predation is likely to be concentrated in preferred locations, but noted that these locations may be influenced more strongly by variables other than depth, noting the concentrated foraging by McMurdo Sound killer whales along retreating fast-ice edges and in newly forming ice cracks. Dr Watters also reported that new unpublished research indicates that in the Ross Sea, killer whales may routinely dive to depths of up to 700 m.

2.104 WG-EMM-14/52 also outlined ongoing research on predators in the Ross Sea, including the use of stable isotopes and biochemical tracers to better understand killer whale

diets and the establishment of a killer whale photo library to enable mark-recapture analysis to estimate population size. The research program (the ‘Top Predator Alliance’) will also focus on Weddell seals, penguins and toothfish and is planned to extend further north along the Victoria Land coast and to Terra Nova Bay.

2.105 The Working Group welcomed the news that New Zealand is seeking partnerships with other CCAMLR Members and coordination with other existing research programs to establish an integrated multinational research and monitoring program for top-predator populations in the Ross Sea. The Working Group noted that the authors of WG-EMM-14/52 are seeking collaboration with Russian colleagues to access data only available in Russian, on which species of fish are important to Type C killer whales at broader temporal and spatial scales. The Working Group welcomed these developments and encouraged other Members to collaborate with the Top Predator Alliance.

2.106 WG-EMM-14/P07 described the distribution of leucocyte types in samples taken from *D. mawsoni* caught in the toothfish fishery in Subarea 88.1. Cell types and frequencies were typical of those cited in other publications on Antarctic fish and the high proportion of eosinophils is likely to be related to the presence of parasites.

2.107 WG-EMM-14/P08 described the incidence and diversity of trematode parasites collected from samples of *D. mawsoni* and common by-catch species caught in the toothfish fishery in Subarea 88.1. Several species were recorded for the first time in the Ross Sea.

2.108 The Working Group noted that the information on parasites presented in WG-EMM-14/P07 and 14/P08 can be a useful tool for stock discrimination and requested that WG-FSA consider the utility of this study for better understanding the stock structure of toothfish in the Ross Sea (see also Annex 5, paragraphs 2.7 to 2.9).

2.109 The Working Group recalled previous commentary regarding consideration of the papers and discussions under this agenda item by WG-EMM and its relationship to discussions in WG-FSA (SC-CAMLR-XXXI, Annex 6, paragraphs 4.9 and 4.10). The Working Group also recalled the FEMA workshops conducted in 2007 and 2009. It recommended that the Scientific Committee consider the best mechanism to ensure that appropriate information and expertise is brought together to provide advice on the impacts of finfish fishing on finfish predators.

## Feedback management strategy

### Introduction

2.110 Drs Jones and Kawaguchi initiated discussion on FBM by reminding the Working Group of several points:

- (i) It is important that Members have a common understanding of FBM, what it is and what it aims to achieve. To help develop such understanding, Dr Jones is scheduled to give a presentation on the topic to the Commission during CCAMLR-XXXIII. Past and present discussions during WG-EMM will provide the content for this presentation.

- (ii) Development of FBM will depend on new and existing data that originate from a variety of sources, including from the fishery, from fishery-independent research surveys, from the CEMP and CEMP-like observation series and from international observation systems designed to study climate change.
- (iii) FBM will develop in a staged approach (SC-CAMLR-XXXII, paragraph 3.15), with advancement from stage 1 to stage 4 depending on, and providing improved understanding of, the krill-centric ecosystem and the potential impacts of krill fishing. In 2014 the Working Group was tasked to evaluate whether stage 1 ('continuation of the current trigger level and its spatial distribution among subareas') is suitable to achieve the objectives of the Convention without further controls on the fishery and to advance discussions that will facilitate advancement to stage 2 ('an increase from the trigger level to a higher interim catch limit and/or changes in the spatial distribution of catches that are adjusted based on decision rules that take account of results from the existing CEMP and other observation series') in 2015.

### Overlap

2.111 Two papers submitted to the Working Group provided updated assessments of overlap between the krill fishery and land-breeding predators. WG-EMM-14/36 included an analysis of overlap in catches taken by the krill fishery and the occurrence of penguins and pinnipeds that were tracked from three breeding colonies in Subarea 48.1 (Cape Shirreff, Copacabana and Hope Bay). The data indicated overlap in several SSMUs, including SSMUs that are not immediately adjacent to the breeding colonies at which animals were instrumented. The greatest degree of overlap occurred in the Bransfield Strait, and this overlap extended through the austral winter. Overlap varied between years and this variation was attributed to changes in the location of fishing, rather than changes in the areas utilised by predators. WG-EMM-14/04 concluded that there are insufficient data to assess the degree of overlap between the krill fishery and land-breeding predators in Subarea 48.2. Predators that have been tracked from breeding colonies on Signy and Laurie Islands do not forage in the area where the fishery currently operates or has operated in the past.

2.112 The Working Group noted that the contrasting amounts of data available to consider overlap between the krill fishery and land-breeding predators in Subareas 48.1 and 48.2 are consistent with its previous advice that FBM be advanced separately in the two subareas (SC-CAMLR-XXXII, paragraph 3.22).

2.113 Characterisations of overlap between land-breeding predators and the krill fishery are desired throughout the Scotia Sea, and the Working Group noted that such work could be advanced by:

- (i) tracking animals originating from additional breeding colonies
- (ii) determining whether the proportion of time that an animal spends in an area is the best proxy for time spent foraging
- (iii) estimating habitat models that predict foraging habitats as functions of environmental variables (paragraph 2.171).

2.114 It will also be important to consider overlap between the krill fishery and predators that are not tracked from breeding colonies on land (e.g. whales and flying seabirds). It was suggested that Members use predator observations collected at sea, either from research vessels or from fishing vessels, to characterise such overlap.

2.115 Some participants noted that overlap should be considered in three dimensions and at the scale of krill swarms. The krill fishery can catch krill at depths that are inaccessible to some land-breeding predators, and it is unclear whether the swarms targeted by fishing vessels are also targeted by these predators (e.g. whether fishing vessels and predators search for swarms that have similar densities). Other participants noted that the depths at which krill occur and the nature of krill swarms change so frequently that overlap should be assessed by integrating over these sources of variability.

2.116 The Working Group agreed that maps depicting spatial and temporal overlap between the krill fishery and krill-dependent predators can usefully indicate where and when the risks of local impacts to dependent species are greatest. Since FBM will potentially involve adjusting the spatial and temporal distributions of krill catches (CCAMLR-XXXII, paragraphs 5.5 to 5.7), overlap should continue to be routinely assessed and results should be summarised in the Krill Fishery Report. Maps of overlap can also help to prioritise the location and timing of future research to understand details about interactions between the fishery and krill-dependent predators.

2.117 The Working Group agreed that it is important to move beyond spatial and temporal assessments of risk by also considering how data might be used to indicate whether competition between the krill fishery and krill-dependent predators has occurred and whether there have been impacts that might be inconsistent with the objectives of Article II. Ongoing 'ecosystem checks' based on such indicators could provide a useful basis for management advice during the staged development of FBM.

#### Simple feedback

2.118 A relatively simple feedback approach could be to advise the Commission of whether the fishery and FBM are developing in a manner that, if continued over a period of years, might be inconsistent with the objectives of Article II. This type of feedback could be implemented by annually updating a set of indicators and comparing the values of these indicators to agreed benchmarks. If the indicators are frequently (in terms of numbers of years or numbers of indicators) more extreme than their respective benchmarks, the Commission could be advised that a management action might be required to change the nature of the fishery and more detailed analysis or new research could be undertaken to investigate potential problems. (This process would be similar to that of a medical doctor who annually monitors a patient's blood chemistry to check for irregularities and, if necessary, take preventative measures while conducting further tests.)

2.119 The Working Group envisioned that several indicators could be used to advise the Commission on the potential risks of the fishery development. These indicators could be derived from data collected by the fishery, during fishery-independent research surveys, from

CEMP and various other sources. It was noted that the indicators used in the simple feedback approach described in paragraph 2.118 would not necessarily be the same as those used in future decision rules to advise on catch limits or the spatial distribution of catches.

2.120 Estimates of local harvest rates may be useful indicators for FBM. The local harvest rate can be computed as an estimate of the krill catch in an area divided by an estimate of krill biomass. If the local harvest rate is relatively low, then the krill fishery is unlikely to have an impact. An example time series (1997–2013) of such harvest-rate indicators was provided in WG-EMM-14/P04, where annual krill catches from the SGW SSMU were divided by acoustic biomass estimates from BAS surveys in the WCB. Annual local harvest rates in this example were estimated to vary between less than 0.1% and about 12%.

2.121 An advantage of using local harvest rates as indicators is that the calculation allows for the use of time-series data that currently exist and are likely to be available in the future. The biomass estimates can be taken from the results of research surveys like those conducted by BAS (in Subarea 48.3, as noted above), Norway (in Subarea 48.2) and Peru and the USA (in Subarea 48.1). During the meeting, the Working Group thus reviewed separate time series (2001–2011) of local harvest rates for the two Bransfield Strait SSMUs combined and the two Drake Passage SSMUs combined. In these cases, krill catches were divided by acoustic biomass estimates from the US AMLR Program. In the Bransfield Strait SSMUs, annual harvest rates varied between zero and about 46%. In the Drake Passage SSMUs, annual harvest rates varied from less than 0.1% to about 33%.

2.122 The Working Group discussed several issues related to using local harvest rates as indicators in a simple feedback approach. These issues included:

- (i) how krill flux might affect the utility of local harvest rates as indicators
- (ii) how an appropriate benchmark against which local harvest rates would be compared might be determined
- (iii) whether local harvest rates need to be considered in context with indicators of predator performance.

2.123 In general, the biomass estimates that are available from research surveys and which can be used to compute local harvest rates are near-instantaneous estimates of standing stock, but the catch data used in these calculations are collected over a longer period of time. Thus, if krill flux is substantive over the fishing period, local harvest rates may be poor indicators of whether the fishery caught a large proportion of the prey that might have otherwise been available to predators. Uncertainties in levels of krill flux are very high. While there is a basic understanding of surface currents in many areas, krill almost certainly do not drift passively with these currents. Behaviours like diel vertical migration and horizontal movement on/off the continental shelf are likely to cause the distribution of krill to be different from what can be inferred from prevailing surface currents. Some participants thought that krill flux is likely to be very high, but others thought that flux is likely to be low in many areas. Growth and localised recruitment of krill over the fishing season can confound estimates of flux if the size composition of krill in a local area is not monitored throughout the fishing season. Future research on krill flux remains of major interest to the Working Group, and it was noted that research to deploy advanced technologies (e.g. moored arrays of acoustic Doppler current profilers) and analyse trends in local CPUE of the fishery or fishery-based acoustics data may

be informative about flux. In the latter cases, it would be important to ensure that data collected by the fishery are sufficiently well standardised to make useful inferences and it might be necessary to design specific data-collection strategies for fishing vessels.

2.124 The Working Group agreed that the Commission requires management advice despite uncertainties in krill flux and, therefore, work to use local harvest rates as indicators in support of FBM should proceed.

2.125 The Working Group further agreed that work should proceed to include time series of local harvest rates in annual updates of the Krill Fishery Report. This would require that Members who regularly conduct surveys to estimate krill biomass formally report such biomass estimates (and the uncertainty in these estimates) to the Secretariat. It was noted that, in the future, it might be possible for the fishery to provide local estimates of krill biomass that extend for the duration of the fishing season. Though biomass estimates obtained from fishing vessels would be uncertain, using estimates made throughout the fishing season might lessen the influence of krill flux on interpretation of harvest-rate indicators.

2.126 Dr Constable presented a method of estimating a benchmark against which local harvest rates could be compared. This method quantifies how, during several years of fishing, the local harvest rate might increase the chances that local krill biomass is less than a critical level which is needed for krill-dependent predators to be successful. The aim of implementing this method would be to solve for the local harvest rate that provides an acceptable risk of local impacts by the krill fishery. Using the solution as a benchmark would enable the Scientific Committee to advise the Commission about whether locally concentrated catches, both below and above the trigger level, would be consistent with the objectives in Article II.

2.127 In summary, the method described by Dr Constable would be to:

- (i) identify a critical level of krill biomass below which predator success in a local area might be expected to decrease and a critical frequency with which it might be undesirable to exceed this level
- (ii) parameterise a krill model with a fixed harvest rate and random vector of recruitments
- (iii) simulate the dynamics of the krill stock in the local area with and without fishing
- (iv) calculate the critical biomass level from the simulation without fishing
- (v) count the number of years in which krill biomass from both simulations fell below the critical biomass level
- (vi) score the simulation as a 'failure', if the count for the simulations with fishing is greater than that for the simulations without fishing
- (vii) repeat steps (ii) to (vi) many times using different recruitment vectors and compute the probability of failure given this recruitment variability
- (viii) repeat steps (ii) to (vii) many times using different harvest rates and identify the local harvest rate that is consistent with a decision rule.

2.128 Further discussion of this method focused on requirements for determining the critical level of krill biomass (needed for step (i)), parameterising models to simulate local variations in krill biomass (needed for steps (ii) to (v)) and an appropriate decision rule (needed for steps (i) and (viii)).

2.129 The Working Group discussed two options for identifying a critical level of krill biomass. Some participants considered that the critical level could be determined by estimating functional relationships between predator success and krill biomass using available data from joint monitoring studies of predators and krill (e.g. the BAS and US AMLR time series). This option would require new data analyses but would have critical levels defined from functional relationships which are specific to local areas of interest to the Commission. Other participants considered that the critical level could be determined from meta-analyses published in the scientific literature (e.g. from results presented by Cury et al., 2011). This option could be implemented immediately, without requiring new analyses, but it is not clear whether general functional relationships taken from meta-analyses are applicable to local areas. These two options are not mutually exclusive, and the Working Group considered it possible that a critical level of krill biomass could be determined from published meta-analyses until new analyses provide results for local areas.

2.130 As indicated in paragraph 2.127, the proposed method of determining a benchmark for local harvest rates requires a model to simulate the dynamics of krill in local areas. The Working Group noted that the GYM could be used for this purpose if it is parameterised appropriately. At a minimum, it would be necessary to consider levels of local recruitment variability and natural mortality (e.g. as explored by Kinzey et al., 2013), as well as relative differences in the timing of surveys used to estimate local krill biomass and the timing of fishery removals. Other models could also be used for simulating the dynamics of krill in local areas (e.g. the integrated assessment model, see WG-EMM-11/43 Rev. 1), and similar care would be needed to parameterise these models appropriately.

2.131 The Working Group discussed the type of decision rule that would be needed for the last step of the method outlined in paragraph 2.127. Such a decision rule might read as follows:

‘Select, as a benchmark, the local harvest rate for which the frequency of the local krill biomass falling below the critical krill biomass is not increased by more than a critical frequency with a probability of no more than a specified risk.’

2.132 This type of decision rule requires three quantities to be specified: the ‘critical krill biomass’ (paragraph 2.129), the ‘critical frequency’ and the ‘specified risk’. Dr Constable suggested a critical frequency equal to 10% of the frequency without fishing and a specified risk of 0.1. This suggestion for the specified risk was based on the depletion risk used in the decision rule that is currently applied to estimate the precautionary catch limit of krill.

2.133 The Working Group did not make any conclusions regarding the critical frequency and specified risk that should be used in a decision rule to identify a benchmark for local harvest rates. Participants noted that more time is needed to consider these quantities.

2.134 The Working Group agreed that the method outlined in paragraph 2.127 should be further developed in the coming year, taking the discussion in paragraphs 2.129 to 2.133 into consideration. Once the method has been fully developed and an appropriate decision rule has

been agreed, the Working Group expects that the benchmark can be compared to estimates of local harvest rates to determine whether the risks of concentrated fishing are too great relative to the objectives in Article II. If, when considering time series of local harvest rates like those previously described for the WCB (paragraph 2.120) and the Bransfield Strait SSMUs (paragraph 2.121), the proportion of years in which the local harvest rate is greater than the benchmark exceeds the specified risk in an agreed decision rule (e.g. paragraph 2.131), then the Scientific Committee might advise the Commission that concentrated fishing may have an unacceptable impact on krill-dependent predators.

2.135 The Working Group used results presented in WG-EMM-14/36 as the basis for discussing whether the simple approach to providing feedback should include indicators of predator performance. WG-EMM-14/36 concluded that results from predator monitoring at Cape Shirreff and Copacabana indicated that the relatively large catch of krill taken from the Bransfield Strait during 2009/10 (about 123 000 tonnes) had a plausible negative effect on recruitment and egg investment by gentoo penguins that forage in the strait. The authors noted that the conclusion of having observed a plausible localised impact by the fishery was also based on comparative observations of chinstrap penguins (which foraged less in the Bransfield Strait and did not show decreased recruitment and egg investment) and observations of prevailing environmental conditions when data on predators were collected (which were not unusual).

2.136 Some participants questioned how the authors' conclusion regarding a plausible impact from localised fishing could be reconciled with observations indicating that the abundance of gentoo penguins is increasing throughout Subarea 48.1 (Lynch et al., 2012). The Working Group noted that observations of plausible fishery effects in a single year would not necessarily be expected to have population-level consequences which would be inconsistent with the objectives in Article II. It would thus be useful to determine whether the relatively large catches taken from the Bransfield Strait since 2009/10 (about 128 000 tonnes in 2012/13 and over 110 000 tonnes in 2013/14) have also had plausible impacts on gentoo penguins (or other predators).

2.137 The Working Group agreed that discussions stemming from results presented in WG-EMM-14/36 demonstrated it would be useful to include indicators of predator performance in a simple feedback approach and to incorporate the results of this effort into the Krill Fishery Report. Future work is needed to identify which indicators should be included in the Krill Fishery Report, and it was noted that inference about the risks of impacts from fishing would likely be more robust if several indicators suggest similar impacts (or lack thereof).

2.138 The Working Group noted that, while the simple feedback approach described here might reveal whether fishing and/or environmental change have had a plausible impact on krill-dependent predators, this approach would likely have little or no power to attribute observed changes to either effects. It was agreed that the power of FBM could be improved by spatially structuring the fishery to purposefully achieve different harvest rates in different areas and/or by establishing reference areas.

## Structured fishing and reference areas

2.139 The power of structured fishing and reference areas to provide a method for attributing observed changes to causative effects would derive from comparing the outcomes of indicators that reflect conditions in different fishing or reference areas. This would be a long-term approach, and the Working Group acknowledged that such comparisons would require sustained monitoring efforts that will aid understanding trends observed within the areas being compared.

2.140 Structured fishing has been considered by the Scientific Committee since 1985. At that time, the ad hoc Working Group on Ecosystem Monitoring agreed that ‘consideration should be given to the application of fishing pressure in selected areas as perturbation experiments giving insight into the responses of key components of the ecosystem to predetermined pressures on the food resources’ (SC-CAMLR-IV, Annex 7, paragraph 47). Some participants noted that reference areas should be established soon, before the krill fishery expands further.

2.141 The Working Group noted that establishing reference areas within a structured fishing strategy would both increase the power of the strategy to separate the potential effects of fishing from those related to climate change and minimise the risks of fishery impacts while management strategies are developed and tested.

2.142 It was agreed that structured fishing should not intentionally be designed to have local long-term impacts on krill-dependent predators (this would be inconsistent with the objectives of Article II), but establishing reference areas within a structured fishing approach could provide sources of krill and/or predators that might ensure inadvertent impacts at local scales do not impact the system as a whole.

2.143 Several issues need to be considered when considering candidate reference areas, including:

- (i) the scale of the candidate reference area relative to spatial variation in CEMP or CEMP-like indicators that reflect (or would reflect) conditions inside and outside the area
- (ii) the level of historical fishing that has occurred within the candidate area
- (iii) whether the candidate area is upstream or downstream of fishing areas.

2.144 The Working Group did not advance discussion on the issues listed in the preceding paragraph, but acknowledged that separating fishing effects from the effects of climate change or other drivers will be challenging even after reference areas are established. In this regard, it was noted that models should be used to predict how individual stocks (e.g. krill alone) and the ecosystem might behave both in the absence of fishing and under various climate change scenarios (see also paragraphs 5.8 to 5.10). These types of predictions can be used to provide reference points for use in decision rules that can be used in all stages of FBM (e.g. paragraphs 2.131 and 2.151).

## Stage 1 of FBM and Conservation Measure 51-07

### Advancement to stage 2 of FBM

2.145 To advise the Commission on options for stage 2, the Working Group developed a pro forma that Members can use to submit ideas for consideration in 2015. The pro forma is intended to ease comparisons of ideas for stage 2. When filling out the pro forma, Members are asked to identify currently available data that would be used to implement their ideas how those data would be analysed and how management advice would be developed from the results of those analyses. Members are also asked to describe practical aspects of their ideas for stage 2 (e.g. how often catch limits or the spatial distribution of catches might be changed). The pro forma is provided in Appendix D.

2.146 The Working Group suggested that responses to questions posed in the pro forma be kept as short and clear as possible, but it was acknowledged that detailed documentation of the scientific basis for some ideas may be required. Such documentation, including performance testing and examples that demonstrate concepts using simulations or analyses of existing data, should be submitted to WG-EMM-15 and cited in the pro forma.

2.147 The authors of WG-EMM-14/04 suggested that the development of FBM in Subarea 48.2 is critically dependent upon the initiation of new research and monitoring and indicated that in the short term the most likely source of information allowing advancement to stage 2 in Subarea 48.2 will be from fishing vessels (e.g. from acoustic surveys that emulate the recent initiative by Norway). Without such new information, the authors of WG-EMM-14/04 believed that the staged development of FBM will not be feasible within Subarea 48.2 and, therefore, a new era of data collection is needed to support adjustment of catch limits and the spatial distribution of catches therein. The authors highlighted that progress is now underway to improve data availability, including, for example, the development of a static camera network and other land-based activities to augment the collection of CEMP data by the UK and Argentina, further development of the annual Norwegian krill survey and the international field season planned for 2015/16 (paragraphs 5.1 to 5.7). The authors suggested that all such work is best carried out collaboratively.

2.148 The Working Group agreed that proposals for ideas to advance to stage 2 of FBM may be feasible if proponents also suggest an appropriate development pathway for data collection and monitoring. These ideas should also be submitted using the pro forma in Appendix D, noting that advancement to stage 2 might be more difficult in Subarea 48.2 than Subarea 48.1.

2.149 Members were encouraged to use the pro forma and submit ideas for stage 2 in advance of SC-CAMLR-XXXIII using the Developing Practical Approaches to Feedback Management for Krill e-group (this e-group replaces the separate e-groups for Subareas 48.1 and 48.2). Submission of pro formas and discussion in e-groups that occurs in advance of SC-CAMLR-XXXIII will facilitate an exchange of views by Members attending the next meeting of the Scientific Committee. This exchange of views should also include discussions related to testing the performance of various ideas for stage 2 (e.g. considering historical data to evaluate how indicators and decision rules might have shaped management decisions in the past and/or by modelling the outcomes of implementing various ideas in the future).

2.150 To aid Members who wish to submit their ideas for stage 2 but are unsure what types of data are currently available and might be used immediately, the Working Group developed Table 2. Many of the datasets that might be used in stage 2 are not currently held by the Secretariat. Some of these datasets are publically available, but others will need to be requested from data holders. The Secretariat offered to help Members contact data holders if needed. In the long term, if particular data will actually be used in FBM, the Members holding those data may need to submit them to the Secretariat or otherwise ensure that they are readily and publically available.

2.151 The Working Group noted that, with the addition of a projection module, the integrated stock assessment model (WG-SAM-14/20) could be used to assess the performance and data requirements of existing and candidate decision rules that might be used in stage 2, including those which reference the state of the system in the absence of fishing. Processes influencing krill dynamics might change in the future (e.g. environmental change could drive a change in recruitment dynamics) and any projections should consider plausible changes in such processes (e.g. by increasing recruitment variability).

2.152 There are various ways to classify the indicators that might be used in FBM. One useful classification scheme is to characterise the types of actions the Commission might take in response to an indicator. In this regard, the Working Group noted that in FBM, indicators may be used to:

- (i) provide advance warning about the potential risks of fishing to advise on requirements for further precaution and/or focused future research and monitoring investments
- (ii) adjust catch limits and the spatial distribution of catches
- (iii) characterise long-term changes in the ecosystem and facilitate strategic decision-making.

2.153 The Working Group noted that most of the discussion recorded in paragraphs 2.120 to 2.133 relates to the first class of indicators, and these indicators, with their attendant benchmarks, will be useful throughout the development and implementation of all four stages of FBM. The second class of indicator will be used in stage 2 and beyond; it is expected that several of these indicators will be identified by Members who submit pro formas to SC-CAMLR-XXXIII and WG-EMM-15. The third class of indicator is likely to have increased importance when stage 4 of FBM is implemented.

#### Conservation Measure 51-07

2.154 The Working Group noted that CM 51-07 (Interim distribution of the trigger level in the krill fishery in Subareas 48.1 to 48.4) will lapse at the end of the 2013/14 fishing season. A basis for new advice to the Commission is needed. The Chair of the Scientific Committee (Dr Jones) clarified that advice from WG-EMM for changes to CM 51-07 should be explicitly supported by science. The Working Group outlined a way forward to progress FBM toward stage 2 (paragraph 2.149) using a pro forma, which could be useful for providing advice with respect to changes in CM 51-07.

2.155 The Working Group noted that the time series of krill biomass from Subareas 48.1 and 48.3 (WG-EMM-14/35 and 14/P04 respectively) show no indication of a trend in krill biomass over the period since 2000. Therefore, while the CCAMLR-2000 Survey was conducted some time ago, based on our current understanding of the ecosystem, there was no reason to suggest that the productivity of the system had changed in such a way as to mean that the advice on catch limits was no longer valid.

2.156 The Working Group noted that absolute estimates of krill biomass and predator biomass/performance for the whole of Area 48 are unlikely to be available on a regular basis and this will be an important consideration for the Scientific Committee in developing approaches to the management of the krill fishery. In particular, 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.

2.157 The Working Group agreed that, based on our current knowledge, a continuation of CM 51-07 in its current form would be consistent with the objectives of Article II. The Working Group recommended that the current interim distribution of the trigger level in the krill fishery in Subareas 48.1 to 48.4 be carried forward, while the science needed to move to stage 2 of the FBM is progressed.

#### Future ecosystem monitoring

2.158 The Working Group discussed twelve papers relevant to issues regarding future monitoring and characterisation of the krill-centric ecosystem in Area 48. The discussion focused on topics related to methods for estimating predator abundance and reproductive success, monitoring predator and prey distributions, observational programs for monitoring biogeochemical cycling and oceanographic modelling.

#### Predator abundance and reproductive success

2.159 The Working Group noted that estimates of predator abundance and reproductive success are important for the work of CCAMLR and that photographic methods may improve spatial and temporal coverage of current monitoring. Estimation methods for satellite imagery, aerial photographic surveys (both manned and unmanned) and remote time-lapse camera systems are being developed for monitoring penguin and pinniped populations around Antarctica.

2.160 WG-EMM-14/05 provided an update on an aerial survey, conducted in November and December 2013, used to estimate penguin population distribution and abundance along the Antarctic Peninsula (manned aerial survey with fixed-wing aircraft) and trials at South Georgia and the South Orkney Islands to use a small unmanned hexacopter to survey penguin breeding colonies. The aerial survey in the Antarctic Peninsula achieved coverage of more than 130 of the planned 140 colonies and trial flights with remotely operated hexacopters confirmed that it is possible to obtain high-resolution aerial photographs of penguin colonies.

2.161 The Working Group noted that such aerial platforms were capable systems for conducting regional and local penguin censuses respectively. Such data are useful for drawing

population-level inferences and are particularly useful for modelling exercises that require spatially resolved estimates of predator abundance. The Working Group noted that providing ground-truth estimates for aerial surveys would be useful to understand error and bias in aerial surveys and facilitate comparisons with satellite-derived estimates of abundance. The Working Group encouraged the authors to process the images and provide abundance estimates, acknowledging that analysis of images can be time-consuming and that development of automated counting methods, such as those reported in WG-EMM-14/54 (paragraph 2.72), will be useful to produce timely estimates of abundance from aerial surveys. The Working Group also noted that further consideration was necessary to understand the frequency with which census data from aerial surveys may be collected and the results be made available for inclusion in an integrated FBM strategy.

2.162 The Working Group noted that estimates of abundance derived from photographic surveys may be improved by including data on availability of count targets at the time a census is conducted. WG-EMM-14/09 presented progress on the development of a Bayesian method to adjust counts of breeding seals based on local demographic data that can be used to address the issue of availability bias. The methods were developed to account for availability biases that can arise from the seasonal patterns of presence and absence of individuals due to foraging trips of nursing mothers, the propensity to breed annually in mothers, the availability of territory-holding males and temporal emigration. Updated estimates of fur seals will be useful for estimating krill consumption and potential overlap with the krill fishery, noting that fur seals from South Georgia often move into the southern Scotia Sea, including areas near the South Orkney Islands. The Working Group encouraged further development and application of the method so that an updated census of breeding fur seals at South Georgia could be presented.

2.163 WG-EMM-14/27 reported on continued work to develop methods for using time-lapse photography to monitor reproduction and phenology in penguins. The paper demonstrated that robustly designed cameras can operate over long periods in the harsh Antarctic environment, identify the timing of important breeding events (phenology), provide accurate estimates of breeding success, standardise population counts made at sub-optimal times and, through a network of cameras, quantify spatial and temporal variation in these parameters. The authors noted that counts of adult birds provide a proxy for establishing breeding phenology, such as egg lay or crèche dates, which can be difficult to accurately identify in photos.

2.164 The Working Group noted that remote cameras usefully extend the spatial coverage of current monitoring under CEMP. The Working Group also agreed that proxy indices, based on adult counts, could be used to infer some reproductive parameters. The Working Group noted that methods relating to photo-derived indices, particularly the use of adult counts as proxy measures of breeding chronology, differ from current CEMP methods for parameters A3, A6 and A9. The Working Group agreed that considering variation in CEMP standard methods will be required and urged interested Members to participate in intersessional discussions to propose appropriate methods. The Working Group also agreed that its methods subgroup, led by Dr Hinke, should consider these issues next year.

## Predator foraging distribution

2.165 Data on the spatial distribution of predators and their prey is considered important for the development of feedback management strategies, spatial planning in Area 48 and the identification of priority monitoring areas. The Working Group discussed six papers related to these topics.

2.166 WG-EMM-14/02 reported on the winter distribution of macaroni penguins (*Eudyptes chrysolophus*) and the potential for competition with the krill fishery by examining spatial overlap in commercial fishing and krill consumption by penguins tagged at South Georgia. The proportion of the estimated krill stock taken by macaroni penguins and the krill fishery was small, both at the scale of the Scotia Sea and the local areas within which the fisheries operate. The authors concluded that competition between macaroni penguins and the krill fishery is low under current management and that this study provides a framework for assessing predator–fishery competition in other systems.

2.167 The Working Group noted that such metrics of spatial overlap are useful, but may not be representative of functional overlap. For example, the diet data necessary to understand krill consumption by macaroni penguins during winter are not currently available for analysis. The Working Group noted the wide pelagic distribution of macaroni penguins in the northern Scotia Sea during winter and encouraged the authors to consider means to incorporate diet estimates into future assessments of overlap with the fishery.

2.168 WG-EMM-14/42 reported a comparison of the diet and the foraging distribution of Adélie penguins at Hope Bay/Esperanza in 2013 and 2014. The authors also compared data from the krill fishery to describe the overlap of Adélie penguin foraging areas with krill fishery activity. Foraging locations during the breeding period were concentrated in the northern Bransfield Strait/Mar de la Flota in both years, while Adélie penguins dispersed from natal colonies and foraged further to the east in the northern Weddell Sea, up to 400 km from the colony, during the pre-moult period. Krill sizes in the diets were observed to increase over time. Finally, spatial and temporal overlap of Adélie foraging areas and fishery activity was evident in 2013 but not in 2014. The authors concluded that the Bransfield–Weddell transition is an important feeding area for Adélie penguins that breed near the tip of the Antarctic Peninsula.

2.169 The Working Group welcomed this analysis and noted the coherent signal of krill cohort dynamics in the diet data at Hope Bay that also are recorded in research survey data reported in WG-EMM-14/13. The Working Group also noted that the foraging areas used by Adélie penguins during the breeding and post-breeding dispersal periods were generally consistent across years, in agreement with results reported in WG-EMM-14/36. Such persistence of habitat may allow for monitoring of conditions in areas other than the local areas where tracked animals were tagged, thus expanding the monitoring footprint of individual CEMP sites.

2.170 WG-EMM-14/03 reported on progress to develop an integrated database developed by SCAR, BirdLife International and BAS to facilitate the analysis of penguin tracking data around the globe. As tracking studies proliferate, coordinating standard analyses and data formats will be important. The penguin database, based on the existing BirdLife Global Procellariiform Tracking Database, is designed to enable spatial analyses to be undertaken that will help inform a variety of CCAMLR analyses, including work on the development of a

variety of feedback management approaches for the krill fishery and work on the spatial planning processes needed for identifying candidate CCAMLR marine protected areas (MPAs).

2.171 The Working Group noted that US AMLR and BAS scientists have agreed to convene a penguin tracking workshop at BAS in mid-May 2015. This workshop will bring together those scientists that hold penguin tracking data for the southwest Atlantic, particularly for those species that are also CEMP monitoring species, with the specific intent of initiating collaborative work to build habitat models. Penguin tracking data are known to be available from Hope Bay on the Antarctic Peninsula and from Livingston Island and King George Island at the South Shetland Islands (Subarea 48.1), Signy Island, Powell Island and Laurie Island at the South Orkney Islands (Subarea 48.2) and from Bird Island and mainland South Georgia (Subarea 48.3). Other scientists with expertise in habitat modelling and spatial analysis of tracking data will also be invited. The outputs of this workshop will be presented to CCAMLR at WG-EMM-15.

2.172 The Working Group encouraged these collaborative efforts, noting that habitat models may help improve the understanding of general spatial distributions of predators throughout the year and extend the utility of tracking data collected from a limited number of breeding colonies. The Working Group noted that it will be important to consider how data products from such modelling efforts are made available for the work of CCAMLR. The Secretariat advised that GIS shape files could be one useful product from tracking data, as those could be incorporated into the CCAMLR GIS and provided to interested users based on established protocols for data access and use. Other formats could also be envisioned and would be welcomed, but appropriate metadata would be necessary to understand how such data products could be used.

2.173 Data from at-sea observational studies are also available for understanding predator distributions. WG-EMM-14/06 Rev. 1 reported the results of at-sea monitoring of seabirds and cetaceans over five summer seasons, 2010 to 2014, near the South Orkney Islands. The authors reported that large aggregations of top predators (seabirds and cetaceans) were recorded mainly in two regions: west and south of the South Orkney Islands. Among birds, Antarctic prion (*Pachyptila desolata*) was the dominant species within the five years, whereas Cape petrel (*Daption capense*) showed successive decreases in abundance. Among cetaceans, fin whales (*Balaenoptera physalus*) had the highest mean encounter rate, followed by humpback whales (*Megaptera novaeangliae*).

2.174 The Working Group thanked the authors for providing these data and noted the similarity in these data with those reported in WG-EMM-14/16. The Working Group agreed that studies such as this allow for monitoring of species at sea, including those that are otherwise not currently monitored; such distributional data are highly valuable to the work of WG-EMM. For example, the observations of krill-dependent predators during these surveys may provide linkages between CEMP monitoring sites and distant foraging areas. The Working Group also noted that predator distributions often exhibit spatial segregation on species levels; such spatial segregation may be important to consider when developing an FBM strategy or when distributing catch throughout Area 48 (paragraph 2.191).

2.175 New methods to understand krill distributions are also being developed. WG-EMM-14/P02 reported on the deployment of an ocean glider equipped with a single-beam echosounder to assess the feasibility of using underwater autonomous vehicles to measure the

distribution of Antarctic krill. The preliminary analyses suggested that it is possible to collect quantitative measurements of acoustic backscatter from zooplankton using an echosounder mounted on a glider and that such tools may provide for increased capacity to estimate krill distribution and abundance.

2.176 The Working Group welcomed this development and noted that further work to use gliders equipped with acoustic sensors has already been conducted. Notably, the device has been tested on other types of gliders and this has alleviated several constraints reported in WG-EMM-14/P02. The Working Group agreed that the miniaturisation of acoustic sensors will be very useful, but identified a series of trade-offs for the use of glider-borne acoustic sensors that will be useful to consider to maximise the potential for data acquisition. For example, the slow speed of gliders requires a trade-off between the temporal and spatial scale of surveys, and surveys may be limited to areas with relatively slow currents. Their small size and relatively low cost may allow deployment from numerous platforms, including krill fishing vessels and shore-based stations. The Working Group suggested that the Scientific Committee note the future potential for the expanded use of gliders to monitor krill distributions.

#### CEMP Site locations

2.177 Monitoring predator and prey distributions may help identify new areas for CEMP monitoring. WG-EMM-14/61 Rev. 1 provided an analysis based on summer foraging ranges of penguin colonies in Subareas 48.1 and 48.2 and total krill catches within those foraging areas. The paper examined 218 penguin colonies located from the South Orkney Islands to Adelaide Island and noted that 72 have had krill catches of 1 000 tonnes or less within the typical foraging range of penguins. The authors suggested that identifying colony locations that had low krill catches over time may be useful to identify reference monitoring areas.

2.178 The Working Group thanked the authors for this analysis and noted that identification of colonies that could serve as reference monitoring sites might usefully consider additional attributes of foraging areas, including temporal shifts in foraging ranges (i.e. winter distributions) and/or habitat models that identify general characteristics of important predator foraging areas. The Working Group noted that the predator foraging workshop (paragraph 2.171) may provide such habitat models for developing this analysis further.

#### Biogeochemical cycling

2.179 WG-EMM-14/59 reported on a new initiative by Poland to provide detailed monitoring of biogeochemical cycling within the Admiralty Bay (King George Island, South Shetland Islands) ecosystem that will build on historical datasets obtained in the area while complementing existing monitoring of krill-dependent predators under CEMP (paragraphs 6.7 to 6.10).

## Oceanographic modelling

2.180 The Working Group discussed two papers that reflect on advancing understanding of hydrographic processes in the Scotia Sea. WG-EMM-14/08 reported on a planned oceanographic modelling project which will cover South Georgia and the South Orkney Islands, including the shelf regions and the pelagic regions in between. The modelling framework used will be the NEMO-Shelf model, which has the capability to resolve tides, atmospheric forcing and sea-ice processes with a roughly 3 km horizontal resolution. The model will help facilitate the evaluation of hydrographic conditions that are important for determining prey aggregations on the scale of 5s to 10s to 100s of km. The proposed modelling work follows earlier use of a particle-tracking study at South Georgia using the POLCOMS model. The authors believe that such detailed analyses will help inform WG-EMM activities aimed at developing spatial and feedback management procedures.

2.181 WG-EMM-14/P03 reported on a study that used trajectories of forty surface drifters released in January 2012 in the northwestern Weddell Sea to examine water movement and physical structuring of surface water masses in the southern Scotia Sea. The data suggested that the Southern Antarctic Circumpolar Current (ACC) Front acts as a dynamical transport barrier to the drifters and influences surface chlorophyll distributions. Specifically, the paper provided the first Lagrangian observations of a direct transport pathway between the Weddell Sea and regions of persistently elevated chlorophyll levels in the Scotia Sea. The authors inferred that ACC fronts partition Weddell source waters in the Scotia Sea and suggest that Scotia Sea ecosystem dynamics are sensitive to variability in ACC fronts in the Drake Passage.

2.182 The Working Group noted that research on the small-scale processes that can influence aggregations of krill and predators are very useful to the work of CCAMLR. The papers provided a useful reminder that water circulation in the Scotia Sea is complex and that such work takes useful steps toward resolving questions related to krill distribution and movement. The Working Group acknowledged that the main objective of both papers was to track water movements in order to frame knowledge of small-scale hydrographic process, but encouraged comparisons of their results with the spatial distributions of historical krill catches or survey data on krill and fish distributions. In particular, the hydrographic model described in WG-EMM-14/08 will allow particle tracking experiments to be carried out within the framework of the model, allowing comparisons between the simulated and real-world scenarios. These simulation studies will also allow simple behaviour to be assigned to particles. Specific outcomes of the planned international field work in 2015/16 (paragraphs 5.1 to 5.7) could also be examined in the context of the model, including better understanding of deployed drifters. The Working Group encouraged studies to be conducted using drifters to further understand important hydrographic processes throughout the Scotia Sea, including movement of sea-ice, noting that drifter trajectories can be sensitive to deployment locations.

## Integrated assessment model

2.183 WG-SAM-14/20 described updating and testing of an integrated krill stock assessment model. The model has previously been considered by both WG-SAM (Annex 5, paragraphs 2.43 to 2.45) and WG-EMM (SC-CAMLR-XXX, Annex 4, paragraphs 2.215

to 2.217; SC-CAMLR-XXXI, Annex 6, paragraphs 2.158 to 2.161). The current implementations use survey data as the basis for estimating various parameters, including growth and stock-recruit parameters, selectivities for each data source and, ultimately, an age-based representation of stock dynamics. The survey data were provided by Germany, the USA and Peru. The data include biomass estimates from acoustics and two types of research nets and length-frequency data from nets. The paper described a number of single-area implementations and tested their sensitivity to different within-year temporal aggregations of the data and to the inclusion of different sources of biomass data. The paper also assessed bias in model estimates of spawning stock biomass and recruitment by fitting the models to simulated data. Most implementations provided good fits to the data and estimated simulated spawning stock biomass and recruitment with minimum bias. However, the most spatially resolved implementation produced very biased estimates. The other three implementations show consistent dynamics, including prominent peaks attributable to strong cohorts, particularly in the early 1990s. However, absolute biomass varied between implementations by two orders of magnitude. The results suggested that growth rate is higher than was assumed when the precautionary yield was calculated.

2.184 WG-EMM-14/35 discussed the results from WG-SAM-14/20 in the context of WG-EMM's work program. It suggested that the integrated krill stock assessment model is useful to develop advice for CCAMLR on annual subarea-scale catch limits for Subarea 48.1. The model provides a credible index of krill biomass but does not currently produce a robust estimate of absolute biomass. Thus, management advice should be developed by considering changes in relative biomass. The models suggested that gear selectivity is an important influence on observed density. Therefore, there is a need for caution in interpreting observed changes in density. The results suggested that krill biomass in Subarea 48.1 during the CCAMLR-2000 Survey was low relative to other times in the past three decades.

2.185 The integrated krill stock assessment model could be used to provide regular stock assessments based on data from various sources, including scientific surveys, fishing vessel surveys, observers, CEMP, etc. Robust estimates of the consumption of krill by predators would help to scale biomass estimates. The model can account for differences in the timing of different data sources, and gear-specific selectivity patterns will be easier to estimate if the gears are fished in the same season. The sampling bias (selectivity) in each data source, especially fishery-dependent sources, could change over time. A potential solution is to define new data sources when characteristics, such as fishing patterns, change substantially.

2.186 The model could be extended to incorporate data from Subareas 48.2 and 48.3 within a year once these data have been compiled in the correct format. The management of the krill fishery includes spatial subdivision of a regional catch limit (for Subareas 48.1, 48.2, 48.3 and 48.4) and there may be an eventual need to develop the model beyond its current subarea scale to consider subdivision at a finer scale (e.g. SSMUs).

2.187 A management approach based on regular (e.g. annual) assessments would be more robust to short-term errors than the current approach based on a single stock assessment. Management advice needs to be robust to important uncertainties, including the uncertainty about krill flux. Management strategy evaluation would be useful to evaluate candidate approaches. A simulated dataset with known properties (especially for flux) would be useful for testing models (see also Annex 5, paragraphs 2.43 to 2.45).

## Fishing vessel surveys

2.188 WG-EMM-14/16 presented the fourth in a series of acoustic trawl surveys conducted around the South Orkney Islands in January 2014 by a Norwegian commercial krill fishing vessel. The survey series objectives are to describe the taxonomy of the macro-zooplankton community, demography and density of Antarctic krill in the region as well as the occurrence and distribution of krill predators. Following the survey, commercial fishing commenced and experiments were conducted to evaluate escape mortality rates (WG-EMM-14/14, paragraphs 2.23 and 2.24), the development of maturity stage composition and vertical distribution in an Antarctic krill hotspot (WG-EMM-14/15, paragraphs 2.48 to 2.51).

2.189 Details of the survey area, acoustic data processing and trawl sampling methodologies used to determine krill density and the spatial distribution of krill were presented. In addition to the acoustic survey, environmental data were collected to provide information on potential variables determining the krill density, and marine mammal and seabird monitoring surveys were conducted to provide information on spatial distribution of associated predators. A total of 19 species of marine predators were identified, including 87 fin whales, 42 humpback whales, 418 Antarctic fur seals, 1 568 southern fulmars (*Fulmarus glacialoides*), 2 230 chinstraps and 20 Adélie penguins. A test deployment of an acoustic mooring was also successful, following which the mooring was redeployed at 60°24.291'S and 45°56.306'W to record for a year.

2.190 The Working Group noted that the acoustic signal of air-breathing predators feeding on krill swarms could be identified within the data. It was noted that swimming speed and swarm behaviour during predation could potentially be monitored using acoustics. Instances of fur seals feeding on, and dispersing, krill swarms around South Georgia had been recorded by the Japanese fishing industry and this form of behaviour could potentially be examined using acoustics. The effects of predator and fishery behaviour on the behaviour of krill and the effects on vessel CPUE would be a valuable source of information for the Working Group.

2.191 It was noted that the distribution of whales reported within the paper was consistent with the results reported in WG-EMM-14/06, which also showed a common distribution of whales along the shelf edge to the north of the South Orkney Islands. The Working Group requested that spatial distribution maps of predator density related to the density of krill observed during surveys be collected more frequently to allow interactions to be monitored, and considered that this form of information would be extremely useful to the work of WG-EMM. The Working Group noted, however, that there would be a need to standardise methods for collecting the data to allow between-survey comparisons (paragraph 2.174).

2.192 WG-EMM-14/47 presented a trial acoustic survey conducted by the Chinese krill fishing vessel *Fu Rong Hai* in waters around the South Shetland Islands during December 2013. Details of the survey area and acoustic data processing were presented. The transect design followed that of the US AMLR survey in the same area. The survey paused for commercial trawling when significant krill swarms were observed on the echosounder and then recommenced once fishing was finished. Although an estimation of krill biomass could not be undertaken in the present study due to insufficient biological sampling during this survey, experience has been gained to guide future work.

2.193 Krill was distributed in the majority of the survey area and the mean density ( $S_v$ ) of krill swarms tended to be higher in inshore waters to the north of the islands with no such tendency observed in the Bransfield Strait. The majority of the krill swarms were found in the upper 100 m with a thickness of less than 30 m. Length distributions were obtained from three hauls which exhibited a uni-modal distribution with similar structure and relatively small differences in mean length. The further data analysis and the experience gained from this initial survey may lead to more scientific data being collected by the Chinese krill fishing vessels in the coming fishing seasons.

2.194 The Working Group noted that the pattern of commercial fishing by the *Fu Rong Hai* relative to the swarm density indicated that fishing did not seem to be occurring in areas with the highest krill swarm densities, although this may be restricted by topography such that fishing might not be possible in the inshore areas where the highest density aggregations occurred.

2.195 The Working Group further discussed the frequency with which samples should be taken on such surveys conducted by commercial fishing vessels. The required sample number is related to the variation in the swarm abundance and distribution with more samples for areas with higher variation but should be sufficient to obtain the structure of the biomass being surveyed. It was noted that this should be more straightforward in commercial fishing as the vessels target krill swarms.

2.196 The Working Group agreed that commercial fishing surveys, such as those described in WG-EMM-14/14 and 14/15, should be encouraged. They provide information on local-scale dynamics and predator interactions and it would be appropriate for SG-ASAM to frame the types of questions and research which they could address and provide advice on standardisation (paragraphs 2.197 to 2.200).

#### SG-ASAM

2.197 The report from the meeting of SG-ASAM that took place in Qingdao, People's Republic of China, 8 to 11 April 2014, was presented by Dr Watkins (Co-convenor). The Subgroup's work is currently focussed on the use of fishing-vessel-based acoustic data to provide qualitative and quantifiable information on the distribution and relative abundance of Antarctic krill and other pelagic species such as myctophids and salps. Specifically, this meeting of SG-ASAM was convened to determine protocols for collection and analysis of acoustic data collected on board fishing vessels.

2.198 The Working Group welcomed the current SG-ASAM focus on protocols for use on standard transects. It noted that the selection of certain representative transects that might be the primary focus for data collection by different fishing vessels would be valuable. In this regard it supported the ongoing discussion between fishing companies and SG-ASAM to identify such transects.

2.199 The Working Group noted that to date surveys undertaken with fishing vessels, such as those described in WG-EMM-12/63, had a degree of uncertainty similar to that applying to

surveys undertaken from scientific research vessels. However, the Working Group noted that the use of different calibration techniques, such as seabed backscatter measurements, would likely add additional levels of uncertainty to the quantitative estimates of krill biomass.

2.200 The Working Group agreed that work on estimating the overall level of uncertainty associated with an acoustic survey was extremely important and that this would need to take account of the uncertainty associated with the performance of different vessels, their level of calibration and the frequencies used to identify the krill targets and generate a quantitative estimate of krill abundance.

#### ARK workshop

2.201 Dr Kawaguchi gave a presentation on the ARK workshop for krill fishery representatives and the scientific community that was held in Punta Arenas, Chile, on 5 and 6 July 2014. The aim of the workshop was to bring together krill fishery operators, including masters of fishing vessels, and scientists working on krill within CCAMLR. The workshop provided a forum for the exchange of information on issues relating to krill management, krill biology, fleet behaviour, estimation of green weight, escape mortality, the efficient use of observers and future developments in fishing technology.

2.202 The first day of the workshop consisted of a series of presentations by fishery operators and krill scientists that formed the basis for discussions between talks and on the second day. Dr Kawaguchi summarised the discussion under the following headings:

(i) Future surveys –

There was no strong pressure to undertake a new basin-scale synoptic biomass survey, rather there was a push to utilise integrated regional surveys using new technologies (such as the proposed 2015/16 multinational investigation of the krill-based ecosystem – WG-EMM-14/10) and input from the fishing fleet.

(ii) How does the current subdivision of the trigger level affect the industry? –

Although the industry can see benefits in having a higher trigger level in Subarea 48.1, they can accept the levels. It was noted that this may be more of a problem if, for example, the number of vessels fishing doubled.

(iii) Fish by-catch –

There was a useful discussion on the division of labour between the vessel crew and the scientific observers. New biochemical/molecular techniques may provide alternative methods for identification of by-catch species.

(iv) Green weight estimation –

A variety of methods are used to estimate the green weight of krill caught. Discussion between operators and the Secretariat clarified some of the issues in its sampling and recording.

(v) Development of the fishery –

The industry saw a very slow growth in the krill fishery aimed at human consumption markets. Increases in demand for krill oil can be met by current catches. ARK members have a good knowledge of markets for krill and should be able to report any significant developments in these markets to CCAMLR in their annual report.

(vi) Fishing fleet behaviour –

Masters select fishing grounds based on past experience and to some degree on product type and fishing gear. Continuous fishing systems can operate in smaller aggregations in comparison to conventional trawlers. Many vessels often fish together in the same general vicinity and communicate the location of favourable catches.

(vii) Issues for krill biology –

- (a) fishing vessels report movement of krill through hotspots and subsequent dispersion over deeper water. At times, swarms also form and disperse unpredictably
- (b) krill are found deeper in the water column during winter and their vertical distribution varies from season to season
- (c) ‘green-head’ krill are not found later in the year but are still getting fatter, so what are the krill feeding on?
- (d) the krill fishing vessels might collect more oceanographic data using CTD, ADCP, fluorometry and drifters
- (e) ARK members have large amounts of data and samples from their operations and this could be made available to scientists in the CCAMLR community, particularly for research that contributes to understanding krill dynamics and management.

2.203 The ARK workshop was viewed by all as a very useful information exchange and resulted in a number of specific outcomes. It was agreed that a similar meeting would be useful in the future. A report of the ARK workshop will be submitted by ARK to SC-CAMLR-XXXIII.

2.204 The Working Group agreed that this meeting had been very beneficial and noted that a number of the points discussed in the ARK workshop had benefited the plenary discussions that had taken place at WG-EMM-14.

## **Spatial management**

Weddell Sea (Domains 3 and 4)

3.1 WG-EMM-14/19 reported on progress with the compilation of scientific evidence and analyses in support of the development of a proposal for CCAMLR MPA(s) in the Weddell

Sea. This is an update on the project which started in 2013 (see WG-EMM-13/22 and SC-CAMLR-XXXII/BG/07), and includes information on the current state of data processing, the scientific analyses undertaken to date and a report on the international expert workshop held in Bremerhaven, Germany, in April 2014. The project has collated more than 10 environmental data layers covering the entire Weddell Sea, as well as more than 20 biological data layers. Major gaps remaining in the compiled data include information on flying seabirds, while available information on zooplankton and fish have yet to be consolidated. A pelagic regionalisation based on environmental data has been completed, and the next stage in the project will be to develop an extensive background document for the Scientific Committee. The area used in this planning process (including MPA Planning Domain 3 and part of Planning Domain 4) does not represent the boundaries of any MPA proposal.

3.2 The Working Group welcomed the progress made by Germany and the participants in the international workshop and discussed ways in which Members could contribute to the further development of this project.

3.3 The incorporation of additional datasets was discussed, including Russian data from toothfish longline surveys for the eastern part of the Weddell Sea, South African and Japanese exploratory toothfish fishery data from the southern part of Subarea 48.6, Argentinian, UK and USA data on Adélie penguin post-breeding habitat use, and the possible inclusion of cetacean data such as the International Whaling Commission (IWC) sightings dataset.

3.4 Several participants supported the potential use of cetacean data in the Weddell Sea MPA analysis, noting that, although CCAMLR does not have responsibility for managing cetacean populations, cetaceans are an important component of Southern Ocean biodiversity and a likely sensitive indicator of ecologically important oceanographic patterns; the aim of this analysis is to identify areas of importance for conservation, irrespective of whether they are managed by CCAMLR. It was also noted that providing for the recovery of cetaceans is part of Article II.

3.5 Prof. Brey noted that cetacean habitat models suggest a correlation between cetacean presence and features such as primary production, ice edge and polynyas and that these could potentially be used as proxies to approximate cetacean habitats as part of the MPA planning process.

3.6 The Working Group endorsed the Weddell Sea pelagic regionalisation (WG-EMM-14/19, Figure 7) as a useful product for characterising the pelagic environment based on large-scale environmental drivers such as ocean depth, water mass characteristics and dynamic sea-ice behaviour, noting that this followed an approach recommended by the Scientific Committee (SC-CAMLR-XXIX, paragraph 5.16).

3.7 The Working Group noted the importance of considering the boundaries of the Weddell Sea planning domain with the neighbouring Planning Domain 1 at the tip of the Antarctic Peninsula. The northern Antarctic Peninsula region encompasses an area of particular ecological interest, and it was suggested that work on the development of MPAs in this region should be undertaken collaboratively with the Domain 1 planning process. The Working Group noted that the intersection of planning domains is a common issue which will

need to be considered across the Convention Area, and is especially relevant if different datasets are being used in separate, but spatially adjoining, planning processes (paragraph 3.16).

3.8 The Working Group agreed that the process of developing the datasets would be facilitated by considering these in relation to a list of specific protection objectives consistent with those indicated in CM 91-04, paragraph 2 (i.e. using, for example, the approach taken for MPA Planning Domain 1). There may be a hierarchy of objectives for the Weddell Sea region from those defined at the regional level to more specific objectives, consistent with the objectives specified in CM 91-04. It was noted that endorsement of relative levels of protection sought for different protection objectives was a decision for the Commission.

3.9 Prof. Brey noted that the Bremerhaven expert workshop agreed that key high-level conservation objectives for the Weddell Sea include: (i) ensuring that the Weddell Sea ecosystem is protected to an appropriate degree, as the Weddell Sea represents one of just a few high-latitude marine ecosystems in the Southern Ocean, (ii) protecting a refuge area, and (iii) protecting a threatened area.

3.10 Dr Petrov made the following statement:

‘This report, which ignores Russian data, seems to be incomplete. We recommend the results of the Russian longline surveys to be considered when planning MPAs in the Weddell Sea. We would like to point out that those boundaries of domain, shown in the Figure 1 of WG-EMM-14/19, are not the boundaries of the prospective MPA. They appear to be a biogeographical area with a potential for establishment of MPAs.’

3.11 The Working Group suggested that for each specific objective, available data for the Weddell Sea could be used to map the distribution of features relevant to the systematic conservation planning process. For some objectives, it is clear that the corresponding spatial data layers have already been collated; for others, finalising a list of objectives would highlight where additional data remain to be assembled, as well as helping to determine those datasets which are not relevant to the definition of protection objectives and so may not need to be elaborated further.

3.12 The Working Group supported the work undertaken on the Weddell Sea MPA planning process to date, and encouraged the proponents to continue this process with the engagement of interested Members. A further international workshop (depending on available resources) could be useful to address some of the next steps. It was suggested that further information on the planning process could be deposited with the Secretariat as a set of reference documents or consolidated into a synthesis report (see paragraphs 3.64 to 3.67) in due course. Such reference documents could include descriptions of the environment and ecosystem at the scale of the planning domain and corresponding protection objectives, and also specific methodological descriptions of the process by which MPA scenarios were designed to achieve those objectives.

3.13 WG-EMM-14/23 referred to background and criteria for the establishment of an MPA in the Weddell Sea. The paper encouraged the establishment of MPAs in the Convention Area, particularly in the Weddell Sea, noting that decisions should have a scientific basis, using approaches such as bioregionalisation. WG-EMM-14/23 presented proposals for possible joint research by Russian and German scientists in the eastern part of the Weddell

Sea, which would aim to enhance the collation and utilisation of data required for MPA development. This research would focus specifically on ichthyoplankton, Antarctic krill in the northwest Weddell Sea, and the toothfish life-cycle, including a proposed survey on the shelf (250–550 m) for smaller fish. The paper also reviewed information on unexploited fish resources in the Weddell Sea, concluding that new research should be initiated.

3.14 The Working Group thanked the authors for this contribution, noting its relevance to discussions in WG-SAM on the development of toothfish habitat models (Annex 5, paragraph 3.3). Data from fisheries could contribute to a better understanding of the nature of toothfish habitat, and this would be useful in the Weddell Sea where toothfish research activities may need to vary in location because of sea-ice. However, the Working Group noted that habitat models relying on extrapolation from spatially restricted data are subject to considerable uncertainty. Data collected by Japan, the Republic of Korea and South Africa on toothfish in the eastern Weddell Sea (Subarea 48.6) could also be considered.

3.15 The Working Group discussed the use in MPA planning of fish distribution data relating to target species. It noted that under a systematic conservation planning process, where protection objectives include the protection of particular life-history stages of the target species, these distributions may be used to define priority areas for protection in their own right. Alternatively, target fish distributions may be considered as a ‘cost’ layer indicative of the potential effects of MPA scenarios on patterns of rational use.

3.16 The Working Group noted that the biologically interesting area at the intersection between MPA Planning Domains 3 and 1 (around the tip of the Antarctic Peninsula/northwest Weddell Sea) could be a focus for collaborative research to better understand the krill-based ecosystem.

3.17 WG-EMM-14/20 reviewed marine research in the southeastern part of the Atlantic sector, carried out between 1968 and 2000. This region includes the South Sandwich Islands, Bouvet Island and Maud Seamount, as well as the southeastern coastal area of the Weddell Sea. The review provided general information on the structure and dynamics of water circulation and ice conditions, including the position of the Frontal Zone of the Weddell Circulation. It also suggested that the distribution of fishable krill concentrations is linked to oceanographic conditions over the continental slope and shelf region between 20°W and 30°E which appeared to be favourable for the formation of such aggregations. The paper also provided information on phytoplankton and ichthyofauna in the region, concluding that some fish species may be of commercial interest.

3.18 The Working Group noted that the compilation of information in WG-EMM-14/20 (Figure 1) is very useful because it could be considered in the context of current ecological modelling (e.g. Thorpe et al., 2004, 2007). The combination of field experience and modelling is very important, and it was suggested that a useful exercise would be to examine historical data in the context of the hydrodynamic model framework for the northern Weddell Sea and Scotia Sea region presented in WG-EMM-14/08.

#### Western Antarctic Peninsula and southern Scotia Sea (Domain 1)

3.19 WG-EMM-14/40 reported on progress on the development of MPAs in Domain 1. This report is a compilation of the progress achieved during the bilateral Chile–Argentina

meeting for identifying candidate MPAs in CCAMLR Domain 1. Twenty-nine conservation objectives have been identified. For 20 objectives, data and shape files (spatial distribution layers) are available. For nine objectives, the shape files are still missing, three further ones are incomplete yet. Human costs, i.e. activities that may threaten the conservation objectives (krill fisheries, tourism, permanent research stations) have been integrated in a single cost layer. There are some data gaps still to be filled. Overall, spatial distribution of biological data is heterogenous; information is concentrated in the region of the South Shetland Islands, Bransfield Strait and South Orkney Islands.

3.20 WG-EMM-14/49 presented the results of a national Chilean workshop with relevant stakeholders on MPA development in Domain 1, focused on conservation objectives and data gaps. This was a follow-up to the Chilean–Argentine workshop in 2013 (WG-EMM-14/40). Major results were (i) an agreement that MPAs are required to complement other CCAMLR conservation measures, (ii) an agreement that MPAs are not the only mechanism available for fishery management to protect dependent species, and (iii) specific comments and recommendations for a number of conservation objectives.

3.21 The Working Group welcomed the progress made by Chile, Argentina and their partners, and appreciated the leading role of Dr Arata in this project. It was agreed that the two papers provide a good demonstration of the MPA development process for Domain 1, including, particularly, the iterative process between scientists and policy-makers in defining MPA objectives, which is consistent with an approach recommended by the Scientific Committee (SC-CAMLR-XXIX, paragraph 5.16).

3.22 The Working Group noted that it is helpful for those outside the planning process to see the process being undertaken, including the protection objectives and the methods being used to identify MPAs in Domain 1, how the objectives correspond to mapped spatial areas or features to be prioritised for inclusion in MPAs and how relative protection priorities have been translated into target percentages. The second phase is intended to involve policy considerations of how much protection is required, allowing alternate scenarios to be evaluated.

3.23 The Working Group considered whether Domain 1 should be subdivided, as the domain includes three ecoregions, and the weightings given to the chain of seamounts near the South Orkney Islands, and to the polynyas to the southwest of the Peninsula, dominate some of the analyses. The Working Group noted that if these features were separated out, there might be a more straightforward way to determine the influence of different conservation objectives. However, the Working Group recalled that Domain 1 was defined to cover the krill-centric ecosystem as well as the important links between the South Orkney Islands and the Antarctic Peninsula, and, consequently, it is important to consider how spatial protection and harvesting might interact across the region. It was therefore concluded that Domain 1 should be maintained as a single planning domain.

3.24 The Working Group encouraged interested Members to get involved in the further process of developing MPA scenarios in Domain 1. The use of the list of objectives and corresponding mapped priority features presented in WG-EMM-14/40 would allow dialogue between Members, and it was proposed that the existing data (shape files) could be made available to Members through the CCAMLR website, under the Rules for Access and Use of CCAMLR Data.

3.25 The Working Group recommended holding a second international technical workshop in support of the planning process for Domain 1 during early 2015. It agreed that the aims of this Workshop could be as follows:

- (i) Review the available data that support the existing specific conservation objectives:
  - (a) perform a critical analysis of existing data
  - (b) identify data that are missing but which might be considered critical for the MPA planning process
  - (c) agree on the scope of data to be included in the process in the future, as new data arises.
- (ii) Consider different candidate MPA scenarios submitted by Members:
  - (a) Members participating in the technical workshop should develop candidate MPA proposals using their preferred protection targets and costs selected from the conservation objectives already defined for Domain 1 (WG-EMM-14/40, Table 1), or other conservation requirements, e.g. reference areas
  - (b) where participating Members do not have the technical expertise to develop candidate MPA proposals, they should consider their preferred protection targets and costs.
- (iii) Undertake a sensitivity analysis of different scenarios:
  - (a) explore the sensitivities associated with using different scenarios in order to identify those targets and costs driving the variability between scenarios.

3.26 The Working Group agreed that during the period between WG-EMM-14 and SC-CAMLR-XXXIII, it would be valuable if the following information were collated using a Domain 1 e-group to:

- (i) make available the existing data, including spatial layers associated with each objective
- (ii) undertake a gap analysis and generate a list of missing data and where they are currently stored; some of these datasets are already identified for each conservation objective (WG-EMM-14/40, Table 1);
- (iii) generate a list of other data that will become available for the planning process in Domain 1 within the next 12 months.

3.27 The outputs from the workshop will be provided to WG-EMM and/or the Scientific Committee and it is envisaged that these will help facilitate a roadmap for preparing future candidate MPA proposals for Domain 1.

3.28 WG-EMM-14/41 reported on progress on the development of a network of MPAs in the vicinity of Akademik Vernadsky Station. Previous work led to outline proposals for MPAs in the Stella Creek and Skua Creek areas. Subsequently, additional scuba dive surveys have been carried out to enhance available information on biodiversity and community composition. In presenting the paper, Dr Pshenichnov proposed a change of name from 'Network of marine protected areas' to 'Network of special investigation/research areas'.

3.29 Some Members wondered whether this proposal would be better suited to designation through the Antarctic specially protected area (ASPA) process, as a special investigation site would fit well with the designation of an ASPA. However, the Working Group recognised that it was for the proponents to decide which route to pursue.

#### East Antarctica (Domain 7)

3.30 WG-EMM-14/48 brought together the information provided to the Scientific Committee and its working groups on the East Antarctica Planning Domain since 2010. The report was structured according to the MPA Report sections initially proposed by WG-EMM-12/49, with an additional section on the assessment and management of threats. It provided a consolidation of information from previous papers on: (i) evaluating ecology and conservation/scientific values of the region, (ii) considering the requirements of what is to be achieved in the representative system of MPAs (RSMMPA), (iii) assessing the effects on rational use of the proposed MPAs, and (iv) considering research and monitoring requirements.

3.31 The description of the planning domain includes information to determine the location and size of MPAs, a description of ecology of the region, biogeographic boundaries at various scales, physical characteristics that define ecosystem structure and function, and regionalisations to classify and determine distribution of benthic and pelagic environment types. This included a test of the utility of environment types in designing MPAs, which concluded that regionalisation captured most ecological properties, but that finer-scale heterogeneity can occur within environment types.

3.32 The section on identification of MPA locations in the planning domain includes: (i) objectives for the planning domain, (ii) the rationale for determining the locations and sizes of MPAs, (iii) a description of conservation values in the planning domain, and (iv) consideration of MPAs in each province, presented as seven possible areas for inclusion in the RSMMPA. Four of these seven areas are highlighted as areas for contribution to the East Antarctica RSMMPA; these have been revised with updated boundaries that have been negotiated intersessionally amongst Members. The report included a description of the relationship of these proposed areas to the features of the planning domain.

3.33 The paper also included information on historical activities within the planning domain, the assessment and management of threats based on a precautionary approach and a description of limits on activities permitted in the MPA. Priority elements for a research and monitoring plan relate to the objectives of individual MPAs within the RSMMPA, and monitoring to evaluate whether the objectives are being achieved.

3.34 The Working Group noted that the information consolidated into this report has been previously reviewed by the Scientific Committee. It further agreed that the report format was a useful way to synthesise and present this large amount of information for ease of reference (see also paragraphs 3.64 to 3.68).

3.35 A number of suggestions were made on additional data to be included, such as further information which became available recently on baleen whale abundance trends and Adélie penguins. It was also suggested that the development of research and monitoring should focus on further understanding the dynamic nature of ecosystems in the East Antarctica planning domain, which could enhance the scientific basis for the proposal. An additional suggestion was to more clearly highlight the data and methods used to develop each scenario where MPA proposals are presented in the report.

3.36 Dr Constable thanked participants for their input, and indicated that an updated reference document would be submitted to the Scientific Committee, taking these comments into account (see paragraph 3.68).

3.37 Dr Petrov made the following statement:

‘Recalling that MPA discussion was announced on the meeting of Scientific Committee (SC-CAMLR-XXXI) and was discussed among the countries and it was supported by several countries and by the Chairman of the Scientific Committee. (Report of SC-CAMLR-XXXI, paragraphs 5.35, 5.74 and 5.77 to 5.80). We think that report in discussion of MPA there should be a clear understanding between the Members. In the case if this proposal (WG-EMM-14/48) will be presented in the Scientific Committee and will be translated in four official languages of CCAMLR according to the procedure we will take part in discussion of this proposal. Now we would like to reserve our opinion on that proposal (WG-EMM-14/48) till the meeting of the Scientific Committee, where as I mentioned above the procedure provides the official translation of documents and interpretation during the discussion.’

3.38 The Working Group noted that advice will need to be sought from the Secretariat on when and how translation of documents supporting MPAs could occur.

#### South Orkney Islands (Domain 1)

3.39 WG-EMM-14/25 presented a draft MPA Report for the South Orkney Islands southern shelf MPA. This report was developed following advice from WG-EMM that the preliminary draft MPA Report submitted in 2013 (WG-EMM-13/10) should be revised to form three separate documents (SC-CAMLR-XXXII, Annex 5, paragraph 3.22).

3.40 The draft MPA Report was structured according to the MPA Report sections initially proposed by WG-EMM-12 (SC-CAMLR-XXXI, Annex 6, paragraphs 3.73 to 3.76), modified to take into account comments from the e-group requested by the Scientific Committee (SC-CAMLR-XXXII, paragraph 5.18). The report contained sections on (i) description of the region, (ii) regional and specific objectives (as defined in previous proposal papers), (iii) a summary of historical and recent activities, and (iv) a summary of research and monitoring activities and results available since 2009. Finally, it included an assessment of the MPA and effects of activities, including the extent to which the MPA objectives have been achieved, as well as an analysis of current and potential threats.

3.41 The Scientific Committee has previously agreed that an MPA Report would allow Members to contribute data and information to the review of the South Orkney Islands MPA in 2014 (SC-CAMLR-XXXI, paragraph 5.38).

3.42 The draft MPA Report demonstrated the range of research activities that have been undertaken since 2009, related to the specific objectives of the MPA, and monitoring activities to evaluate the extent to which these objectives are being met (WG-EMM-14/25, Tables 4 and 5). These are cross-referenced to the MPA research and monitoring plan (WG-EMM-14/24) and to other papers submitted to this Working Group describing the results of recent research. It also describes the requirements for new research and monitoring.

3.43 The final section of the draft MPA Report was an assessment of the MPA and the effect of activities, which concludes that the scientific basis supporting the protection of the features within the MPA remains the same as at the time of its adoption. However, the report also noted that five years is a short time frame in which to assess regional ecological characteristics, and that fully analysed results from some of the research and monitoring activities carried out during recent years will only start to become available during the next reporting period.

3.44 Drs Grant and Trathan thanked those who had contributed to the e-group discussion on the structure and content of the document, and welcomed further contributions from Members to enhance the report, particularly on other data which may be available for the region (e.g. WG-EMM-14/06 Rev. 1).

3.45 The Working Group noted the draft MPA Report and agreed that the structure and content provided a good example for structuring MPA Reports in the future.

3.46 The Working Group provided some suggestions for improvements to the draft MPA Report, including clarification of the protection objectives and the inclusion of further information on recent research activities undertaken in the South Orkney Islands region. The importance of addressing protection objectives for the wider region, and not just the MPA itself, was also highlighted. It was suggested that information could be included to list the research completed to date, and to highlight elements of ongoing research that are critical to the achievement of specific objectives.

3.47 Dr Kasatkina asked the authors whether the South Orkney Islands MPA was designed to protect the ecosystem from the effects of climate change, or from the impacts of human activities including from fishing activity.

3.48 Dr Trathan noted that when the Commission designated the South Orkney Islands MPA, it had provided protection for a number of ecosystem components, including representative protection for a number of bioregions, for penguin foraging habitat during a period when birds have significant resource demands as they replenish their body reserves lost during the breeding season, for biodiversity associated with the Weddell Front which is an important oceanographic feature and the southern boundary of the Weddell Scotia Confluence, as well as important benthic habitats. These are detailed in Tables 2 and 3 in WG-EMM-14/25. Section 5.2 in WG-EMM-14/25 provided information concerning current and potential threats to the MPA.

3.49 The Working Group discussed whether an analysis could be undertaken to calculate the contribution of the South Orkney Islands southern shelf MPA to the wider protection objectives for Planning Domain 1, for example the extent to which this MPA protects representative bioregions that are present across Domain 1. It was suggested that this could be undertaken as part of the ongoing Domain 1 planning process.

3.50 WG-EMM-14/24 presented a draft research and monitoring plan for the South Orkney Islands southern shelf MPA. This identified research and monitoring activities that will help to support and inform the management of the MPA; these are divided into three categories:

- (i) scientific research pursuant to the specific MPA objectives to evaluate the attributes of the MPA relative to its specific objectives and to enhance understanding of these objectives
- (ii) monitoring to determine the degree to which the specific MPA objectives are being met to help manage the MPA and evaluate the impacts of specific activities
- (iii) other research consistent with the specific MPA objectives to provide new information about the features protected and to facilitate further development of a representative system of MPAs across the region.

3.51 The draft research and monitoring plan also provided information on the process for submitting data to the Secretariat and for the review of research and monitoring results.

3.52 The Working Group welcomed the draft research and monitoring plan, and agreed that it provided a good format for describing research and monitoring activities. In particular, the plan included a useful way to report on research activities that are completed or ongoing by cross-referencing to other published papers or CCAMLR working group documents. This clearly shows where to find the relevant information, and it is also an incentive to submit papers on relevant research to CCAMLR. It was suggested that these references could be developed into electronic links for easier access.

3.53 The Working Group recalled the Scientific Committee's advice that research and monitoring plans should be organised geographically (SC-CAMLR-XXXI, paragraph 5.58), and noted that because the South Orkney Islands is itself a single coherent region within the larger Domain 1 planning area, this format (i.e. with a single research and monitoring plan devoted to the South Orkney Islands MPA) is consistent with that advice.

3.54 The Working Group noted that WG-EMM-14/24 clearly described the process of relating research activities to the objectives of the MPA, as well as addressing the requirements of CM 91-04. It further noted that individual research and monitoring plans are likely to vary depending on the characteristics of different MPAs.

3.55 The Working Group provided some suggestions for improvements to the draft research and monitoring plan, including clarification of how monitoring activities could compare the status of features inside the MPA with those outside, and the elaboration of research activities that could contribute to the wider planning process for Domain 1. The Working Group noted the importance of research and monitoring outside an MPA to support management and to determine whether the objectives remained relevant.

3.56 The Working Group noted that the amount and nature of research and monitoring activities that are likely to be required to inform the review of MPAs in different areas will vary depending on the specific protection objectives that are relevant in different locations within the MPA.

3.57 Some participants noted that, for example, areas primarily providing representative protection of bioregions may require monitoring to demonstrate that bioregions have not moved or changed; areas protected to reduce potential ecosystem threats from fishing may require monitoring to establish that the threatened or vulnerable species still occurs within the MPA; where MPAs are intended to serve as reference areas, the purpose of the MPA itself is to deliver scientific outcomes, so monitoring requirements in those locations will depend upon the specific research questions to be addressed inside vs. outside the MPA.

3.58 The Working Group noted that it takes time to establish the necessary funding and collaboration needed to undertake research and monitoring, and that research budgets are often uncertain; this is a generic issue which will potentially apply to the development and implementation of research and monitoring plans for all other MPAs in the future.

3.59 WG-EMM-14/26 summarised the review process for the South Orkney Islands southern shelf MPA. At the time of its adoption in 2009, the Commission agreed to review CM 91-03, based on advice from the Scientific Committee, at its meeting in 2014 and at subsequent five-year periods. This paper listed the types of information which may be relevant to the review of CM91-03, which includes an assessment of whether the MPA objectives are being met, an evaluation of the impacts of activities on these objectives, reports on research and monitoring activities and further research to be undertaken. Based on this assessment, it is suggested that the grounds for protection of the South Orkney Islands southern shelf remain the same as at the time of its designation.

3.60 The Working Group agreed with the approach for the review of CM 91-03, as outlined in WG-EMM-14/26, noting that information relevant to the review can be found in WG-EMM-14/24 and 14/25, and agreed that this information is adequate to help the Scientific Committee provide advice to the Commission on the review of CM 91-03.

3.61 WG-EMM-14/P01 described a new bathymetric compilation for the South Orkney Islands. The increase in spatial depth resolution showed new detail and features which previously had not been possible to determine, and added significantly to the understanding of benthic habitats in this region.

3.62 The Working Group noted that improved bathymetric data is valuable for many aspects of CCAMLR's work. Existing data such as GEBCO may be inadequate in some areas and variable between regions. It suggested that Members should make this type of high-resolution bathymetric data available through the CCAMLR GIS where possible. Members would then be able to use the data for their own purposes, such as computing seabed areas for use in fisheries assessments or to design future surveys.

3.63 WG-SAM-14/13 and 14/22 described a proposal for research fishing to be undertaken by Ukraine in Subarea 48.2. These papers had been referred to this Working Group by WG-SAM, because two of the proposed set points are located inside the South Orkney Islands southern shelf MPA. However, Dr Pshenichnov advised that the proposed survey design will be changed such that all sets will be to the east of 38°W and will, therefore, be outside the MPA.

## MPA Reports

3.64 Following the discussions on WG-EMM-14/19 (Weddell Sea), 14/40, 14/49 (Domain 1), 14/48 (East Antarctica) and 14/25 (South Orkney Islands), the Working Group agreed that there was a distinction between an MPA Report (SC-CAMLR-XXXI, paragraph 5.33) and documents supporting the MPA planning process in different planning domains or regions. An MPA Report would be expected to be developed in support of one or more MPAs after adoption of those MPAs. The Working Group recommended to the Scientific Committee that the content of MPA Reports would best be managed by WG-EMM.

3.65 For documents supporting MPA planning and proposals, the Working Group agreed that these could include: (i) documents providing background information (e.g. ecological descriptions of the planning domain), (ii) descriptions of spatial data used in the planning process, (iii) methodological descriptions of approaches to designing MPA scenarios, and (iv) documents containing or describing the MPA proposals. Information contained in all of these reference documents would then form the basis of future MPA Reports.

3.66 The Working Group agreed that these documents should be assembled as the regional/planning domain MPA planning reference documents and placed on the CCAMLR website in order to make the reference materials readily accessible to all Members. The Working Group suggested that the Scientific Committee and Commission will need to consider where on the CCAMLR website would be an appropriate place for compiling these reference documents, as the documents will inevitably contain materials derived from the work of both bodies.

3.67 The Working Group agreed that it would be helpful for the information presented for the Weddell Sea (WG-EMM-14/19) and MPA Planning Domain 1 (WG-EMM-14/40 and 14/49) to be assembled as MPA planning reference documents. However, it noted that there should be flexibility for proponents to decide on the extent to which they may also wish to develop synthesis or summary documents, as the requirement for such documents may vary between planning domains.

3.68 The Working Group further agreed that WG-EMM-14/48 was a useful synthesis of many documents, noting the comments for editing the document above (paragraph 3.35), and, once updated, could be the primary reference document supporting the proposal for the East Antarctica RSMMPA.

3.69 The Working Group endorsed WG-EMM-14/25 as an appropriate MPA Report for the South Orkney Islands southern shelf MPA and recommended that an updated version be submitted to the Scientific Committee, taking into account the comments above (paragraph 3.46).

## General procedures for establishing MPAs

3.70 WG-EMM-14/32 described a planned proposal for a resolution on a standardised procedure to establish CCAMLR MPAs in accordance with CM 91-04. The aim of this proposal was to provide a common platform to Members for their evaluation of respective MPA proposals, including its scientific objectives, and to streamline the discussions on proposals. The proposed draft resolution included a set of three checklists relating to the

conservation measure for establishing an MPA, the MPA management plan, and the research and monitoring plan. It also suggested a procedure for how a proponent would use the checklists at various stages of the MPA proposal process.

3.71 Mr H. Moronuki (Japan) noted that this draft proposal has already been circulated in advance to interested Members, and he thanked those who had provided comments and advice. Those comments, together with comments to be received, would be duly considered by the proponent (Japan) when it elaborates a final proposal for submission to the Scientific Committee and the Commission in October.

3.72 The Working Group suggested that participants should inform their Scientific Committee Representatives and Commissioners of its content, so that they can correspond directly with Japan or bring relevant comments to the Scientific Committee and Commission meetings in October.

### **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 fishery –
  - (a) Activities in 2013/14 (paragraph 2.9)
  - (b) Notifications for 2014/15 (paragraph 2.12)
  - (c) Green weight estimation (CM 21-03) (paragraphs 2.17 to 2.20)
  - (d) Catch and effort reporting system (CM 23-06) (paragraphs 2.21 and 2.22)
  - (e) Finfish by-catch (paragraphs 2.37 and 2.40)
  - (f) Scientific observations (CM 51-06) (paragraphs 2.26 and 2.41 to 2.44)
  - (g) Krill biology and ecology (paragraph 2.64).
- (ii) Role of fish in the ecosystem–
  - (a) Impacts of finfish fishing on fish predators (paragraph 2.109).
- (iii) Feedback management –
  - (a) Development of the strategy (paragraphs 2.117 and 2.124)
  - (b) Proposals for Stage 2 and beyond (paragraphs 2.145 and 2.149)
  - (c) Interim distribution of the trigger level (CM 51-07) (paragraph 2.157).
- (iv) Spatial management –
  - (a) Technical workshop, planning domain 1 (paragraph 3.25)
  - (b) South Orkney Islands southern shelf MPA (paragraphs 3.52 and 3.60)
  - (c) MPA Reports (paragraphs 3.66 and 3.69).

- (v) Future work–
  - (a) Frequently asked questions about the krill fishery (paragraph 5.13)
  - (b) Procedure for submitting meeting papers by non-Members (paragraph 5.15)
  - (c) Work of SG-ASAM (paragraph 5.19)
  - (d) Development of multi-species models (paragraph 5.21)
  - (e) Symposium on spatial modelling (paragraph 5.22)
  - (f) Collaboration with IWC SC (paragraph 5.25).
- (vi) CEMP Special Fund –
  - (a) Special Fund Management Group (paragraph 6.1)
  - (b) Proposals (paragraph 6.5).

## Future work

### 2015/16 multinational investigation of the krill-based ecosystem

5.1 WG-EMM-14/10 outlined plans for a coordinated multinational study focusing on the krill-based ecosystem in Area 48 during the 2015/16 austral summer to further the work of CCAMLR in managing the krill fishery. The aims of the study presently include:

- (i) exploration of the spatial variability in krill abundance and distribution across the South Atlantic
- (ii) determination of krill responses to varying oceanographic conditions, school dynamics and fisheries interactions
- (iii) krill–predator interactions at scales from the individual school to broad regional scales.

5.2 A central part of this study is based on the established cooperation between BAS, the Institute of Marine Research (Bergen) and the Norwegian Polar Institute (Tromsø). It will include the coordinated use of the Norwegian vessel RV *G.O. Sars* and the ice-strengthened research vessel RRS *James Clark Ross* (BAS). The krill–predator studies will be facilitated by land-based teams instrumenting penguins and seals at the South Orkney Islands in the Scotia Sea and on Bouvetøya. Data will be collected at sea from research and fishing vessels, together with remotely sensed data obtained from moorings and gliders, with links to land-based studies of predator foraging behaviour, diet and reproductive success.

5.3 The Working Group thanked the authors, noting that the design of the study has now been supplemented by proposals of coordinated activity with the USA and Germany on the Antarctic Peninsula and Bellingshausen Sea respectively. It also noted that other Members that conduct surveys in the area were encouraged to contribute as they can. Further, the Working Group considered this to be a very valuable initiative for CCAMLR.

5.4 The Working Group noted also:

- (i) the timeliness of this investigation and the importance of this initiative with respect to further development of the FBM system

- (ii) that other groups in the Antarctic scientific community may be able to add value to this research, either in the field or in analytical and/or modelling support, such as through SCAR specialist groups, Integrating Climate and Ecosystem Dynamics in the Southern Ocean (ICED) and SOOS
- (iii) as for the CCAMLR-2000 Survey, the IWC SC may be interested in providing participants to help observe cetaceans and other wildlife from the different vessels involved
- (iv) the importance of standardising the acoustics and other sampling across all participating vessels
- (v) the value of also including predator tracking into the following winter period when additional resources are available
- (vi) that data management will need to be considered during planning
- (vii) that engagement with modellers will be needed during planning to tailor modelling to the opportunities offered by the extensive sampling, as well as helping design field sampling that will enable results of this work to be used for local- and regional-scale ecosystem and food-web models
- (viii) proposals by national programs for activities in the Indian and Pacific sectors will be a valuable part of this research activity
- (ix) the potential interest from a number of Members in participating in this research, but that funding and planning cycles may not be aligned across nations.

5.5 The Working Group encouraged Members and Parties to CCAMLR to develop plans consistent with the objectives of this project and, where possible, to standardise methods of data collection and analysis. Where possible, Members and Parties are also encouraged to coordinate activities with these plans for 2015/16 because of the value that the data would have from being obtained in the same year from studies with similar objectives. These activities may include work from research or fishing vessels or land-based activities. Further, the Working Group encouraged Members to correspond with other scientific groups to determine if they may be able to be involved in this program.

5.6 Dr Godø undertook to coordinate a paper for submission to the Scientific Committee, which is intended to update the plans for the regional study. The paper will include a framework for methods and operations that will help Members to join with whatever level of resources they have available both for vessel-based and land-based activities. The Working Group encouraged the development of the paper, noting that it will be further coordinated using a CCAMLR e-group. It also encouraged Members who may be able to participate in this work to participate in the e-group and to submit to the Scientific Committee any concrete plans indicating how they may participate in the field program in 2015/16 or in similar studies in subsequent years. It suggested that an SC CIRC be distributed as soon as possible to encourage Members to these ends.

5.7 The Working Group agreed that this was an important initiative for progressing its work on the development of feedback management approaches for the krill fishery and noted that investigations on krill in many parts of the Southern Ocean in the same year will help

elucidate key drivers of krill dynamics, krill predation and fisheries. It suggested that one potential mechanism to progress and finalise aspects of the 2015/16 multinational investigation of the krill-based ecosystem would be to hold a special focus topic during WG-EMM-15. The Working Group recalled that focus topics have been used in past meetings of WG-EMM as a means of progressing a number of different issues in a timely fashion.

## Interactions with ICED

5.8 WG-EMM-14/07 summarised progress by ICED in investigating how climate change might impact Southern Ocean ecosystems. This modelling work is expected to help inform management of Southern Ocean fisheries. As part of this work, ICED convened a workshop in November 2013 on ‘Southern Ocean Food Webs and Scenarios of Change’ and is currently preparing an academic paper on:

- (i) plausible quantitative scenarios of how the Southern Ocean ecosystems may change, based on the latest available climate models, ecological data and models and information on fisheries
- (ii) the future role that sea-ice may play in governing ecology in the Southern Ocean
- (iii) challenges in projecting future scenarios for Southern Ocean ecosystems
- (iv) a set of future scenarios for the Southern Ocean from which to explore the potential responses to, and consequences of, change, including quantitative scenarios of sea-ice change and other key environmental parameters, together with qualitative scenarios (including the recovery of key species such as whales).

5.9 The Working Group thanked the authors and ICED for providing this update. It noted that ICED can play a key role for CCAMLR in improving the basis for future monitoring and management of Southern Ocean ecosystems, and encouraged active two-way engagement between ICED and CCAMLR. The Working Group encouraged this work by ICED and looked forward to seeing the products next year in order to consider how ICED may help the work of the Working Group in the future. It noted that the development of priority scenarios would be useful but it would also be beneficial if plausible scenarios that would have important consequences for Southern Ocean ecosystems, even if they are currently considered to have a low chance of occurring, could be identified.

5.10 In further considering the role that ICED might play in the work of WG-EMM, the Working Group recalled the paper submitted by ICED last year, WG-EMM-13/12, on its work plan and particularly regarding future research on krill for CCAMLR. The Working Group noted the following would be useful to the work of WG-EMM:

- (i) an understanding of the interactions of krill in food webs, such as from the planned 2015/16 multinational investigation of the krill-based ecosystem, and the importance of non-krill pathways in the ecosystem, including the role of fish

- (ii) further development of ecological models of krill and Southern Ocean food webs, and comparison of the performance of minimal realistic models used by CCAMLR with results from end-to-end ecosystem models being developed in ICED
- (iii) key drivers of krill, krill habitats and krill predators over the next 30 to 50 years
- (iv) better understanding of the importance of krill flux to krill and food-web dynamics
- (v) estimation of the quantity of krill and the nature of krill swarms in the pelagic SSMUs of Area 48
- (vi) the potential impact on fisheries of ocean acidification and warming
- (vii) further development of the observing program, such as might be facilitated through the ICED Southern Ocean Sentinel and SOOS.

5.11 WG-EMM-14/12 reported on a cross-sector two-day workshop co-hosted by BAS, WWF and ICED on krill fishing and conservation in the Scotia Sea and Antarctic Peninsula region held in June 2014 in the UK on 'Understanding the Objectives for Krill Fishing and Conservation in the Scotia Sea and Antarctic Peninsula Region'. It involved participants from the science, conservation and fishing industry sectors and aimed to: (i) identify each sector's objectives and information requirements for the krill-based ecosystem in the Scotia Sea and Antarctic Peninsula region (Subareas 48.1 to 48.4), (ii) explore and agree constructive ways for the three sectors to work together to ensure the responsible management Antarctic krill, and (iii) develop recommendations to help guide CCAMLR in the development of its management approach for the krill fishery. The paper summarised the key initial conclusions and recommendations from the workshop, noting:

- (i) those from the fishing industry indicated that there was no urgent need for the fishery to expand above the trigger level and that the fishing industry can help provide information needed for expansion to stage 2
- (ii) that priorities for research need to be developed, which would be expected to include understanding the economic drivers of future fisheries expansion
- (iii) the need for these stakeholders to better understand the processes of CCAMLR, which could be facilitated by more information being made available on the CCAMLR website, such as the provision of answers to frequently asked questions (FAQs)
- (iv) it would be valuable to find mechanisms for these stakeholders to increase their engagement in CCAMLR processes.

5.12 The Working Group thanked the organisers for hosting this workshop as the outcomes looked very useful to WG-EMM.

5.13 The Working Group agreed that answers to FAQs about the krill fishery, including those provided by the workshop organisers to the Secretariat, should be posted on the CCAMLR website, as suggested by the workshop. It recommended that the Scientific Committee endorse this initiative and suggested the following procedure could be used to manage the process:

- (i) answers to FAQs be developed by the Science Manager and reviewed by the Convener of WG-EMM and the Chair of the Scientific Committee before posting on the website
- (ii) each year, WG-EMM review the FAQs and provide advice on whether they should remain, be updated or deleted.

5.14 The Working Group noted the following for consideration by the Scientific Committee:

- (i) the external community needs to communicate through the representatives of Members in the first instance who would be expected to facilitate exchange of information on CCAMLR with stakeholders
- (ii) a mentoring group within the Scientific Committee may help facilitate the transfer of information to scientists wishing to be involved in CCAMLR
- (iii) workshops may be a useful way to involve external experts and scientific representatives of non-governmental organisations (NGOs) in the work of the Scientific Committee and its working groups
- (iv) an open forum at the time of WG-EMM may provide access to participants in the working group, such as was undertaken with the ARK workshop this year (paragraphs 2.201 to 2.204)
- (v) opportunities for industry and environment NGOs may be needed to participate in the work of working groups, such as through ad hoc TASO.

5.15 The Working Group also recalled the endorsement by the Scientific Committee of a process for having papers from non-Member scientists able to be submitted for consideration by the working groups (SC-CAMLR-XXVII, paragraph 10.9). This could be a useful mechanism for any scientist to contribute to the working groups without having to submit through a Member's representative to the Scientific Committee. It suggested the Scientific Committee consider whether such a mechanism could help overcome some of the concerns expressed by the workshop about broader participation in CCAMLR work and what this process will be.

5.16 The Working Group noted that the ICED Conference on Assessing Status and Trends of Habitats, Key Species and Ecosystems in the Southern Ocean, being planned to be held in Hobart, Australia, in 2018, would be useful to the work of WG-EMM and encouraged Members to contribute to the conference where possible. The conference is expected to have the following themes:

- (i) assessments of status and trends in habitats, species and ecosystems and the causes of change (attribution)
- (ii) the responses of species to changing habitats, including ocean acidification, sea-ice and temperature
- (iii) modelling and analytical methods to assess status and trends
- (iv) implementation of observing systems to estimate dynamics and change.

## Interactions with SOOS

5.17 Dr Constable presented an update on progress in the development of SOOS and its relevance to CCAMLR. In particular, he highlighted:

- (i) the workshop at Rutgers University in March 2014 on developing ecosystem Essential Ocean Variables
- (ii) a second proposal submitted to SCOR for a working group on developing ecosystem Essential Ocean Variables
- (iii) the use of the Southern Ocean Knowledge and Information wiki ([www.soki.aq](http://www.soki.aq)) to exchange information, as well as provide peer-reviewed published information on the internet of field and analytical methods, knowledge of Southern Ocean habitats, biota and ecosystems and developments in the work of SOOS and ICED.

5.18 The Working Group welcomed these advances in the work of SOOS. It recalled its consideration of SOOS in 2012 (SC-CAMLR-XXXI, Annex 6, paragraphs 2.82 to 2.85) and encouraged Members to participate in this work, where possible. The Working Group noted that, in the first instance, this work would be designing ecosystem observing at the circum-polar and regional scales and may not have emphasis at the local scale of interactions of krill, krill predators and krill fisheries currently under investigation. It noted that the CCAMLR community has the competence and the research capacity to contribute to modelling at local scales and referred particularly to the 2015/16 planned field effort as a good opportunity to promote such modelling. It also noted that in the future, it is expected this work, along with the work of ICED, will help identify methods for integrating observing and modelling across the different spatial and temporal scales of interest to WG-EMM, particularly in relation to long-term trends and regional differences in the ecosystem.

## SG-ASAM

5.19 Dr Watkins noted that SG-ASAM had a full workload for a future meeting even before the requests brought forward at this meeting. The task of standardising methods and developing acoustic designs for the 2015/16 research effort, along with methods to manage and analyse the data arising from these activities, would occupy a complete meeting in 2015. The Working Group agreed that such a meeting was necessary and recommended that the Scientific Committee advise on the prioritisation of tasks for SG-ASAM and consider how to structure this meeting as a matter of priority in the coming intersessional period.

## Modelling

5.20 The Working Group noted the need to model ecosystem processes at spatial and temporal scales that are relevant for management. The Working Group noted that regional-scale and global modelling approaches are appropriate for understanding the effects of long-term drivers such as climate change, but understanding the potential ecosystem effects of the krill fishery will likely require higher-resolution models of interactions that occur at much

shorter and smaller scales and that spatially explicit modelling approaches may be required. The Working Group recalled that some spatially explicit multi-species krill models have already been developed for use in CCAMLR and are available for further use or development (e.g. Watters et al., 2013).

5.21 The Working Group agreed that priority needs to be given to the further development of multispecies models to support its work in developing feedback management strategies for krill. It requested the Scientific Committee consider how this might be achieved, given the large number of priority items in the work plan. For example, WG-SAM along with WG-EMM would have a role in the development of these models.

5.22 The Working Group noted recent progress in the development of spatially explicit and multispecies population models for toothfish and toothfish prey fitted to fisheries data, including multispecies interactions and harvest by fisheries (WG-SAM-14/31; WG-EMM-14/51) and that similar approaches may be useful for top predators and for krill. The Working Group recalled the advice of the Scientific Committee in 2012 that WG-SAM and WG-EMM hold a joint symposium on spatially explicit modelling in 2014 (SC-CAMLR-XXXI, paragraph 15.2) but that this did not eventuate due to conflicts with other priorities. The Working Group recommended that both WG-SAM and WG-EMM be involved in this work and suggested that the Scientific Committee might consider how this could be achieved, such as perhaps holding in 2016, as previously recommended, a joint symposium on spatial modelling.

#### Activities of mutual interest with the IWC SC

5.23 Dr Watters, in his capacity as IWC Observer to WG-EMM, indicated that work undertaken by at least three subcommittees/working groups of the IWC SC, including the Sub-Committee on Other Southern Hemisphere Whale Stocks, the Sub-Committee on In-depth Assessments and the Working Group on Ecosystem Modelling, is of relevance to WG-EMM.

5.24 The Working Group thanked Dr Watters for serving as the IWC Observer to WG-EMM, noting that Dr R. Currey (New Zealand) was the SC-CAMLR Observer to IWC SC and will be the IWC SC Observer to SC-CAMLR. It encouraged the Chair of the Scientific Committee to work with Drs Currey and Watters to determine how best to exchange information between SC-CAMLR and IWC SC, as had been successfully achieved by Dr Kock in the past.

5.25 The Working Group agreed that a joint workshop between the two scientific committees proposed by IWC SC for developing activities of mutual interest to the two bodies was a good proposal and recommended the Scientific Committee consider how this might be achieved. It noted that a potential mechanism of interaction with WG-EMM could be through joint workshops of experts. It suggested that the term of reference proposed by IWC SC might be modified to:

‘To foster collaboration between IWC SC and SC-CAMLR, including the development and application of multispecies models to the Antarctic marine ecosystem, as well as other activities that would be of mutual interest.’

## Other business

### CEMP Fund

6.1 During the 2013 meeting of the Scientific Committee, a CEMP Special Fund Management Group (hereinafter referred to as the ‘management group’) was established with Dr Godø appointed as Convener and Dr Arata as the Junior Vice-Chair (SC-CAMLR-XXXII, paragraphs 13.3 and 13.4). In accordance with the decision of the Scientific Committee, a Senior Vice-Chair, Dr T. Ichii (Japan), was appointed to the management group.

6.2 The management group evaluated two research proposals for 2014/15 submitted by the deadline. Both proposals coordinate and integrate multinational efforts and were submitted by Dr Watters and include contributions from Argentina, Australia, Poland and Ukraine.

6.3 The first proposal applied for funds for a camera network for CEMP sites in Subarea 48.1 that support participating Members in collecting breeding phenology and success data from CEMP sites, thus expanding the data quality and spatial scope of the monitoring that is currently undertaken. The involvement of an external expert on camera networks is an important step to secure efficient and correct operation.

6.4 The second proposal focused on tracking penguins with the aim of estimating spatial overlaps between penguin foraging, particularly during winter, and the krill fishery. The results will be of direct relevance for the FBM system.

6.5 Both proposals were consistent with the main objectives of the CEMP Special Fund (SC-CAMLR-XXXII/BG/11). The management group welcomed the level of collaboration and coordination among multiple Members in this type of work and recommended that the available CEMP fund for 2014 be allocated to the proponents of these two proposals, recognising that the total amount requested for the two proposals was in excess of the current balance of the CEMP Special Fund. The management group did not prioritise the proposals but left it to the proponents to provide details to the Scientific Committee on how the available funds will be used and what matching funds are available.

### The CCAMLR Scientific Scholarship Scheme

6.6 The Convener of WG-EMM invited the three current recipients of a CCAMLR scholarship that were attending the meeting this year, Dr Anna Panasiuk-Chodnicka (Poland), Lic. Mercedes ‘Mecha’ Santos (Argentina) and Mr Xinliang Wang (People’s Republic of China) to give a presentation to the Working Group on the research they were undertaking in association with the scholarship scheme.

6.7 Dr Panasiuk-Chodnicka described a proposal for a comprehensive ecological monitoring program in Admiralty Bay, King George Island, South Shetland Islands, to be undertaken by Poland. This monitoring will integrate biological, chemical and geophysical data from both marine and terrestrial environments, will build upon the long history of scientific research and monitoring conducted by Poland in Admiralty Bay and will provide an important basis upon which to measure change in the Antarctic ecosystems. Dr Panasiuk-Chodnicka described how Admiralty Bay is located in a region of dynamic climate

characterised by variable maritime conditions which make this region particularly susceptible to climate change. It is also a breeding site of the three *Pygoscelis* penguin species that have been monitored as part of CEMP.

6.8 Dr Panasiuk-Chodnicka also presented data from marine biological monitoring samples collected during an expedition to the H. Arctowski station in the austral summer 2008/09. Samples were collected in the central part of Admiralty Bay, in Ezcurra Inlet and in the smaller coves of the bay using a WP2 net with a mesh size of 200 µm. The results showed that macro-zooplankton was represented by species such as *E. superba*, *E. frigida*, *E. crystallorophias* and *T. macrura*. *Thysanoessa macrura* occurred in higher numbers in Admiralty Bay and was recorded at all stations, whereas *E. superba* occurred less regularly and in smaller numbers. Net sampling gear selectivity will be investigated as part of the new monitoring program by using multiple nets.

6.9 The Working Group welcomed the presentation and agreed that a broad-based ecological monitoring program would provide important context for the interpretation of species-specific monitoring data. It also agreed that there was opportunity to link the monitoring data from Admiralty Bay to research survey data collected in the Bransfield Strait, including the planned 2015/16 multinational investigation of the krill-based ecosystem.

6.10 The Working Group also noted that, while the existing data suggested that *E. superba* were less common than other euphausiids in Admiralty Bay, it was apparent from the recent catches of krill in the bay that *E. superba* were occasionally abundant and the seasonal aspect of the Polish monitoring would be useful in understanding this variability.

6.11 Dr Panasiuk-Chodnicka thanked CCAMLR for granting her the scholarship for 2014/15, the participants of WG-EMM for their welcome and support in the first year of the scholarship. She also thanked her mentor, Dr M. Korczak-Abshire (Poland), for her support and advice.

6.12 Lic Santos provided an update from the work outlined at WG-EMM-13, including the overview of two consecutive years of data on the diet and the foraging distribution of Adélie penguins at Hope Bay/Esperanza, during the late part of the breeding season and their subsequent post-breeding dispersal (WG-EMM-14/42). During both seasons, the bulk of the diet was represented by krill. Foraging locations during the breeding period were concentrated to the west of the colony and in the northern Bransfield Strait/Mar de la Flota in both years. During the pre-moulting period, Adélie penguins dispersed away from the colony and foraged further to the east in the northern Weddell Sea up to 400 km from the colony.

6.13 Lic. Santos described the importance of understanding the influence of local conditions, such as extensive snow fall, on penguin breeding success and the interpretation of CEMP indices, particularly in the context of FBM. Although the diet and foraging behaviour of penguins from Hope Bay/Esperanza was very consistent between years, the breeding success was substantially different because in one year penguins incubated eggs in deep snow, there was a high level of nest failure and hence low breeding success that was unrelated to prey availability. Lic. Santos suggested that this demonstrated the important role of intensive monitoring at CEMP sites in providing important context for remote monitoring but also noted that it would be important to consider how to detect years of low krill abundance that coincided with years when heavy snow fall also caused reduced breeding success.

6.14 Lic. Santos also presented the key outcomes of WG-EMM-14/43 which sets out to investigate the spatial scale of monitoring by three countries, Argentina, Poland and the USA, conducted at closely located CEMP sites. Toward this goal, five indices that fall under three main categories of census (breeders and chicks), reproductive success (crèche rates) and chick growth (fledge weights) from two Pygoscelid penguin species monitored at three sites on King George Island/Isla 25 de Mayo were investigated. There were strong positive correlations across sites in census data, implying similar information is being collected at all three sites. There was also evidence of site- and species-specific differences that highlighted heterogeneity in indices of reproductive success and chick growth at local scales.

6.15 Within a broad network of CEMP monitoring, it may also be useful to have several monitoring clusters, as is the case on King George Island, to help identify the relative importance of local environmental factors and better estimate the range of variability that such factors can introduce into CEMP indices. Lic. Santos suggested that such a CEMP cluster that included monitoring sites at Hope Bay and Seymour Island could also be established.

6.16 The Working Group welcomed the progress made by Lic. Santos in the contribution of Argentina to CEMP monitoring and to the Working Group in general, particularly in the enhanced multi-Member collaboration and coordination of CEMP monitoring and associated research in both Subareas 48.1 and 48.2. The Working Group also welcomed the commitment from Argentina to support the participation of Lic. Santos in the work of CCAMLR following the period of the scholarship.

6.17 Lic. Santos thanked CCAMLR for granting her the scholarship for 2013/14, she also expressed her gratitude for all the support received during the two years of the scholarship and in particular thanked her mentor, Dr Hinke, for his guidance, patience and all-round niceness.

6.18 Mr Wang presented an overview of the work that he had undertaken under the scholarship that was focussed on the use of acoustic data from krill fishing vessels and has been presented to WG-EMM-13 and SG-ASAM-14. He provided an overview of work to digitalise photographs of the screen of the echosounder on krill fishing vessels and to develop an algorithm to produce an estimate of the swarm characteristics and relative density of krill swarms encountered during fishing operations in order to provide information on the spatio-temporal variation of krill swarms. He also presented work on developing a post-processing technique to noise reduction algorithms to address the problem of 'spike noise' on acoustic data.

6.19 In December 2013, Mr Wang participated in a trial acoustic survey conducted by the Chinese krill fishing vessel *Fu Rong Hai*, which was equipped with an EK60 echosounder. He presented the work in WG-EMM-14/47, which described the detailed information on this survey and the preliminary results on krill distribution around the South Shetland Islands. The transect design followed that of the US AMLR survey in the same area and krill was found in most parts of the survey area. The mean  $S_v$  of krill swarm tend to be higher in inshore waters in the north of the islands; however, no such tendency was observed in the Bransfield Strait. The majority of the krill swarms were found in the upper 100 m with a thickness less than 30 m. Mr Wang highlighted the positive experience of conducting this research survey, which may lead to more scientific data being collected by Chinese krill fishing vessels in the coming fishing seasons.

6.20 Mr Wang noted that the CCAMLR scholarship had been a catalyst for engagement in the Chinese national observer program and highlighted the potential for the large spatial and temporal scale collection of acoustic data from the Chinese krill fishing vessels to benefit the understanding of the distribution and variation of krill swarms as well as its interaction with the fishery. He also noted his potential participation in the 2015/16 multinational investigation of the krill-based ecosystem in Area 48.

6.21 Mr Wang expressed his gratitude to CCAMLR for granting him with the scholarship (2013/14) and was grateful to Dr Xianyong Zhao (People's Republic of China) as his mentor. He also thanked SG-ASAM-14 and WG-EMM-14 participants for their constructive advice on his work during the meeting and on the e-group.

6.22 The Working Group thanked Mr Wang for his presentation and agreed that his contribution to the developing field of krill-fishing-vessel based acoustic data was very valuable to CCAMLR, especially given the increased engagement of China in krill research.

6.23 The Working Group agreed that all three presentations from scholarship recipients demonstrated that the CCAMLR Scientific Scholarship Scheme had emerged as a great mechanism to engage early career scientists in the work of CCAMLR.

### **Adoption of the report and close of the meeting**

7.1 The Working Group welcomed the level of engagement during the meeting's discussions and preparation of the report. As a result, the report of the meeting of WG-EMM was adopted on schedule on the last day of the meeting.

7.2 In closing the meeting, Dr Kawaguchi thanked all participants for their expert contributions to the work of WG-EMM and discussions during the meeting, including subgroup coordinators, rapporteurs, CCAMLR scholarship holders and the Secretariat. Dr Kawaguchi also thanked INACH and Dr Arata and colleagues for their kind hospitality and welcoming assistance during the meeting.

7.3 Dr Jones, on behalf of the Working Group and Scientific Committee, thanked Dr Kawaguchi for his guidance in leading discussions and detailed consideration of the work of WG-EMM, including bringing together advice on advancement to stage 2 of FBM in the krill fishery and a representative system of MPAs.

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Table 1: Issues to be clarified in krill fishery notifications.

Vessel	Issues identified to be clarified
All Chilean-notified vessels (Notification ID_84030)	All vessels reported the same echosounder models and types. Notifying Member to confirm this information. <sup>a</sup>
<i>Kai Shun, Kai Li</i> (Notification ID_83786)	These vessels have an echosounder, but this appears to be misreported as sonar. Notifying Member to confirm this information. <sup>b</sup>
<i>Insung Ho</i> (Notification ID_84026)	This vessel will install an echosounder in November. Notifying Member to provide detail on the model/frequency. <sup>b</sup>
<i>Sejong</i> (Notification ID_84026)	There appears to be an error in the echosounder model reported. Notifying Member to confirm this information. <sup>b</sup>
<i>Antarctic Sea, Juvel</i> (Notification ID_84045)	There appears to be an error in the frequencies used by the echosounders. Notifying Member to confirm this information. <sup>b</sup>

<sup>a</sup> This was confirmed during the meeting.

<sup>b</sup> Revised information was submitted during the meeting.

Table 2: Data available for stage 2.

Category	Data type	Source	Temporal scale collected	Spatial scale collected	Available from CCAMLR
Krill	Biomass	National surveys	Month	SSMUs ex APDPW, APE	No
	Length frequency	Surveys, fishery, predators	Monthly to year-round		Yes (fishery)
Predator	Catch CEMP	Fishery	December to August/September	SSMUs ex APDPW, APE	Yes
		CEMP – arrival	Summer	CEMP sites/foraging areas	Yes
		CEMP – breeding/foraging	Summer	CEMP sites/foraging areas	Yes
Fishery	Catch Distribution	CEMP – multi-year	Summer	CEMP sites/foraging areas	Yes
		Haul by haul	December to August/September	Exact fish location	Yes
Environment	SST CTD	Haul location (VMS)	December to August/September		Yes
		Data portal(s) SOOS	Daily	Global (ice)	No
		National surveys	Month (associated with krill surveys)	SSMUs ex APDPW, APE	No

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(Punta Arenas, Chile, 7 to 18 July 2014)

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## Agenda

### Working Group on Ecosystem Monitoring and Management (Punta Arenas, Chile, 7 to 18 July 2014)

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 CEMP and WG-EMM-STAPP
    - 2.1.5 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
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.

### List of Documents

Working Group on Ecosystem Monitoring and Management  
(Punta Arenas, Chile, 7 to 18 July 2014)

- |                     |  |
|---------------------|--|
| WG-EMM-14/01        | Net diagrams and MED of CM 21-03<br>Delegation of the European Union   |
| WG-EMM-14/02        | Do krill fisheries compete with macaroni penguins? Spatial overlap in prey consumption and krill catches during winter<br>N. Ratcliffe, S.L. Hill, I.J. Staniland, R. Brown, S. Adlard, C. Horswill and P.N. Trathan (United Kingdom)  |
| WG-EMM-14/03        | Update for CCAMLR WG-EMM on the BAS, BirdLife, SCAR penguin tracking database development and analysis project<br>P. Trathan, B. Lascelles (United Kingdom) and M. Hindell (Australia)   |
| WG-EMM-14/04        | Practical options for developing feedback management for the krill fishery in Subarea 48.2<br>P. Trathan (United Kingdom), M. Santos (Argentina) and O.R. Godø (Norway)  |
| WG-EMM-14/05        | Advances in the use of airborne aerial survey techniques to estimate krill-eating penguin populations in Area 48<br>P.N. Trathan, A.J. Fox, N. Ratcliff and P.T. Fretwell (United Kingdom)   |
| WG-EMM-14/06 Rev. 1 | Long-term study of the at-sea distribution of seabirds and marine mammals in the Scotia Sea, Antarctica<br>J.L. Orgeira, M. Alderete, Y.G. Jiménez and J.C. González (Argentina)   |
| WG-EMM-14/07        | Short paper to CCAMLR on the ICED Southern Ocean food webs and scenarios workshop: ICED information paper for CCAMLR WG-EMM<br>R.D. Cavanagh, E.J. Murphy, S.L. Hill and N.M. Johnston (United Kingdom)<br>(on behalf of the ICED workshop and ICED Scientific Steering Committee) |
| WG-EMM-14/08        | Developing high-resolution hydrodynamic models of the shelf regions around South Georgia and the South Orkney Islands<br>E.J. Murphy, E.F. Young, S.E. Thorpe, P.N. Trathan (United Kingdom) and O.R. Godø (Norway)  |

- WG-EMM-14/09 Estimating abundance of Antarctic fur seals at South Georgia  
J. Forcada, I.J. Staniland, A.R. Martin, A.G. Wood and  
P.N. Trathan (United Kingdom)
- WG-EMM-14/10 Plans for a multi-national coordinated investigation focusing on  
the krill-based ecosystem in Area 48 during the 2015–16 austral  
summer  
J. Watkins (United Kingdom), O.R. Godø, K. Kovacs (Norway)  
and P. Trathan (United Kingdom)
- WG-EMM-14/11 Exploring variability in the locations used by the krill fishery in  
Area 48 in relation to intra- and inter-annual variability in  
seasonal sea ice  
J. Silk, S.L. Hill and P.N. Trathan (United Kingdom)
- WG-EMM-14/12 Recommendations from a cross-sector workshop on krill fishing  
and conservation in the Scotia Sea and Antarctic Peninsula  
region  
S. Hill, R. Cavanagh, R. Downie, C. Knowl and and S. Grant  
(United Kingdom)
- WG-EMM-14/13 Winter distribution and condition of Antarctic krill in relation to  
sea-ice and water column production in the South Shetland  
Islands during Austral Winter 2013  
C.S. Reiss, J. Walsh, K. Dietrich and J.A. Santora (USA)
- WG-EMM-14/14 Assessment of escape mortality of Antarctic krill (*Euphausia  
superba*) in trawls  
B.A. Krafft (Norway) and L.A. Krag (Denmark)
- WG-EMM-14/15 Development in maturity stage composition and vertical  
distribution in an Antarctic krill (*Euphausia superba*) hotspot  
B.A. Krafft, G. Skaret and T. Knutsen (Norway)
- WG-EMM-14/16 Report from the annual survey of Antarctic krill and apex  
predators distribution at South Orkney Islands in 2014, and  
assessing escape mortality of krill in trawls  
B.A. Krafft (Norway), L.A. Krag (Denmark), T.A. Klevjer,  
G. Skaret and R. Pedersen (Norway)
- WG-EMM-14/17 The southernmost find a Magellanic penguin *Spheniscus  
magellanicus* in Antarctica  
P. Dmytro (Ukraine)
- WG-EMM-14/18 Additional information on notification of intent to participate in  
the 2014–2015 fishery for *Euphausia superba*  
Delegation of Chile

WG-EMM-14/19	Progress report on the scientific data compilation and analyses in support of the development of a CCAMLR MPA in the Weddell Sea (Antarctica) K. Teschke, K. Jerosch, H. Pehlke and T. Brey (Germany)
WG-EMM-14/20	Review of the Russian marine researches in the south-eastern part of the Atlantic Antarctic Area (20°W–30°E) V. Shnar and S. Kasatkina (Russia)
WG-EMM-14/21	Analysis of krill fishery operations in Subarea 48.1: spatial-time distribution of CPUE and fishing efforts S. Kasatkina and P. Gasyukov (Russia)
WG-EMM-14/22	Variability of krill fishery operations in Subarea 48.2 in relation to fishing methods: spatial–temporal distribution of CPUE and of fishing efforts S. Kasatkina (Russia)
WG-EMM-14/23	Background and criteria of establishment of Marine Protected Area (MPA) in the Weddell Sea A.F. Petrov, V.A. Bizikov, K.V. Shust and E.F. Uryupova (Russia)
WG-EMM-14/24	Draft Research and Monitoring Plan for the South Orkney Islands Southern Shelf (MPA Planning Domain 1, Subarea 48.2) Delegation of the European Union
WG-EMM-14/25	Draft MPA Report for the South Orkney Islands Southern Shelf (MPA Planning Domain 1, Subarea 48.2) Delegation of the European Union
WG-EMM-14/26	Review of the South Orkney Islands Southern Shelf (MPA Planning Domain 1, Subarea 48.2) Delegation of the European Union
WG-EMM-14/27	Expanding Antarctic seabird monitoring in east Antarctica using a remote camera network: potential use for monitoring for feedback management C. Southwell and L. Emmerson (Australia)
WG-EMM-14/28	A proposed observer logbook for the 2015 krill trawl fishery Secretariat
WG-EMM-14/29	Estimation of the green weight of krill caught Secretariat
WG-EMM-14/30	CEMP indices: 2014 update Secretariat

- WG-EMM-14/31 Update on the analysis of fish by-catch in the krill fishery using data from the CCAMLR Scheme of Scientific Observation Secretariat
- WG-EMM-14/32 Proposal for a Resolution on Standardised Procedure to Establish CCAMLR MPAs in accordance with the Conservation Measure 91-04  
Delegation of Japan
- WG-EMM-14/33 Net diagrams and mammal exclusion devices of Chinese krill fishing vessels  
Delegation of the People's Republic of China
- WG-EMM-14/34 Net diagrams for Norwegian vessels notified for krill fishery in 2014/15 – Notification ID 84045  
Delegation of Norway
- WG-EMM-14/35 Discussion on recent results from an integrated assessment of Antarctic krill (*Euphausia superba*) in Subarea 48.1  
G.M. Watters, C.S. Reiss and D. Kinzey (USA)
- WG-EMM-14/36 Spatial overlap of krill-dependent predators and krill fishery catches and a proposal for subdivision of catch limits in Subarea 48.1  
J.T. Hinke, M.E. Goebel (USA), M.M. Santos (Argentina), P.N. Trathan (UK), W.Z. Trivelpiece and G.M. Watters (USA)
- WG-EMM-14/37 A comparison of gear selectivity among three fishing gears for Antarctic krill with notes on the demographic patterns and productivity of Antarctic krill during summer 2014  
C. Reiss (USA) and M. Espino Sanchez (Peru)
- WG-EMM-14/38 *Pleuragramma antarcticum* distribution in the Ross Sea during late austral summer 2013  
C. Brooks and K. Goetz (USA)
- WG-EMM-14/39 Squeezed from both ends: Decline in Antarctic fur seals in the South Shetland Islands driven by both Top-down and Bottom-up processes  
M.E. Goebel and C.S. Reiss (USA)
- WG-EMM-14/40 Progress report on the development of MPAs in Domain 1  
J. Arata, C. Gaymer, F. Squeo (Chile), E. Marschoff, E. Barrera-Oro and M. Santos (Argentina)
- WG-EMM-14/41 Realization of the Marine Protected Area network in the Akademik Vernadsky Station region  
A.Yu. Utevsky, E.I. Sennaya and M.Yu. Kolesnykova (Ukraine)

- WG-EMM-14/42 Breeding and post-breeding foraging locations of Adélie penguins at Hope Bay/Esperanza, Antarctic Peninsula  
M.M. Santos (Argentina), P.N. Trathan (UK), S. Thanassekos (Secretariat), E.F. Rombolá, M.A. Juárez (Argentina), K. Reid (Secretariat) and J.T. Hinke (USA)
- WG-EMM-14/43 How similar are CEMP indices from adjacent locations? A case of study using *Pygoscelis adeliae* and *P. papua* monitoring data from three breeding colonies on King George Island  
M.M. Santos (Argentina), M. Korczak-Abshire (Poland), M.A. Juárez (Argentina), W.Z. Trivelpiece and J.T. Hinke (USA)
- WG-EMM-14/44 Apparent decrease of Weddell seal numbers in the western Ross Sea  
D.G. Ainley, M.A. Larue (USA), I. Stirling (Canada), S. Stammerjohn and D.B. Siniff (USA)
- WG-EMM-14/45 Rev. 1 Net diagrams and MED of CM 21-03 for Korean krill fishing vessels  
Delegation of the Republic of Korea
- WG-EMM-14/46 Приложение 21-03/А Уведомление о намерении участвовать в промысле *Euphausia superba*  
[Notification of intent to participate in a fishery for *Euphausia superba*]  
Delegation of Ukraine (in Russian, partially available in English)
- WG-EMM-14/47 The krill distribution in waters around the South Shetland Islands: Preliminary results from an acoustic survey conducted by a Chinese krill fishing vessel in December 2013  
X. Wang, X. Zhao, G. Qi, T. Zuo, J. Zhu, J. Zhang and X. Li (People's Republic of China)
- WG-EMM-14/48 A draft MPA Report for the East Antarctica Planning Domain  
A. Constable (Australia), P. Koubbi (France), J. Melbourne-Thomas, M. Sumner, S. Jacob and M. Guest (Australia)
- WG-EMM-14/49 Identifying priority areas for conservation within Domain 1  
J. Arata (Chile)
- WG-EMM-14/50 Stable isotope analysis of tissue samples to investigate trophic linkages of Antarctic toothfish (*Dissostichus mawsoni*) in the Ross and Amundsen Sea regions  
M.H. Pinkerton, S.J. Bury, J.C.S. Brown, J. Forman and A. Kilimnik (New Zealand)

- WG-EMM-14/51                      Development of a spatially-explicit minimum realistic model for Antarctic toothfish (*Dissostichus mawsoni*) and its main prey (Macrouridae and Channichthyidae) in the Ross Sea  
S. Mormede, M. Pinkerton, A. Dunn, S. Hanchet and S. Parker (New Zealand)
- WG-EMM-14/52                      Update on the Top Predator Alliance project, 2013–14 season: Killer whales  
R. Eisert, M.H. Pinkerton (New Zealand), L. Torres (USA), R.J.C. Currey, P.H. Ensor, E.N. Ovshynikova, I.N. Visser (New Zealand) and O.T. Oftedal (USA)
- WG-EMM-14/53                      Infectious diseases of Antarctic penguins: current status and future threats  
W.W. Grimaldi, P.J. Seddon, P.O.B. Lyver, S. Nakagawa and D.M. Tompkins (New Zealand)
- WG-EMM-14/54                      Semi-automated software to count and validate Adélie penguin colonies from aerial photographs  
S.J. McNeill, K.J. Barton and P.O'B. Lyver (New Zealand)
- WG-EMM-14/55                      Adélie penguin colony size predicts south polar skua abundance on Ross Island, Antarctica  
D.J. Wilson, P.O'B. Lyver (New Zealand), A.L. Whitehead (Australia), T.C. Greene (New Zealand), K. Dugger (USA), B.J. Karl, J.R.F. Barringer, R. McGarry (New Zealand), A.M. Pollard and D.G. Ainley (USA)
- WG-EMM-14/56                      Censuses in the northernmost colony of Emperor penguin (*Aptenodytes forsteri*) in the tip of the Antarctic Peninsula at Snow Hill Island, Weddell Sea, Antarctica  
M. Libertelli and N. Coria (Argentina)
- WG-EMM-14/57                      Vacant
- WG-EMM-14/58                      Draft Krill Fishery Report  
Secretariat
- WG-EMM-14/59                      Admiralty Bay (South Shetland Islands) as a model area for the long-term marine monitoring program – reasons and opportunities  
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-14/60 Species variability and population structure of Euphausiacea in Admiralty Bay (King George Island; South Shetland Islands) during Antarctic summer  
A. Panasiuk-Chodnicka, J. Wawrzynek and M. Iwona Żmijewska (Poland)
- WG-EMM-14/61 Identifying areas for monitoring studies  
J. Arata and F. Baeza (Chile)
- Other documents
- WG-EMM-14/P01 A new bathymetric compilation for the South Orkney Islands, Antarctic Peninsula (49°–39°W to 64°–59°S): insights into the glacial development of the continental shelf  
W.A. Dickens, A.G.C. Graham, J.A. Smith, J.A. Dowdeswell, R.D. Larter, C.-D. Hillenbrand, P.N. Trathan, J.E. Arndt and G. Kuhn  
*Geochemistry, Geophysics, Geosystems*, (2014),  
doi: 10.1002/2014GC005323
- WG-EMM-14/P02 An assessment of the use of ocean gliders to undertake acoustic measurements of zooplankton: the distribution and density of Antarctic krill in the Weddell Sea  
D. Guihen, S. Fielding, E. Murphy, K. Heywood and G. Griffiths  
*Limnol. Oceanogr.: Methods*, 12 (2014): 373–389,  
doi: 10.4319/lom.2014.12.373
- WG-EMM-14/P03 Surface exchange between the Weddell and Scotia Seas  
A.F. Thompson and M.K. Youngs  
*Geophys. Res. Lett.*, 40 (2013): 1–6,  
doi: 10.1002/2013GL058114
- WG-EMM-14/P04 Interannual variability in Antarctic krill (*Euphausia superba*) density at South Georgia, Southern Ocean: 1997–2013  
S. Fielding, J.L. Watkins, P. N.Trathan, P. Enderlein, C.M. Waluda, G. Stowasser, G.A. Tarling and E.J. Murphy  
*ICES J. Mar. Sci.*, (2014), doi: 10.1093/icesjms/fsu104
- WG-EMM-14/P05 First global census of the Adélie penguin  
H.J. Lynch and M.A. LaRue  
*The Auk*, (2014), in press
- WG-EMM-14/P06 Risk maps for Antarctic krill under projected Southern Ocean acidification  
S. Kawaguchi, A. Ishida, R. King, B. Raymond, N. Waller, A. Constable, S. Nicol, M. Wakit and A. Ishimatsu  
*Nature Climate Change*, 3 (2013): 843–847,  
doi: 10.1038/NCLIMATE1937

- WG-EMM-14/P07      Composition of Leucocytes in Peripheral Blood of Antarctic Toothfish *Dissostichus mawsoni* (Nototheniidae)  
I.I. Gordeev, D.V. Mikryakov, L.V. Balabanova and V.R. Miktyakov  
*J. Ichthyol.*, 54 (6) (2014): 422–425,  
doi: 10.1134/S0032945214030047
- WG-EMM-14/P08      New data on trematodes (Plathelminthes, Trematoda) of fishes in the Ross Sea (Antarctic)  
S.G. Sokolov and I.I. Gordeev  
*Invert. Zool.*, 10 (2) (2013): 255–267
- WG-EMM-14/P09 Rev. 1      Congruent, decreasing trends of Gentoo Penguins and Crozet Shags at sub-Antarctic Marion Island suggest food limitation through common environmental forcing  
R.J.M. Crawford, B.M. Dyer, L. Upfold and A.B. Makhado  
*S. Afr. J. Marine Sci.* (2014),  
doi: 10.2989/1814232X.2014.926293

**Pro forma for submission of stage 2  
feedback management ideas**

Note: Please include tables and figures as necessary. It is not necessary to answer all questions in this pro forma; it is also acceptable to provide negative answers to the questions in this pro forma. For example, if an idea does not describe how future catch limits will be determined, Question 1 may be left blank or answered 'Not applicable'.

1. How will catch limit(s) be determined and adjusted?
  - (i) identify the data (with sources) and analyses that will be used
  - (ii) characterise any decision rules that would apply
  - (iii) describe implementation details such as the frequency at which catch limits would be estimated or adjusted.
  
2. How will the spatial distribution of krill catches be determined and adjusted?
  - (i) identify the data (with sources) and analyses that will be used
  - (ii) characterise any decision rules that would apply
  - (iii) describe implementation details such as the frequency at which the spatial distribution of catches would be adjusted.
  
3. Will the spatial distribution of catches be fixed with the specific intent to test a management strategy; that is, will this proposal involve 'structured fishing'?
  - (i) describe the fixed distribution of catches among small-scale management units (SSMUs) or other areas (e.g. between coastal and pelagic areas, groups of SSMUs, or smaller fishing locations)
  - (ii) identify the period over which the spatial distribution of catches will be fixed
  - (iii) describe the data that will be collected during the fishing experiment
  - (iv) describe how the outcomes of the experiment will be evaluated.
  
4. Does your idea include one or more reference areas?
  - (i) identify the boundaries of the suggested reference area(s)
  - (ii) describe the data that will be collected inside and outside the reference area(s)
  - (iii) specify the period for which the reference area(s) will be required
  - (iv) describe how comparative results from inside and outside the reference area(s) will be used to address Questions 1, 2 or 3 above.

5. Does your idea include additional requirements, consistent with, or similar to, those listed in Conservation Measure 51-04, that identify additional data collection, analyses or support that would be required in particular circumstances (e.g. if a local catch limit is reached)?
  - (i) explain, in detail, these additional requirements, when they might be imposed, and how the results from them would be expected to advance FBM.
6. Describe any fall-back plans that accompany your idea:
  - (i) describe how your suggestions for such plans and checks specifically relate to your responses to Questions 1 to 4.
7. Provide a list of references that include supporting documentation if needed:
  - (i) reference documents that provide rationales for decision rules or describe analytical approaches that will be applied.

**Report of the Working Group  
on Fish Stock Assessment**  
(Hobart, Australia, 6 to 17 October 2014)



## Contents

	Page
<b>Opening of the meeting</b> .....	281
<b>Organisation of the meeting and adoption of the agenda</b> .....	281
<b>Review of available information</b> .....	282
Data requirements .....	282
CCAMLR GIS .....	283
Data quarantine .....	284
Toothfish trade .....	284
IUU fishing activity .....	285
Fishery surveys .....	285
Data on sea-ice .....	286
Tag-overlap statistic .....	287
Depredation .....	288
<b>Established fisheries</b> .....	289
<i>Dissostichus eleginoides</i> Subarea 48.3 .....	289
Management advice .....	289
<i>Dissostichus eleginoides</i> and <i>D. mawsoni</i> Subarea 48.4 .....	289
Management advice .....	290
By-catch limits for Subarea 48.4 .....	290
<i>D. eleginoides</i> Heard Island (Division 58.5.2) .....	290
Management advice .....	293
<i>Dissostichus eleginoides</i> Division 58.5.1 and Subarea 58.6 .....	293
<i>D. eleginoides</i> Kerguelen Island (Division 58.5.1) .....	293
Management advice .....	294
<i>D. eleginoides</i> Crozet Islands (Subarea 58.6) .....	294
Management advice .....	294
South African EEZ (Subareas 58.6 and 58.7) .....	295
<i>C. gunnari</i> South Georgia (Subarea 48.3) .....	295
Management advice .....	295
<i>C. gunnari</i> Kerguelen Island (Division 58.5.1) .....	295
Management advice .....	296
<i>C. gunnari</i> Heard Island (Division 58.5.2) .....	296
Management advice .....	296
<b>Exploratory and other fisheries in 2013/14</b> .....	297
Exploratory fishery notifications for 2014/15 .....	298
<i>Dissostichus</i> spp. Subarea 88.1 .....	299
Management advice .....	299
<i>Dissostichus</i> spp. SSRU 882H .....	299
Management advice .....	302
<i>Dissostichus</i> spp. SSRUs 882C–G .....	302
Management advice .....	304
Research to inform current or future assessments .....	304

Subarea 48.2 – South Orkney Islands .....	304
Subarea 48.6 .....	305
Subarea 48.5 – Weddell Sea .....	306
Management advice .....	309
Division 58.4.4a and 58.4.4b (Ob and Lena Banks) .....	310
Division 58.4.3a (Elan Bank) .....	311
Divisions 58.4.1 and 58.4.2 .....	312
Subarea 88.1 and SSRUs 882A–B .....	314
Ross Sea sub-adult survey .....	314
SSRUs 882A–B .....	315
Multiyear research plan .....	316
Summary of advice on the catch limits of exploratory and other fisheries .....	317
<b>Vulnerable marine ecosystems (VMEs) .....</b>	<b>319</b>
Review of VMEs notified in 2013/14 .....	319
<b>Scheme of International Scientific Observation (SISO) .....</b>	<b>320</b>
<b>Non-target catch in CCAMLR fisheries .....</b>	<b>322</b>
Fish by-catch .....	322
Marine mammal and seabird by-catch .....	325
Marine debris .....	326
<b>Biology, ecology and interactions in fish-based ecosystems .....</b>	<b>327</b>
<i>Dissostichus mawsoni</i> .....	327
<i>Dissostichus eleginoides</i> .....	328
Surveys .....	329
Macrourids .....	329
Rajiformes .....	330
Modelling approaches .....	330
<b>Future work .....</b>	<b>331</b>
Steepness and stock-recruit relationship .....	331
External review of assessments .....	331
Communication of the work of WG-FSA .....	332
Prioritisation of future work .....	332
CASAL course .....	332
<b>Advice to the Scientific Committee and its working groups .....</b>	<b>333</b>
<b>Adoption of the report .....</b>	<b>334</b>
<b>Close of meeting .....</b>	<b>334</b>
<b>References .....</b>	<b>335</b>
<b>Tables .....</b>	<b>336</b>
<b>Figures .....</b>	<b>342</b>

<b>Appendix A:</b> List of Participants .....	352
<b>Appendix B:</b> Agenda.....	358
<b>Appendix C:</b> List of Documents .....	360



**Report of the Working Group  
on Fish Stock Assessment**  
(Hobart, Australia, 6 to 17 October 2014)

**Opening of the meeting**

1.1 The meeting of WG-FSA was held in Hobart, Australia, from 6 to 17 October 2014. 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.

**Organisation of the meeting and adoption of the agenda**

2.1 The meeting's agenda addressed the priorities and topics identified by the Scientific Committee and Commission in 2013 and during the recent 2014 meeting of WG-SAM, including:

- (i) provision of advice on fisheries for Patagonian toothfish (*Dissostichus eleginoides*), Antarctic toothfish (*D. mawsoni*) and mackerel icefish (*Champscephalus gunnari*) which are assessed annually and on the fishery for *D. eleginoides* in Division 58.5.2, which is usually assessed biennially (SC-CAMLR-XXXII, paragraphs 3.115 and 3.116)
- (ii) development of standard diagnostic tools for integrated assessments
- (iii) further development of protocols for validating and approving updates for assessment software
- (iv) development of mechanisms to partition research plan catches in the exploratory fishery for *Dissostichus* spp. in the Ross Sea (Subarea 88.1 and small-scale research units (SSRUs) 882A–B)
- (v) evaluation of progress in developing stock assessments of *Dissostichus* spp. in exploratory fisheries, closed areas and areas with zero catches, including review of research proposals and advice on catch limits in 2014/15.

2.2 Other matters considered at the meeting included:

- (i) CCAMLR's Scheme of International Scientific Observation (SISO) and outcomes from the recent SISO Review
- (ii) non-target catch in CCAMLR fisheries, including by-catch of rajiformes and macrourids in longline fisheries, and a review of the efficacy of season extensions in the fisheries for *D. eleginoides* in Subarea 48.3 and Division 58.5.2
- (iii) biology and ecology of target and non-target fish species and interactions in fish-based ecosystems.

2.3 The Working Group renamed Agenda Items 4 and 5 to better reflect the organisation of discussions of items listed above and the revised agenda was adopted (Appendix B).

2.4 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 the authors for their valuable contributions to the work presented to the meeting.

2.5 The Working Group discussed the development of a ‘fishery dashboard’ containing agreed fishery indicators and a summary of the status, assessment and catch limits in place for each fishery (Annex 5, paragraph 5.7). The dashboard would also outline progress in the development of CCAMLR fisheries, including data-poor fisheries and research fishing, within the context of the Commission’s regulatory framework for CCAMLR fisheries ([www.ccamlr.org/node/74615](http://www.ccamlr.org/node/74615)). Templates were developed and are available for consideration by the Scientific Committee. The ‘dashboard’ is intended to provide summary information for use by the Commission, as well as a web-based overview of information contained in the Fishery Reports.

2.6 In this report, paragraphs dealing with advice to the Scientific Committee and other working groups have been highlighted. These paragraphs are listed in paragraph 11.2. The information used in developing assessments and other aspects of the Working Group’s work is included in the Fishery Report for each fishery ([www.ccamlr.org/node/75667](http://www.ccamlr.org/node/75667)).

2.7 The Working Group was introduced to a new, web-based system to support the development of the meeting’s report. The system, developed by the Secretariat, provides a secure platform which allows rapporteurs and participants to develop and edit report text and track comments, contributed text and versions. The system may be accessed remotely by meeting participants and integrates the Secretariat’s workflow associated with the production of the meeting report.

2.8 The report was prepared by Drs R. Currey (New Zealand), C. Darby, T. Earl, J. Ellis (UK), Mr I. Forster (Secretariat), Mr N. Gasco (France), Dr S. Hanchet (New Zealand), Mr C. Heineken (South Africa), Drs C. Jones, D. Kinzey (USA), K.-H. Kock (Germany), S. Mormede (New Zealand), G. Nowara (Australia), S. Parker (New Zealand), D. Ramm, K. Reid (Secretariat), K. Ross, M. Soffker (UK), D. Welsford and P. Ziegler (Australia).

## **Review of available information**

### Data requirements

3.1 The Working Group reviewed data submitted to the Secretariat from CCAMLR fisheries and fishery-based research in 2013/14, 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 the CCAMLR *Dissostichus* spp., *D. eleginoides*, *C. gunnari* and Antarctic krill (*Euphausia superba*) fisheries (Table 1) and *Dissostichus* spp. captured outside the Convention Area (Table 2).

3.3 The Working Group noted that management areas in five exploratory fisheries for *Dissostichus* spp. were closed by the Secretariat in 2013/14. These closures were triggered by catches of *Dissostichus* spp. approaching the relevant catch limits (CCAMLR-XXXIII/BG/01), and the catch limits in the fishery in Subarea 88.2 were exceeded. The Working Group noted that up to 14 vessels had fished in Subarea 88.2 in January 2014 and the fishery had experienced a rapid increase in fishing effort following the closure of the fishery in Subarea 88.1 on 17 January 2014 (Figure 1).

3.4 The Working Group noted the Secretariat's developments in data management and related matters in 2013/14, including:

- (i) implementation of an information management framework
- (ii) revision of the data management strategy
- (iii) further development of the CCAMLR data model
- (iv) improvements in data quality assurance, including tagging data
- (v) implementation of the CCAMLR Geographic Information System (GIS) (see paragraph 3.5)
- (vi) preparation of a web-based VME registry
- (vii) further development of the nautical twilight calculator ([www.ccamlr.org/node/74642](http://www.ccamlr.org/node/74642))
- (viii) scoping options for 'smart' data forms
- (ix) implementation of the online submission of fishery notifications ([www.ccamlr.org/node/78963](http://www.ccamlr.org/node/78963))
- (x) upload of historic conservation measures and resolutions ([www.ccamlr.org/node/57043](http://www.ccamlr.org/node/57043))
- (xi) publication of the CCAMLR *Statistical Bulletin*, Volume 26 ([www.ccamlr.org/node/74362](http://www.ccamlr.org/node/74362)).

## CCAMLR GIS

3.5 The Working Group noted that the Secretariat had worked closely with the British Antarctic Survey (BAS) to create the CCAMLR GIS in 2014 ([www.ccamlr.org/node/82341](http://www.ccamlr.org/node/82341)). The GIS facilitates improved access to CCAMLR spatial data and enables a variety of data formats to be visualised along with other Antarctic datasets. Users with log-in access to the CCAMLR website have the ability to upload their own datasets for display on the GIS. These datasets can remain private or be shared selectively with other CCAMLR users. The Secretariat has also developed a CCAMLR GIS R Package to convert georeferenced data into

shapefiles. The resulting files can then be uploaded to CCAMLR GIS or any other GIS. The Secretariat will continue adding CCAMLR-related content to the GIS, including maps of fishery catch limits and catches of target species (as reported in the *Statistical Bulletin*).

#### Data quarantine

3.6 The Working Group noted the outcomes of the investigation on anomalous CPUE which had been conducted by the Republic of Korea (COMM CIRC 14/93, September 2014). The Working Group acknowledged the efforts made by Korea to address and resolve this issue and agreed that the process undertaken by Korea is a good template for future investigations.

3.7 The Working Group drew the attention of the Scientific Committee to the need for a wide-scale analysis of CPUEs which would be useful to identify any other potential issue related to anomalous CPUE. It was noted that observer reports may contain information which may inform such analysis.

3.8 The Working Group requested the Scientific Committee advise on how to deal with data that is quarantined, particularly in relation to attributing the catches for stock assessment purposes.

3.9 The Working Group also noted that the Secretariat had implemented the Scientific Committee's advice that all data, including tagging data, collected from three *Insung* longline fishing vessels operating in the exploratory fisheries for *Dissostichus* spp. in seasons with anomalous CPUE data should be flagged as not suitable for routine analysis (SC-CAMLR-XXXII, paragraph 3.228). In addition, data from the *Paloma V* fishing in Divisions 58.4.1 and 58.4.3b in 2006/07, which had been identified by WG-FSA in 2008 (SC-CAMLR-XXVII, Annex 5, paragraph 3.4), have also been flagged as not suitable for routine analysis.

3.10 As a result, the following fishery and observer data will be quarantined and excluded from future data requests and analyses, and metadata provided with data extracts will include details of any quarantined data, which would be available on specific request:

- (i) *Insung No. 2* in Subarea 48.6 and Divisions 58.4.1 and 58.4.2 in 2009/10
- (ii) *Insung No. 7* in Subareas 48.6 and 88.1 and Divisions 58.4.1 and 58.4.2 in 2010/11
- (iii) *Insung No. 22* in Subarea 48.6 and Divisions 58.4.1 and 58.4.2 in 2008/09
- (iv) *Paloma V* in Divisions 58.4.1 and 58.4.3b in 2006/07.

#### Toothfish trade

3.11 The Secretariat reported on an analysis of global patterns of trade volume and price of *Dissostichus* spp. using United Nations Commodity Trade Statistics (CCAMLR-XXXIII/BG/14 Rev. 1). Initial results revealed a strong relationship between supply and demand within international markets, as well as the influence of country-specific factors. This analysis aims to identify trends in the global market and assist in the management of fisheries for *Dissostichus* spp. The Working Group thanked the Secretariat for this initiative and referred this analysis to the Scientific Committee for further consideration.

3.12 The Secretariat informed the Working Group that during the meeting the EU had provided a clarification on imports by Greece that had been incorrectly coded and referred to cod (*Gadus* spp.) not toothfish.

#### IUU fishing activity

3.13 The Working Group discussed the spatial characterisation of illegal, unreported and unregulated (IUU) fishing activity within the Convention Area based on recent sightings of fishing vessels and gear, and satellite data from vessels' Automatic Identification Systems (CCAMLR-XXXIII/BG/28 Rev. 1). These data provide limited information on vessel movements and fishing activities, however, this information cannot currently be used to estimate IUU catches.

3.14 In 2013, the Working Group had considered the requirement under Conservation Measure (CM) 10-02 that vessels report all other vessel sightings in the Convention Area to their Flag State and that the provision of these data may be useful in developing a vessel detection model (CCAMLR-XXXII, Annex 6, paragraph 3.5). The Working Group noted that these data had not been provided in 2014 and requested that the Scientific Committee and Commission develop a mechanism for implementing such a requirement. The Working Group noted greater effort was needed to ensure all information required by CM 10-02, Annex 10-02/A, was provided to the Secretariat.

3.15 The Working Group noted the joint proposal submitted by France and the Secretariat to implement a pilot initiative to use satellite-derived imagery to detect the presence of IUU fishing vessels in the Convention Area (CCAMLR-XXXIII/07). The Working Group noted that sightings data from vessels were generally restricted to the times when areas are open to fishing and agreed that the proposed use of a satellite-based method was a positive step towards improving estimates of IUU fishing activity.

#### Fishery surveys

3.16 WG-FSA-14/41 presented the annual random stratified trawl survey in Division 58.5.2 that was conducted in June 2014. The random stratified trawl survey consisted of 158 stations and included an additional five stations at Shell Bank, which had not been sampled since 2005. Hauls were conducted at randomly selected points within the designated strata. Most of the *C. gunnari* were taken on Gunnari Ridge and the plateaus in the southeast and west. The Working Group noted that catches in the survey were within the range of the values that had been observed over the history of the survey. In 2014, while the catches of *C. gunnari* were less than half of those in 2013, the catches of both *D. eleginoides* and *C. gunnari* were higher than the average since 2006. Catches of *Channichthys rhinoceratus* and *Lepidonotothen squamifrons* were also higher than average.

3.17 The Working Group recalled that the most recent comparison of trends between surveys of *C. gunnari* across the entire Kerguelen Plateau (random stratified trawl and POKER surveys) was presented in WG-SAM-11/20 in 2011 and noted that this may be a useful analysis to undertake in the near future. The Working Group also noted that, while abundance declined since the 1970s and increased in recent years, the relative distribution had

appeared stable since the 1980s. It was noted that the changes in abundance may be related to water temperature, given the apparent relationship between temperature and fish condition. The Working Group noted that while *C. gunnari* in the South Shetland Islands remain within a given depth range and move in response to krill availability, the Kerguelen Plateau is not a krill-dominated ecosystem and myctophids, amphipods and other zooplankton are more likely to be important components of the diet. The Working Group requested biomass trend information and associated coefficients of variation (CV) over time be presented for the survey for all species, but noted that trends for toothfish had been presented in WG-SAM-14/23.

#### Data on sea-ice

3.18 WG-FSA-14/54 presented an automated method to summarise sea-ice concentration dynamics. The method used passive microwave radiation data available from 1978 and allowed data to be summarised in both spatial and temporal views while linking sea-ice concentration to fishing events. From this, sea-ice concentrations can be summarised to aid research planning by predicting fishery feasibility in specified areas as well as understanding potential bias in tag recoveries from inaccessible areas due to sea-ice (e.g. Figure 12). The spatial animations were illustrated with an example 'bad' ice year in Subarea 88.1 in 2007/08, and temporal views were illustrated for Mawson Bank from 2000. Over 86% of fishing events took place in ice conditions where the concentration was less than 20%. Comparing the fishing and ice concentration in Subarea 88.1 showed a reduction in the fishing events as ice concentration values increased from 40% to 60%, although fishing at high ice concentrations occurred in areas such as those adjacent to ice shelves where there was little ice movement. Annual ice concentration trends in SSRUs 881H, I, K showed either an early December or early January pattern in summer ice melt indicative of 'good' or bad ice years. Future developments are planned that will automate characteristics of access to areas.

3.19 The Working Group noted that the spatial data of sea-ice concentration could be incorporated into the CCAMLR GIS and be used to characterise areas that had research fishing proposals. The Working Group congratulated the authors on the paper and recommended its further development.

3.20 The Working Group noted that passive microwave radiation can underestimate sea-ice concentration when ice becomes waterlogged, and that the bias may differ spatially and suggested that it may be useful to look at the approaches taken by Murase et al. (2012) to correct satellite-derived data when estimating sea-ice extent. Dr Parker noted that while passive microwave data were not precisely calibrated with surface observations, they could still be used as a relative index when linked with observed vessel activity; however, calibration would be useful if the data were to be applied for ecological applications. The Working Group also noted that future analysis could consider vessel ice class, although the experience and motivation of the captain and situational circumstances may also be influential in the decision to fish in particular sea-ice conditions.

3.21 WG-FSA-14/55 Rev. 1 provided a method for indexing the effects of ice on fishing operations and used the toothfish fishery in Subarea 88.1 as a case study. The paper showed how ice can impact fishery performance and its management by displacing effort and spatially restricting its activities. The analysis involved overlaying >15% sea-ice extent spatial layers

with polygons that reflect historical fishing effort and used this to assess the areal proportion of polygons available to be fished. The fishing polygons reflected established fishing grounds that were bounded to encompass the operational extent of area required to set multiple lines. Comparing these values across months and years yielded an index of good and bad ice years in Subarea 88.1.

3.22 The Working Group thanked the authors for the paper and noted that it presented information in a manner that complemented the method developed in WG-FSA-14/54. Future directions for this work might include assessment of vessel access, assessing the proportions of tags available for inclusion in assessments or looking at buffer zones in the high-Antarctic zones for a number of tagging programs.

3.23 The Working Group recommended that sea-ice analyses be broadened to encompass other areas, and may be useful to identify trends in ice coverage and access of areas available to fishing – particularly in light of the Intergovernmental Panel on Climate Change (IPCC) findings of changing sea-ice conditions in the Ross Sea. Combined analysis of sea-ice analysis and fish habitat modelling might also provide insights that could assist the design of research and assessment programs.

#### Tag-overlap statistic

3.24 WG-FSA-14/31 reported on the false positive in the CCAMLR tag-overlap statistic arising from low catch volume and the resulting limited sample size. In 2013/14 in Subarea 88.2, the tagging rate by the FV *Argos Georgia* was higher than the required minimum set by the Commission but the achieved tag-overlap statistic was 52%. The paper recalled that CM 41-01 requires a tag-overlap statistic of at least 60% for catches of at least 10 tonnes, but noted that in this case the tag-overlap statistic was sensitive to moving a single fish from one 10-centimetre size bin to the adjacent size bin when the catch was slightly above 10 tonnes.

3.25 The Working Group noted that the required tag-overlap statistic was not achieved for the *Argos Georgia*, *Palmer* and *Yantar 31* in Subarea 88.2 in 2014 and agreed that these three events represented sampling artefacts, rather than compliance concerns, due to the tag-overlap statistic being calculated on a small number of fish tagged and released. The Working Group agreed that this information should be passed to SCIC in order that it be included in the consideration of the CCEP.

3.26 The Working Group recommended that the fifth sentence in CM 41-01, Annex 41-01/C, paragraph 2(ii), be revised as follows:

**'For any vessel the minimum tag-overlap statistic of 60% shall not apply from 2014/15 onward for each species of *Dissostichus* where a catch of less than 10 tonnes; and less than 30 fish tagged, provided the vessel has achieved the required tagging rate; in a fishery.'**

3.27 The Working Group noted that this change in criteria would not have resulted in a different evaluation of historic tag-overlap statistic compliance issues as the only situations where vessels have caught more than 10 tonnes of *Dissostichus* spp., achieved the required tagging rate (but tagged less than 30 fish) and had a tag-overlap statistic of <60%, were the three events identified in Subarea 88.2 in 2013/14.

3.28 The Working Group recalled the importance of the tag-overlap statistic (SC-CAMLR-XXIX, paragraph 3.139) and emphasised its importance for vessels with small catches. Accordingly, the Working Group requested that the Secretariat continue to calculate the tag-overlap statistics for all vessels and provide those estimates to the Working Group.

## Depredation

3.29 Killer and sperm whale depredation occurs in a number of sub-Antarctic toothfish longline fisheries with economic and, potentially, conservation impacts. Three papers described aspects of depredation in the Crozet EEZ. The findings were relevant to other areas with depredation and some members of the Working Group were keen to adopt the monitoring and avoidance approach described.

3.30 WG-FSA-14/10 presented two indirect methods of assessing fish losses due to depredation: CPUE comparisons and a novel method examining differences in the proportion of by-catch (*Macrourus* spp.). The assessment methods gave consistent results and indicated very high levels of depredation (27% to 29% of the total catch) compared with estimates for other subareas. The results highlighted the importance of accounting for depredation when assessing and managing fish stocks.

3.31 WG-FSA-14/P04 showed that killer whales (*Orcinus orca*) can quickly become habituated to a proprietary acoustic harassment device (AHD) intended to deter depredation. In addition, it was suggested that this AHD could cause harmful hearing disturbance to killer whales. The use of alternative mitigation measures was therefore recommended.

3.32 Methods of mitigating killer whale depredation by changing fishing practices were described in WG-FSA-14/P03. Models using data from fishery observers and killer whale monitoring indicated that the frequency of interactions with whales could be decreased by: (i) increasing the number of vessels operating simultaneously in an area, (ii) fishing deeper (as in the absence of vessels, whales primarily inhabit shallow waters). CPUE was predicted to increase if vessels (iii) used relatively short lines, and (iv) increased hauling speed (to over 50 hooks per minute) in the presence of killer whales. The tendency of a specific pod to follow a vessel was reduced if (v) vessels move more than 100 km between sets (lines).

3.33 The Working Group reflected that the findings of these studies on mitigation (including the inefficacy of AHDs) are consistent with observations in other subareas where depredation occurs. The occurrence of depredation and rates were noted to vary wildly across the Convention Area and differences in depredation behaviour between killer whale ecotypes was recalled.

3.34 The Working Group encouraged the collection of similar information on whale depredation in other fisheries.

3.35 In his capacity as the SC-IWC Observer to the Scientific Committee, Dr Currey suggested that the Scientific Observer Scheme Coordinator (SOSC) contact the Southern Ocean Research Programme (SORP) coordinator to determine how photo libraries of Southern Ocean cetaceans being used in CCAMLR and in the IWC could be coordinated.

## Established fisheries

### *Dissostichus eleginoides* Subarea 48.3

4.1 The fishery for *D. eleginoides* in Subarea 48.3 operated in accordance with CM 41-02 and associated measures. In 2013/14, the catch limit for *D. eleginoides* was 2 400 tonnes. Fishing was conducted by six vessels using longlines and the total reported catch was 2 180 tonnes.

#### Management advice

4.2 The Working Group recommended that its advice from 2013 with a catch limit for *D. eleginoides* in Subarea 48.3 of 2 400 tonnes be carried forward in its entirety for 2014/15.

### *Dissostichus eleginoides* and *D. mawsoni* Subarea 48.4

4.3 The catch limit for *D. eleginoides* in 2013/14 for Subarea 48.4 was 45 tonnes. The total reported catch was 44 tonnes. The catch limit for *D. mawsoni* in Subarea 48.4 in 2013/14 was 24 tonnes. The total reported catch was 24 tonnes.

4.4 WG-FSA-14/29 Rev. 1 presented a preliminary CASAL population assessment of *D. eleginoides* in Subarea 48.4 based on data for the 2009–2014 fishing seasons. The fishery is still largely based on a range of strong recruitment events that occurred around 1994–1996. The Working Group noted the importance of ageing data in estimating these recruitment events and recommended stratified sampling of length data to spread the lengths across the entire age and length distribution, removing the clustering of observations within the dominant ages and allowing greater influence of the shorter and larger fish. The Working Group also noted that without future strong recruitment events, the future catch is likely to be reduced to research catch only.

4.5 WG-FSA-14/30 Rev. 1 implemented a tag-based Petersen estimator to provide the species-specific biomass estimates for *D. mawsoni* in Subarea 48.4. The Petersen estimator was calculated as the geometric mean of all estimates from annual tag-release events and annual recaptures. The stock of *D. mawsoni* was estimated to be 1 023 tonnes during 2013/14. The catch limit for 2014/15 was estimated by applying the same harvest rate as in previous years, which is based on the harvest rate of *D. eleginoides* in Subarea 48.3 ( $\gamma = 0.038$ ).

4.6 The Working Group recommended that  $\gamma$  be estimated using biological parameters for *D. mawsoni* from this area in the future.

4.7 Based on discussion developed during WG-FSA-14 about the desirability of using the Chapman estimator instead of the Petersen estimator where the number of annual recaptures is lower than 10, the biomass was re-estimated with the Chapman estimator during the meeting. Using the Chapman estimator, the stock of *D. mawsoni* was estimated to be 725 tonnes during 2013/14. Accordingly, a total catch limit of 28 tonnes was recommended for 2014/15.

## Management advice

4.8 The Working Group recommended that the catch limit for *D. eleginoides* in Subarea 48.4 should be set at 42 tonnes for 2014/15 based on the outcome of this assessment.

4.9 The Working Group recommended that the catch limit for *D. mawsoni* in Subarea 48.4 should be set at 28 tonnes for 2014/15 based on the outcome of the this assessment.

## By-catch limits for Subarea 48.4

4.10 The Working Group recommended catch limits for by-catch species in Subarea 48.4 for macrourids of 11.2 tonnes (16% of the catch limit for *Dissostichus* spp.) and a limit for skates of 3.5 tonnes (5% of the catch limit for *Dissostichus* spp.).

4.11 The Working Group also recommended the maintenance of a move-on rule for by-catch species, with a minimum macrourid trigger of 150 kg and 16% of the catch by weight of *Dissostichus* spp. per line, and a trigger for skates set at 5% of the catch by weight of *Dissostichus* spp. per line.

## *D. eleginoides* Heard Island (Division 58.5.2)

4.12 The fishery for *D. eleginoides* in Division 58.5.2 operated in accordance with CM 41-08 and associated measures. In 2013/14, the catch limit for *D. eleginoides* was 2 730 tonnes. Fishing was conducted by one trawl and three longline vessels and the total reported catch up to 20 September 2014 was 1 909 tonnes.

4.13 A series of research papers presented new information for consideration in the development of the Division 58.5.2 stock assessment, centred around recommendations on the assessment from WG-FSA-13, SC-CAMLR-XXXII and WG-SAM-14. WG-FSA-14/42 described the spatial distribution of *D. eleginoides* using data collected from the fishery and research surveys in Division 58.5.2 since 1997. Statistical analyses examined the effect of bathymetry in structuring the spatial distribution of different length classes and sex composition after controlling for gear selectivity, year and sex. The results allow further development of hypotheses about the spatial segregation of life stages and sex in the Division 58.5.2 part of the Kerguelen Plateau.

4.14 WG-FSA-14/43 analysed data from tagged and recaptured *D. eleginoides* within Division 58.5.2 between 1997 and 2014 in view of estimating population parameters for the *D. eleginoides* stock assessment in Division 58.5.2. The paper reviewed spatial structure, mortality, movement rates and growth.

4.15 The Working Group noted that 4.3% of all tag recaptures of fish tagged in Division 58.5.2 had been caught in Division 58.5.1, demonstrating movement of toothfish between the stocks. It also noted that since France commenced tagging in 2006, over 22 tags have been recorded moving from Division 58.5.1 to 58.5.2. The Working Group was unable to determine whether this rate of tag emigration would bias the assessment to any great extent. It recalled that a joint population model had been presented in 2011 (WG-SAM-11/20) and

encouraged France and Australia to continue to collaborate to improve understanding of the impacts of fishing in Division 58.5.2 and 58.5.1, and the implications for management advice.

4.16 Dr Welsford noted that tagged toothfish had been recaptured up to five times in the same area, indicating high site fidelity similar to that seen within Subareas 48.3, 48.4 and the Ross Sea. He noted that the Australian research program was working to determine the effects of restricted fish movement on the potential bias in the assessment and that they were further collaborating with France towards research to account for toothfish dynamics at a range of scales across the Kerguelen Plateau.

4.17 WG-FSA noted that although the inclusion of tagging data within the Division 58.5.2 assessment model results in some bias in the assessment (Annex 5, paragraph 2.29) and the lower tag-overlap in the longline fishery prior to 2012, the increased spread of fishing effort and high tag overlap since 2012 is likely to have reduced that bias. It was also noted that inclusion of tag data into the assessment helps the model improve the precision of the estimate of  $B_0$  relative to models that do not include tagging data.

4.18 WG-FSA-14/45 presented recent information gained from new ageing data for *D. eleginoides* in Division 58.5.2. The paper outlined procedures for quality control in age reading, including re-reading of otoliths where two readers disagreed in their initial reads, and a check against the otolith weight–age relationship for identifying systematic interpretation errors. The new age data from over 2 000 fish sampled from the 2012–2014 random stratified trawl surveys and from the 2013 commercial fishery were included in the stock assessment presented in WG-FSA-14/34, which improved the information available on fish older than 20 years and led to a re-estimation of the von Bertalanffy growth parameters. Changes in the way in which otoliths are processed had reduced the cost of ageing by 31%.

4.19 WG-FSA-14/46 presented a revised estimated ageing error matrix, which specifically addressed ageing errors at the extremes of the matrix and included 50 new otoliths with an average age of >25 years. The new matrix aggregated positive errors into a plus group and truncated negative errors below the minimum age. The new ageing error matrix was evaluated against other methods for specifying the errors in ageing within the CASAL model, such as assuming a normal distribution of ageing errors with a constant CV, and was found to be more appropriate. It was concluded that the revised error matrix should be included within future assessment of this stock.

4.20 The Working Group welcomed the considerable amount of work that had been put into the ageing of the Division 58.5.2 otoliths and the development of the stock-specific ageing error matrix. The Working Group considered that the methodology could be used as an example for research conducted in other assessment areas. The Working Group recommended that the Australian Antarctic Division (AAD) otolith image reference collection be made available electronically to CCAMLR Members via the CCAMLR website and requested the Secretariat work with Dr Welsford to expedite this.

4.21 The Working Group noted that the work conducted by Australia had considerably extended the number of year classes observed in recent years and that this has resulted in a substantially improved characterisation of growth in older age classes. The introduction of the new ageing error matrix was considered to be an important step. The Working Group noted that it would be useful to investigate how the ageing error matrix may influence the assessment estimates and decision-rule projections and considered that this topic could be

presented to WG-SAM. One approach to explore this issue would be by simulating one assumption about ageing errors in an operating model and evaluating a stock assessment that assumes alternative ageing error structures.

4.22 WG-FSA-14/34 presented a step-wise development of models starting from the previous assessment presented in WG-FSA-13/24. The paper took into consideration the recommendations made at WG-FSA-13, SC-CAMLR-XXXII and WG-SAM-14. It incorporated new ageing data (WG-FSA-14/45), a Beverton-Holt stock recruitment relationship, an updated error matrix (WG-FSA-14/46), an updated growth model (WG-FSA-14/45) and an externally estimated prior for survey catchability  $q$  (WG-FSA-14/43). The new proposed model was simpler and more stable than the 2013 assessment and resulted in an estimate of  $B_0$  at 137 000 tonnes and an estimated current SSB status of 0.72.

4.23 The Working Group congratulated Australia on embarking on the work required to address the concerns of WG-FSA-13 and considered that it had addressed all the recommendations. It particularly noted the overall improved stability of the Division 58.5.2 CASAL assessment (Figure 2) and that, with and without tagging data, the median trajectory of the stock did not move below the target levels during the projection period, in contrast to the assessment presented to WG-FSA-13.

4.24 The Working Group also noted the conclusion by the authors of WG-FSA-14/43 that bias would be introduced by the inclusion of historic tagging data due to the spatially restricted distribution of fishing effort and agreed that the addition of the more recent and future tagging data from the expanding longline fishery in Division 58.5.2, and development of methods for accounting such patterns in historical tagging data, should have a high priority.

4.25 The Working Group noted that the method of estimating  $q$  using tag recaptures in the main survey ground indicated that it was likely that  $q$  had been too high in previous assessments, where it had been assumed to be 1.

4.26 The Working Group noted that the base-case model presented in WG-FSA-14/34 indicated the very high correlation between  $q$  and  $B_0$ . It further noted that the likelihood profile indicated that  $B_0$  is most likely to have been above 80 000–90 000 tonnes, however, there was relatively poor precision of  $B_0$ . This contrasted with the well-defined  $B_0$  estimate that resulted from the inclusion of the two most recent years of tagging data as presented in WG-FSA-14/43. In addition, following a review of the data available from the early years of the assessment to estimate year-class strength (YCS), the Working Group considered that the low YCS estimated by the model presented in WG-FSA-14/34 for the years 1982–1985 were poorly determined in the observations. Consequently, two new assessment models in addition to those listed in WG-FSA-14/34 were evaluated during the meeting:

(13) estimating YCS for 1986–2009

(14) estimating YCS for 1986–2009 and including tag release data for 2012 and 2013.

4.27 The Working Group noted that without the addition of the tag data to the model, the upper bound of  $B_0$  is still poorly defined (Figure 2). Adding the tagging data allowed  $B_0$  and  $q$  to be estimated with higher precision, with comparable estimates of  $B_0$  indicated by both years of tagging. The Working Group recommended that the model including tag data for 2012 and 2013 and fixing year class strength before 1986 to 1.0 (Figure 3) should be used to provide management advice.

4.28 The assessment results from the revised model estimated median  $B_0$  to be 108 586 (92 263–132 167; 95% CI) tonnes, with the median SSB status in 2013 at 0.65 (0.59–0.71) of  $B_0$  (Figure 4). The Working Group agreed to use the average recruitment and CV from 1992 to 2009 for the stock projections with a lognormal empirical randomisation method of recruitment. This projection indicated a precautionary catch limit of 4 410 tonnes resulting from the application of the CCAMLR decision rule (Figure 5).

4.29 For future work, the Working Group noted that, because toothfish movements and spatial patterns of fishing effort can generate bias in tag-based biomass estimates, actual fishing effort patterns and apparent fish movements in this area should be considered when using tag-release and recapture data as an index of abundance for adult toothfish in the assessment. The Working Group welcomed the current research project undertaken by Australia to address these issues and to enable the unbiased inclusion of tag-recapture data into stock assessments (Annex 5, paragraph 2.6). The Working Group noted that tag-recapture data were likely to improve the precision of the estimation of spawning stock biomass and recommended that tag-recapture data for as many years as possible be developed for inclusion in the assessment.

4.30 The Working Group also welcomed the ongoing ageing of otoliths from Division 58.5.2 which is intended to include otoliths of the most recent fishing seasons as well as those from earlier seasons. The Working Group recommended to re-estimate growth parameters, particularly as more data characterising size at age in older year classes become available.

4.31 With regard to survey data, the Working Group recommended that the method to estimate survey catchability  $q$  in the model be presented to WG-SAM along with sensitivities around these calculations, and that the inclusion of survey data as biomass and proportions at age should be investigated in the future model runs.

#### Management advice

4.32 The Working Group recommended a catch limit of 4 410 tonnes for 2014/15. The Working Group noted that an updated assessment will be presented in 2015.

#### *Dissostichus eleginoides* Division 58.5.1 and Subarea 58.6

##### *D. eleginoides* Kerguelen Island (Division 58.5.1)

4.33 The fishery for *D. eleginoides* in Division 58.5.1 is conducted in the French EEZ. In 2013/14, 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 20 September 2014 was 3 017 tonnes.

4.34 WG-FSA-14/36 Rev. 1 presented an updated stock assessment of *D. eleginoides* at Kerguelen Island (Division 58.5.1 inside the French EEZ), which included the results of the POKER 3 survey and fishery data up until September 2014. The Working Group congratulated the authors on progress achieved on this stock assessment in the last few years

and on their commitment to carry out ageing, which is currently under way. The Working Group recommended that YCS should not be estimated until age data were available.

4.35 The Working Group noted that the annual pattern in the number of tags recaptured, showing consistently lower numbers of recaptures in the first year compared to the second year, requires further investigation. The Working Group recommended that age frequencies be included for both the survey and commercial data once age data are available and that YCS be then estimated as a sensitivity analysis. The Working Group also recommended that estimated YCS could be compared with that estimated in the stock assessment of *D. eleginoides* in Division 58.5.2, due to their proximity and potential connectivity. The Working Group welcomed the ongoing investigations into the connectivity and interaction of fish within the wider Kerguelen Plateau area (SC-CAMLR-XXXII, paragraph 3.110ii).

#### Management advice

4.36 The Working Group agreed that model KR3.3 with fixed YCS as described in WG-FSA-14/36 Rev. 1 could be used to provide management advice for 2014/15. Although the long-term yield was not calculated, the current catch limit of 5 100 tonnes satisfied the CCAMLR decision rules.

4.37 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.

#### *D. eleginoides* Crozet Islands (Subarea 58.6)

4.38 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 2013/14 the catch limit for *D. eleginoides* was 700 tonnes. Fishing was conducted by six vessels using longlines and the total reported catch up to 20 September 2014 was 382 tonnes.

4.39 WG-FSA-14/36 Rev. 1 presented the results of 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. The Working Group welcomed this updated stock assessment, which addressed stability issues with data weighting in the model, model fits and some parameters estimated at bounds present in the previous iteration (SC-CAMLR-XXXII, Annex 6, paragraph 4.63). The Working Group recommended that age frequencies be included once age data are available and that YCS be estimated as a sensitivity analysis. It further recommended that alternative estimates of whale depredation, as estimated in WG-FSA-14/10 (see also paragraph 3.30), be investigated further in future models.

#### Management advice

4.40 The Working Group agreed that model CR2.1 with fixed YCS as described in WG-FSA-14/36 Rev. 1 could be used to provide management advice for 2014/15. Although a

maximum catch limit was not calculated, the current catch limit of 700 tonnes, with the addition of an allowance for 60 tonnes of killer whale depredation, satisfied the CCAMLR decision rules.

4.41 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 2014/15.

#### South African EEZ (Subareas 58.6 and 58.7)

4.42 Mr S. Somhlaba (South Africa) informed the Working Group that the catch limit for 2013/14 in the Prince Edward and Marion Islands (PEMI) was 450 tonnes and that two vessels were allowed to conduct fishing in this area. An assessment model used to set the catch limit has recently been updated in South Africa, enabling the model to incorporate more data and it was used to set the 2014/15 catch limit. Mr Somhlaba indicated that the catch limit for 2014/15 is likely to be similar to last season's catch limit.

#### *C. gunnari* South Georgia (Subarea 48.3)

4.43 The fishery for *C. gunnari* at South Georgia (Subarea 48.3) operated in 2013/14 in accordance with CM 42-01 and associated measures. The fishing season started on 1 December 2013 and remains open. The catch of *C. gunnari* in Subarea 48.3 up to 20 September 2014 was 4 tonnes.

4.44 Details of the stock assessment for *C. gunnari* in Subarea 48.3 for 2013/14 and 2014/15 are provided in WG-FSA-13/27. The catch limits calculated from the assessment for *C. gunnari* in Subarea 48.3 were 4 635 tonnes for 2013/14 and 2 659 tonnes for 2014/15.

#### Management advice

4.45 The Working Group agreed that a catch limit for *C. gunnari* in Subarea 48.3 of 2 659 tonnes for 2014/15 be carried forward.

#### *C. gunnari* Kerguelen Island (Division 58.5.1)

4.46 In the French EEZ of Kerguelen, trawl fisheries have been closed since 1994/95 (see CCAMLR *Statistical Bulletin*) due to the decline of stocks prior to those years. The Working Group was requested by France to review the potential yields for 2013/14 and 2014/15 estimated by a new stock assessment based on the 2013 POKER biomass survey for *C. gunnari* in Division 58.5.1 (WG-FSA-14/11).

4.47 The assessment method followed that agreed by CCAMLR (SC-CAMLR-XVI, paragraph 5.70) for assessing yield in *C. gunnari*. Biomass estimates and weight at length

were obtained from the random trawl survey. Densities at age were estimated with CMIX and supplied to the GYM. The lower one-sided 95% confidence bound of the biomass estimate was used as the estimate of the standing stock at the start of the projection period.

4.48 Only the 1+ to 3+ cohorts were projected for evaluating whether proposed catches met the CCAMLR decision rules. These projections indicated that catches of 840 tonnes in the 2013/14 season and 580 tonnes in the 2014/15 season or 0 tonnes in the 2013/14 season and 1 490 tonnes in the 2014/15 season satisfied the CCAMLR decision rules.

#### Management advice

4.49 The Working Group agreed that a catch limit for *C. gunnari* in 2014/15 of 1 490 tonnes would meet the CCAMLR decision rules, based on no catch being taken in the remainder of the 2013/14 season.

#### *C. gunnari* Heard Island (Division 58.5.2)

4.50 The fishery for *C. gunnari* at Heard Island (Division 58.5.2) operated in 2013/14 in accordance with CM 42-02 and associated measures. Fishing was conducted by one vessel with a total catch of 1 123 tonnes.

4.51 The results from the annual random stratified trawl survey to estimate the abundance of *D. eleginoides* and *C. gunnari* in Division 58.5.2 for 2014 were described in WG-FSA-14/44. The Working Group noted a continuation in the 2014 survey of a pattern first noted in 2011 of multiple apparent cohorts of *C. gunnari* in the survey catches. This is a change from years previous to 2011 when a single cohort dominated the survey catches.

4.52 The assessment method followed that agreed by CCAMLR (SC-CAMLR-XVI, paragraph 5.70) for assessing yield in *C. gunnari*, and was identical to that used to estimate yields for *C. gunnari* on the Heard Island and McDonald Islands Plateau in previous years. Biomass estimates and weight at length were obtained from the random trawl survey. Densities at age were estimated with CMIX and supplied to the GYM. The lower one-sided 95% confidence bound of the biomass estimate was used as the estimate of the standing stock at the start of the projection period.

4.53 With the expectation that the current 4+ and 5+ cohorts are fully exploited, only the 1+ to 3+ cohorts were projected for evaluating whether proposed catches met the CCAMLR decision rules. These projections indicated that catches of 309 tonnes in 2014/15 and 275 tonnes in 2015/16 satisfied the CCAMLR decision rules.

#### Management advice

4.54 The Working Group recommended that the Scientific Committee consider a catch limit for *C. gunnari* in 2014/15 of 309 tonnes and 275 tonnes for 2015/16.

## Exploratory and other fisheries in 2013/14

5.1 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 2013/14; the season's catches from these fisheries are summarised in Table 1 and activities in these fisheries are detailed in the relevant Fishery Reports. No new fishery was conducted in 2013/14.

5.2 The exploratory fisheries operated as follows in 2013/14:

- (i) In Subarea 48.6 (CM 41-04) the catch limit for *Dissostichus* spp. was 538 tonnes. Research fishing was conducted in two research blocks by two vessels using longlines and the total reported catch up to 20 September 2014 was 153 tonnes.
- (ii) In Division 58.4.1 (CM 41-11) the catch limit for *Dissostichus* spp. was 724 tonnes. Research fishing was conducted in the areas designated for a depletion experiment by one vessel using longlines and the total reported catch up to 20 September 2014 was 101 tonnes.
- (iii) In Division 58.4.2 (CM 41-05) the catch limit for *Dissostichus* spp. was 35 tonnes. Research fishing was planned in the research block by two vessels using longlines. The total reported catch up to 20 September 2014 was 0 tonnes.
- (iv) In Division 58.4.3a (CM 41-06) the catch limit for *Dissostichus* spp. was 32 tonnes. Research fishing was conducted in the research block by two vessels using longlines and the total reported catch up to 20 September 2014 was 32 tonnes.
- (v) In Subarea 88.1 (CM 41-09) the catch limit for *Dissostichus* spp. was 3 001 tonnes. Fishing was conducted by 20 vessels using longlines and the total reported catch was 2 900 tonnes. In addition, a research catch limit of 43 tonnes was set aside in SSRUs J, L and M to enable completion of the 2014 sub-adult survey (paragraphs 5.107 to 5.110).
- (vi) In Subarea 88.2 (CM 41-10) the catch limit for *Dissostichus* spp. was 390 tonnes. Fishing was conducted by 14 vessels using longlines and the total reported catch was 426 tonnes, which exceeded the catch limits (paragraph 5.3).

5.3 The Secretariat monitored all fisheries in 2013/14 using the catch and effort reporting system and notifications of vessel movements (CCAMLR-XXXIII/BG/01; see also paragraph 3.3). During that season, management areas in the exploratory fisheries in Division 58.4.3a and Subareas 48.6, 88.1 and 88.2 were closed by the Secretariat when the catches of *Dissostichus* spp. approached the relevant catch limits:

- (i) in Division 58.4.3a, the whole fishery was closed on 31 August 2014 following completion of research fishing and the total catch of *Dissostichus* spp. was 32 tonnes (100% of the catch limit)
- (ii) in Subarea 48.6, SSRU D was closed on 10 February 2014 following completion of research fishing and the total catch of *Dissostichus* spp. in that SSRU was 50 tonnes (100% of the catch limit)

- (iii) in Subarea 88.1, SSRUs B, C and G were closed on 19 December 2013, SSRUs H, I and K were closed on 11 January 2014 and SSRUs J and L and the whole fishery were closed on 17 January 2014; the total catch of *Dissostichus* spp. in these management areas ranged from 87% to 100% of the catch limits
- (iv) in Subarea 88.2, SSRU H was closed on 24 January 2014 and SSRUs C, D, E, F and G and the whole fishery were closed on 26 January 2014; the catch limits for *Dissostichus* spp. in that fishery were exceeded (paragraph 3.3 and Figure 1) and the total catch of *Dissostichus* spp. in the management areas ranged from 103% to 122% of the catch limits.

5.4 All vessels fishing in exploratory fisheries are required to tag and release *Dissostichus* spp. in accordance with the tagging protocol and requirements (CM 41-01) and rates specified in CMs 41-04 to 41-07 and 41-09 to 41-11. In 2013/14, all vessels met the required tagging rates, and all but three vessels achieved, or exceeded, the required tag-overlap statistic (see relevant Fishery Reports). The requirements for the tag-overlap statistic were reviewed in paragraphs 3.24 to 3.28.

#### Exploratory fishery notifications for 2014/15

5.5 Notifications for exploratory fisheries for *Dissostichus* spp. were submitted by nine Members for a total of 24 vessels in Subarea 88.1, nine Members and 23 vessels in Subarea 88.2, two Members and two vessels in Division 58.4.3a, four Members and four vessels in Subarea 48.6, four Members and four vessels in Division 58.4.1 and three Members and three vessels in Division 58.4.2 (Table 3 and CCAMLR-XXXIII/BG/02; details of vessels including withdrawn notifications can be viewed at [www.ccamlr.org/en/fishery-notifications/notified](http://www.ccamlr.org/en/fishery-notifications/notified)). There were no notifications submitted for the exploratory fishery in Division 58.4.3b or for new fisheries.

5.6 The Working Group noted that these notifications followed a pattern similar to previous seasons with most notifications being for fishing in Subareas 88.1 and 88.2 (nine Members and 19 vessels in Subarea 88.1 and eight Members and 18 vessels in Subarea 88.2). The Working Group noted the relatively large number of notifications in Subarea 88.2 and agreed that information on vessels' priorities for fishing in Subareas 88.1 and 88.2 would be informative in order to evaluate the notifications. This matter was referred to the Scientific Committee and Commission for further consideration.

5.7 The research plans associated with the notifications for exploratory fisheries in Subarea 48.6 and Divisions 58.4.1, 58.4.2 and 58.4.3a were submitted to WG-SAM and that Working Group's consideration of these plans is reported in Annex 5. Revised research plans were reviewed during this meeting.

5.8 The Working Group recalled that the requirements for notifications for exploratory fisheries (CM 21-02) were implemented in order to:

- (i) evaluate the distribution, abundance and demography of the target species, leading to an estimate of the fishery's potential yield
- (ii) review the fishery's potential impacts on dependent and related species

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

5.9 At this meeting, the Working Group reviewed the research and fishing plans provided in notifications for exploratory fisheries in 2014/15 for the purpose of developing stock assessments in these fisheries (i.e. requirements (i) and (iii) above). However, the Working Group did not have sufficient time to review each fishery's potential impacts on dependent and related species (requirement ii).

5.10 The Working Group sought advice from the Scientific Committee on the priorities and elements of work associated with reviewing the potential impacts of exploratory fisheries on dependent and related species. The Working Group also noted that extensive developments have taken place in recent years in relation to research fishing in exploratory fisheries, closed fisheries and other areas, and that the requirements of CM 21-02 and related measures (e.g. CMs 21-01 and 24-01) may require review.

#### *Dissostichus* spp. Subarea 88.1

5.11 The exploratory fishery for *Dissostichus* spp. in Subarea 88.1 operated in accordance with CM 41-09 and associated measures. In 2013/14, the catch limit for *Dissostichus* spp. was 3 044 tonnes including 43 tonnes set aside within the SSRUs 881J, L catch limit for the sub-adult survey.

5.12 Fishing was conducted by 20 vessels using longlines. The fishery closed on 17 January 2014 and the total reported catch was 2 900 tonnes plus 25 tonnes from the sub-adult survey.

#### Management advice

5.13 The Working Group recommended that its advice from 2013 with a catch limit for *D. mawsoni* in Subarea 88.1 of 3 044 tonnes be carried forward in its entirety for 2014/15.

#### *Dissostichus* spp. SSRU 882H

5.14 The exploratory fishery for *Dissostichus* spp. in Subarea 88.2 operated in accordance with CM 41-10 and associated measures. In 2013/14, the catch limit for *Dissostichus* spp. was 390 tonnes. Fishing was conducted by 14 vessels using longlines. The fishery closed on 26 January 2014 and the total reported catch was 426 tonnes.

5.15 WG-FSA-14/52 summarised data from the historic toothfish fishery for *Dissostichus* spp. in Subareas 88.1 and 88.2 from 1997 to 2014. The main SSRUs fished during 2014 were 881C, 881J and 882H. Fish of the strong mode of 90–120 cm, observed previously on the shelf area (C–G) in 2010–2013, were not observed in the catches during 2014, but fish in SSRU 882H were on average caught slightly younger. Further otolith readings were

recommended to ascertain this trend. The Working Group noted that the observed decline in median age could be due to the low number of fish aged in the earlier years and that this issue was being investigated further.

5.16 WG-FSA-14/56 responded to the request from WG-SAM-14 to investigate alternative assessment models to fit the declines recorded in tagged fish recaptured in SSRU 882H (Figure 6). The paper investigated several options for population dynamics through simulation of scenarios that included emigration, immigration and various rates of exploitation. It concluded that a model with a single area was not able to replicate the observed tag-recapture patterns. However, a model that included two areas, immigration, emigration and high exploitation was the only model that was able to capture the observed patterns.

5.17 The Working Group agreed that the two-area-model described in WG-FSA-14/56 (option H3b), which included a constant emigration and immigration biomass and high exploitation rate, described the observed trends in tag recapture within SSRU 882H well and that the requirements to reconstruct the observed tag-recapture patterns are relatively specific. In the analysis, the exploitation rate needed to replicate observed tag-recapture patterns is around 20%, which is substantially higher than the recommended exploitation rate for exploratory research at 4%.

5.18 The Working Group requested further development of the two-area model but noted that in order to provide data to determine the immigration and emigration rates, more tagging information from SSRUs 882C–G was required, as currently this was considered to be the area to which tagged fish were moving, but none had been recaptured.

5.19 WG-FSA-14/58 presented a Petersen-based biomass estimate for SSRU 882H based on the recommendation of WG-SAM-14 to use only tag recaptures of 1–3 years at liberty in the seamount fishery of SSRU 882H. The estimated biomass trends declined on the seamounts over time, with a slight increase since 2012. The observed patterns indicated that tag dilution was taking place due to immigration of untagged fish, which would also contribute to a progressive upward bias of biomass estimates from mark-recapture data. It concluded that the biomass estimates would be most accurate for recaptures after one year at liberty but noted that this estimate is already biased upwards.

5.20 The Working Group evaluated the paper and validated its calculations. It noted that biomass estimates are biased upward by around 1 800 tonnes each successive year of tag liberty and that even recaptures after one year result in an upward bias in biomass estimate. The most plausible cause of the bias is immigration onto the seamounts, which dilutes the tagged population proportions over time.

5.21 The biomass estimation bias is lowest for populations calculated after one year of tag liberty. Therefore the Working Group suggested that the advised catch limit should be derived from an exploitation rate of 4% of the biomass calculated using tags recaptured after one year. The resulting catch limit was 200 tonnes for SSRU 882H.

5.22 The Working Group also highlighted that this assumption of one year of tag liberty for inclusion in the Petersen estimate is specific to the stock in SSRU 882H, for which evidence of a violation of the assumption of a closed population is unambiguous.

5.23 The Working Group agreed that there is evidence for immigration and emigration which will require a two-area model and that there is currently the need to consider how residence time of tags is biasing the Petersen population estimates, and that the level of emigration is confounded with additional possible factors that may be occurring in SSRU 882H such as IUU fishing and predation.

5.24 WG-FSA-14/14 Rev. 1 also presented a stock assessment of *D. mawsoni* in SSRU 882H. The stock assessment was calculated employing the Petersen tag-recapture method using all years of tag releases. The estimated stock biomass in 2014 was 20 649 tonnes. Applying an exploitation rate of 3%, 5% or 10%, the catch limit for 2014/15 would be 619, 1 032 and 2 064 tonnes respectively.

5.25 The Working Group noted that the method used all of the years of tag release rather than the WG-SAM-14 recommendation to use 3, 2 or 1 year of tag-at-liberty data.

5.26 Dr A. Petrov (Russia) suggested that the catch limit recommended by WG-FSA should be 619 tonnes in SSRU 882H and scientific investigation into this matter should be continued. In response to questions on the difference between his assumptions and those of WG-SAM-14, he noted the calculations in WG-FSA-14/14 Rev. 1 used all years of tag recaptures to derive a total biomass for the whole stock caught and released in Subarea 88.2. He considered that the resulting catch limit of 619 tonnes (based on a 3% exploitation rate) should be taken on the seamounts in SSRU 882H, with an additional catch limit set for areas C–G. The Working Group asked Dr Petrov to provide a scientific rationale for the suggested catch limit of 619 tonnes being applied to just SSRU 882H as this was likely to result in substantial fishing mortality rates on the seamounts.

5.27 The Working Group reviewed all of the information available to it provided by the submitted papers and within the discussions and advice from WG-SAM-14. The datasets indicate:

- (i) declining recaptures by year of release in SSRU 882H indicating a loss of tagged fish from the seamounts and annual immigration of untagged fish
- (ii) increasing rate of decline in recaptures by year of release, i.e. recaptures of tags released in more recent years are declining at a faster rate in the recaptures than the declines observed in tags released in earlier years (Figure 6)
- (iii) estimates of biomass on the seamounts – the least biased are those recaptures at liberty of one year
- (iv) simulations indicate that the trends observed in the data are difficult to replicate but could be replicated with an exploitation rate on the seamounts of around 20% and loss of tagged fish at around 20%.

5.28 The Working Group noted that the level of emigration is confounded with additional possible factors that may be occurring in SSRU 882H such as IUU fishing and predation.

5.29 Discussions on stock structure (see WG-SAM-14/26) identified the following points:

- (i) toothfish can move a long way in the season and that the seamounts are only part of the stock area

- (ii) the stock is assumed to be part of an Amundsen Sea stock where the stock moves from the coast to the seamounts and returns. The scale of the area is not known but the seamounts are central (WG-SAM-14/26). This is similar to the stock in the Ross Sea Region and in East Antarctica
- (iii) the tag estimate of abundance determined by WG-FSA-14/14 Rev. 1, using all years of tagging, assumes the tags are present in the whole stock area rather than on the seamounts only.

5.30 The discussion then considered how to harmonise the hypotheses and to make them consistent with the data.

5.31 The decline on tags on the seamounts will be a combination of immigration, emigration, fishing and/or predation and possibly IUU. Thus the population estimate will be biased high if it is based on total tag releases and only discounting by natural mortality. The least biased estimate is that based on tags only one year after release. The Working Group can therefore conclude the following:

- (i) the recent harvest rate was higher than required for the abundance on the seamounts to be stable
- (ii) the number of historical tags in the water is currently unknown because of the extra sources of mortality or population dynamics. This means that a catch determined on the basis of all released tags is too high
- (iii) the recent exploitation rate was likely to be around 20% rather than 4%, although it has decreased in 2013/14 due to a reduction in the catch limit.

#### Management advice

5.32 The Working Group concluded that it could not reach consensus in recommending a catch limit for SSRU 882H due to differences of opinion. Two options for the catch limit for the sea mounts in SSRU 882H were put forward.

- (i) A catch limit of 200 tonnes in SSRU 882H based on the advice of WG-SAM-14, using the least-biased estimate of the seamount population abundance derived from tag recaptures after one year at liberty. This option was supported by the Working Group with the exception of Drs Petrov and L. Pshenichnov (Ukraine).
- (ii) A catch limit of 619 tonnes, based on all tags and the biomass estimate for the whole stock in Subarea 88.2, should be taken in SSRU 882H only. This option was supported by Drs Petrov and Pshenichnov.

#### *Dissostichus* spp. SSRUs 882C–G

5.33 WG-FSA-14/59 outlined a strategy to improve data availability for an assessment of *D. mawsoni* stock abundance estimation in SSRUs 882C–G. The poor tag-recapture rates (of

0.0025 per released fish) in the region are likely due to poor spatial overlap of tag releases and subsequent fishing. The paper recommended mandatory set completion in four identified fishing grounds (Figure 7) and an increase in the tagging rate to 3 tags per tonne in the short term. These measures aim to improve the estimate of abundance and increase information on fish movement from SSRUs 882C–G.

5.34 The Working Group discussed the problem of minimal data available on stock structure in SSRUs 882C–G and recalled that a priority for Scientific Committee 2013 was to estimate stock size in SSRUs 882C–G. The Working Group recognised that operations in the area are affected by varying ice conditions, which prevent consistent fishing every year. However, the ice condition analysis carried out in WG-FSA-14/54 showed that at least two of four fishing grounds are usually available and recommended to increase the tagging rate in SSRUs 882C–G to 3 fish per tonne.

5.35 The Working Group requested that the Scientific Committee consider relevant approaches for these SSRUs given the limited availability of data.

5.36 The increase in the tagging rate recommended in WG-FSA-14/59 for SSRUs 882C–G to 3 tags per tonne differs from the tag rate in SSRU 882H at 1 tag per tonne, and this difference could possibly trigger false positives in the tag-overlap statistic. The Working Group recognised that the size composition in SSRUs 882C–G is substantially different from SSRU 882H, consisting of high numbers of small fish in the catch. The Working Group recognised the issue, but referred to the conclusions drawn from WG-FSA-14/31 and agreed that similarly, the Working Group looks at potential overlap statistic violations individually and advises accordingly.

5.37 The Working Group discussed the suggested tag rate of 3 tags per tonne. It noted that there is currently no assessment for Subarea 88.2 and recalled the decision by the Scientific Committee that an assessment for this area is a priority (SC-CAMLR-XXXII, paragraph 3.167).

5.38 Most of the Working Group therefore agreed to a tag rate of 3 tags per tonne in SSRUs 882C–G in order to progress towards a stock assessment in Subarea 88.2, noting the proposed flexibility needed in the location of fishing because of sea-ice.

5.39 Drs Petrov and Pshenichnov disagreed that an increase in tagging rate would improve the biomass estimate in SSRUs 882C–G as ice conditions prevent recapture, and suggested that in order to increase the tagging rate, the status of the SSRUs 882C–G fishery should be changed from ‘exploratory fishery’. Both members were concerned that an increased tagging rate could impact research fishing because of the need for compliance with the tag-overlap statistic.

5.40 The Working Group noted that there is a requirement for a suitable tagging rate that achieves an assessment of abundance in this area, regardless of the classification of the fishery and noted:

- (i) a tag rate of 1 fish per tonne in areas where accessibility is known to be impacted by sea-ice is unlikely to produce an assessment for many years

- (ii) the experience in Subareas 48.6 and 58.4 shows how fishing in designated research blocks with high tagging rates can yield good tag-recapture rates
- (iii) the constraints of undertaking research for assessment purposes in areas affected by sea-ice has been identified as a topic of high priority for WG-SAM.

5.41 The Working Group was unable to reach consensus on a recommendation of an increase in tagging rate in this management area.

5.42 In the course of discussion, the Working Group learned that in some instances small fish were released alive without tags. The Working Group expressed concern that this was occurring but insufficient information is currently collected to understand the extent of bias that this practice may introduce into the assessments considered by the Working Group and requested this be considered further at the Scientific Committee.

#### Management advice

5.43 The Working Group recommends all fishing sets be completed within the boxes that define the bounds of the four identified fishing grounds (Figure 2; Table 4).

5.44 The Working Group agreed that the catch limit for SSRUs 882C–G be retained as that agreed for 2013/14 at 124 tonnes in SSRUs 882C–G.

#### Research to inform current or future assessments

##### Subarea 48.2 – South Orkney Islands

5.45 The Working Group considered WG-FSA-14/08, a proposal by Ukraine to undertake research fishing for *Dissostichus* spp. in Subarea 48.2. The aim of the program is to provide CCAMLR with the data necessary to estimate biomass of *Dissostichus* spp. by undertaking a longline research survey during February–April over a 3-year period (2015–2017).

5.46 An earlier proposal had been reviewed at the meeting of WG-SAM (WG-SAM-14/22), where a number of suggestions for improving the survey were made and resubmission was encouraged (Annex 5, paragraphs 4.1 to 4.5). The Working Group agreed that the revised proposal adequately incorporated the recommendations set out by WG-SAM. However, it was also noted that there was no indication as to how biomass would be estimated and reported using the existing research design. There were further uncertainties with respect to how ageing would be undertaken by Ukraine for the two species of *Dissostichus*.

5.47 Dr Pshenichnov noted that results and analysis for the first year's research would be reported to WG-SAM-15, and that this would include work toward ageing otoliths for the two species. Ukraine was encouraged to collaborate with other Members who currently have otolith ageing programs. It was noted that the issue of methodology to estimate biomass would be referred to WG-SAM-15.

5.48 The Working Group recalled the advice from WG-FSA-13, paragraph 6.76(i), that the target tag-overlap statistic be increased to at least 80%. The Working Group endorsed the research plan for *Dissostichus* spp. in Subarea 48.2. The survey sets in 2015 year shall be effort limited (a total of 30 sets) with a research catch limit of 75 tonnes.

#### Subarea 48.6

5.49 WG-FSA-14/67 provided an updated progress report on research fishing activities for *Dissostichus* spp. undertaken in 2012/13 and 2013/14 in Subarea 48.6 being jointly undertaken by Japan and South Africa.

5.50 The Working Group noted that effort in four research blocks and tagging efforts appear to be yielding encouraging results, with a total of 42 tagged toothfish having been recaptured during the first 19 months of the research program. However, a substantial number of the recaptures were within season, with 17 recaptured *D. mawsoni* and four *D. eleginoides* from the northern part of Subarea 48.6 and three *D. mawsoni* from the southern area suitable for use in a tag-based assessment model. The paper contended that at the present rate of recaptures, there should be sufficient data to undertake a tag-based assessment of *D. mawsoni* in the northern part of Subarea 48.6 by the end of 2015.

5.51 The Working Group expressed concern with respect to the possible increase in IUU activity in the area, which could have negative impacts on the research being undertaken.

5.52 WG-FSA-14/17 and 14/37 provided revised research plans for the exploratory fisheries for *Dissostichus* spp. in Subarea 48.6 in 2014/15 by Japan and the Republic of Korea respectively. The Working Group noted that South Africa intends to collaborate with Japan on research activities in 2014/15 as well.

5.53 The Working Group noted that predicted numbers of recaptures and estimated stock size using the Petersen and CPUE methods (using SSRU 882H as a reference area) were relatively consistent with the observed numbers for *D. mawsoni* in research block 486\_2 for 2012/13 and 2013/14, though were inconsistent for *Dissostichus* spp. in other blocks.

5.54 WG-FSA-14/17 proposed to continue the current research operation for at least three years with the same sample size as decided at the last CCAMLR meeting in the current research blocks. It also proposed to allow flexibility (i.e. enlarged buffer zone) in cases of research operations under extraordinary adverse ice conditions.

5.55 The Working Group undertook to update the Petersen estimates for research block 486\_2. The new estimates of biomass for this research block are set out in Table 5.

5.56 The Working Group agreed that providing advice with respect to increased flexibility in terms of enlarging buffer zones is very difficult, as there is the potential that the probability of recapturing tags may be reduced.

5.57 The Working Group noted that sea-ice analysis in some of the southern research blocks of Subarea 48.6 indicated that consecutive-year research activities may be difficult. The Working Group acknowledged that rolling over catch limits would be associated with a high degree of uncertainty and associated risks, as there is an absence of knowledge relative

to biomass and productivity in these areas and thus a risk for the stock to be negatively impacted. In the absence of an analysis characterising the potential risk that carrying over research catch limits will not overly impact the stock, the Working Group felt that it was not appropriate to advise on this at this stage.

5.58 The Working Group discussed the proposal set out in WG-FSA-14/17 to increase the research catch limit in research block 486\_3 from 50 tonnes to 100 tonnes. The rationale for this proposed change was based on a significantly lower number of recaptured tagged fish than those predicted, owing to a limited number of hauls (only 13 and 14 hauls in 2013 and 2014 respectively) and a research catch limit of 50 tonnes in the research block, which corresponds to 1.4% of the estimated biomass.

5.59 The Working Group agreed that it was important to remain consistent when undertaking a planned multiyear research activity. Consistency across survey seasons will ensure that the signals coming from the research will not be compromised by alterations of the research design during the course of the planned activity. At the end of the planned research, changes to the attributes of the design or recommendations that other approaches should be explored can be advised.

5.60 The Working Group agreed that the priority research areas in Subarea 48.6 should be the two northern research blocks 486\_1 and 486\_2, followed by the three southern research blocks 486\_3, 486\_4, and 486\_5. The Working Group recommended that the research catch limits from last year be retained for this year. These catch limits are set out in Table 5.

#### Subarea 48.5 – Weddell Sea

5.61 WG-FSA-14/03 Rev. 2 presented a progress report on stage II of the Weddell Sea research program. The Working Group noted that options 1 and 2 of the survey were carried out from 10 to 22 February 2014 with a total of 34 longlines set. Within the option 1 area, 30 longlines were set (10 in the east of the research block, 20 outside) and four longlines were set within the option 2 area. The total catch of *D. mawsoni* was 228 tonnes, with a by-catch of approximately 2 tonnes. The Working Group thanked Russia for the detailed report of biological sampling and analyses.

5.62 The Working Group identified several inconsistencies while reviewing this report, including:

- (i) hauling times
- (ii) tag-overlap statistic
- (iii) tagging rate.

5.63 These inconsistencies were investigated by the Secretariat, at the request of the Working Group. The Working Group expressed concern that some of the data used to compile the report differed in several critical respects from that provided to the Secretariat and expressed concern that there may be other errors in the report which had not been identified.

5.64 Dr Petrov explained that the tagging overlap figure that was presented in WG-FSA-14/03 was unintentionally attributed to Subarea 48.5 but was in fact from Subarea 88.1. He reiterated that the data which had been provided to the Secretariat were correct.

5.65 The Working Group then went on to review aspects of the data that had been submitted to the Secretariat and compared them to catches and catch rates in other parts of the Convention Area.

5.66 The Working Group agreed that it would be valuable to develop a stock hypothesis for *D. mawsoni* in the Weddell Sea, as has been done for the Ross Sea, Amundsen Sea and the Indian sector of the Southern Ocean. It agreed it would be useful to look at the hydrography, bathymetry and oceanographic features of the Weddell Sea, noting the likely relationships of these areas to the shelf areas in Subarea 48.6, to start building these hypotheses. Following on from this, it was noted that a comparison between option 1 and option 2 areas would be useful, as the former appears to have larger fish, and the latter has early stage recruits.

5.67 The Working Group noted the remarks in relation to by-catch at WG-SAM-14 (Annex 5, paragraph 4.7), where it was noted that the proportion of by-catch to target catch was low compared with other toothfish fisheries elsewhere in the CCAMLR area. Further analysis by the Working Group indicated that the by-catch rates per set were similar to those observed in the southern areas of Subarea 48.6 (Figure 8) and that the low ratio of by-catch was a function of the high catches of target species.

5.68 It was acknowledged that this was the first two years of research in an area which has never had a CCAMLR fishery for toothfish before, and had exceptionally high catch rates (among the highest in the Convention Area). These high catch rates could be because the area had not been previously fished. However as this was ‘research fishing’ as opposed to ‘commercial fishing’ (i.e. the station coordinates had been supplied to the vessel), the catch rates may be expected to be lower and more variable than when vessels were actively targeting known hot spots.

5.69 The Working Group considered some potential hypotheses as to what may give rise to the high catch rates in Subarea 48.5:

- (i) there could be the potential that Subarea 48.6 has been impacted by IUU fishing, although it was noted that known IUU fishing activities in this subarea have not been as high as in other regions of the Convention Area
- (ii) there could be substantial movement of fish to the areas where option 1 and option 2 have been sampled. However, it was noted that tagging results of *D. mawsoni* elsewhere have not demonstrated large movements within the first few years
- (iii) there may be very different fine scale densities at these locations, as there are clear differences in CPUE spatial structure for the *D. mawsoni* stock in the Ross Sea
- (iv) the vessel achieved these high catch rates simply by chance.

5.70 The Working Group also reviewed the pattern of catch rates seen during the survey. It noted that toothfish catch rates in the Convention Area typically show a frequency distribution where the highest frequency of catch rates are in the bins of lowest catch rates (first one or two bins/columns of a frequency distribution plot) with a long right-hand tail of occasional high catch rates. However, the data for Subarea 48.5 showed a complete absence

of low catch rates. To determine whether this pattern was unusual, the Working Group asked the Secretariat to carry out an analysis of CPUE frequency distributions for all vessel\*area combinations and some of the highest catch rates recorded in the Convention Area. This analysis indicated that of the 992 year\*vessel\*management area combinations for longline fisheries in the Convention Area, there were 16 for which the maximum frequency of CPUE (kg/hook) was not in the first three bins (Table 7 and Figure 9).

5.71 In seeking to understand the operational implications of such high catch rates, the Working Group also reviewed the catch rates in fish landed per minute for all autoline vessels operating in the exploratory and research fisheries in Subareas 88.1, 88.2, 48.4 and 48.5 in the last three years. It would be expected that with high catches it would take a longer time than average to retrieve the gear. However, it appeared that the *Yantar 35* had taken relatively little time to haul each set considering the very large toothfish catches. To determine whether this pattern was unusual, the Working Group asked the Secretariat to carry out an analysis of haul times for various vessel\*area combinations. The analysis was restricted to autoline vessels to ensure consistency between gear types. The Secretariat conducted the analysis by calculating the number of fish hauled per minute during each set of the survey and compared that with other autoline vessels fishing in Subareas 48.4, 48.5, 88.1, and 88.2 combined across all years (Figure 10).

5.72 The Working Group noted that almost all vessel\*area combinations in Subareas 48.4, 88.1 and 88.2 had a mean haul rate of less than 0.5 fish per minute. The exception was the *Yantar 31* in Subarea 88.2 but this was based on only seven sets (Table 7). In contrast, the *Yantar 35* had a mean haul rate of over 1 fish per minute when fishing in Subarea 48.5 compared to a mean haul rate of less than 0.5 fish per minute when it was fishing in Subareas 88.1 and 88.2. The difference in hauling speeds between vessels is also demonstrated clearly in Table 7, where it shows that the *Yantar 35* hauled 52% of its sets at a speed of over 1 fish per minute compared to all other vessels (excepting *Yantar 31*), which hauled less than 6% of their sets at that speed.

5.73 The Working Group also considered the effect of a higher tagging rate on the haul rates by comparing the hauling rate (fish per minute) for vessels which had fished in both Subareas 48.4 where the tagging rate is 5 fish per tonne, and Subareas 88.1 and 88.2 where the tagging rate is 1 fish per tonne (Figure 10). All three vessels which have fished one or more of these three subareas have a substantially lower hauling rate in Subarea 48.4, even though the catch rate is also lower. However, the *Yantar 35* had a much higher hauling rate in Subarea 48.5 than it did in either of the other two subareas.

5.74 The Working Group reviewed the spatial location of catches conducted in 2013 and 2014 as part of the research program and noted that there was limited overlap between the location of fishing in 2013 and 2014 and also between the proposed location of research in 2014 and the actual location of catches in 2014 (Figure 11).

5.75 The Working Group further noted that although the *Yantar 35* released a total of 1 792 tags in Subareas 48.5, 88.1 and 88.2, none of these tags have been recaptured.

5.76 WG-FSA-14/09 described a plan of research in Subarea 48.5 for the 2014/15 season submitted by the Russian Federation. The Working Group noted the schedule and research plan with respect to the third stage of a multiyear research program in the Weddell Sea, as well as the plan to continue the research for a total of five years.

5.77 The plans and activities undertaken in Subarea 48.5 were examined in detail by the Working Group.

5.78 The Working Group noted that the proposed research in 2014/15 included setting 50 lines in the option 1 area (30 outside the block, 20 inside), 40 lines in the option 2 area (plus four lines on each of two seamounts) and 40 lines within the option 3 area (20 lines in western region, 20 lines in eastern region). It was noted that the proposed catch required to complete the survey in year 3 (2014/15) was specified as 383.3 tonnes in the option 1 area (240 tonnes inside the research block, 143.3 tonnes outside the block), 58 tonnes in the option 2 area (48 tonnes in the option 2 area, 5 tonnes on each of 2 seamounts) and 110 tonnes in the option 3 area. The overall proposed research catch totals 551 tonnes.

5.79 The Working Group noted that the spatial design of the research within the option 2 area comprises a prospecting phase that includes four lines at each elevation on two seamounts in the eastern part of the Weddell Sea. Dr Kock informed the Working Group that recent bathymetric swath mapping of this region by the RV *Polarstern* indicates that these two seamounts may not exist.

#### Management advice

5.80 Because of the problems with the inconsistencies in the data presented in WG-FSA-14/03 and the data provided to the Secretariat and also the anomalous nature of these data when compared to data from other vessels fishing in the Convention Area, most members of the Working Group were unable to complete the review of the proposed research program for 2014/15 and were therefore unable to endorse the further proposal to continue the research in 2015. They recommended that a thorough review of all aspects of the data be carried out by the Secretariat during the intersessional period.

5.81 Some members further considered that these data should be quarantined until this review had taken place.

5.82 Dr Petrov made the following statement:

‘Russian research programs in the Weddell Sea was adopted by the CCAMLR Commission on the Thirty-first (CCAMLR-XXXI, paragraphs 5.37 to 5.43) and Thirty-second (CCAMLR-XXXII, paragraphs 5.59 and 5.60) Meetings. The research programs were carry out by Russia within two years (2012/13 and 2013/14). Data on biology and fishing for toothfish have been collected for the first time ever from the area which has not been investigated for 31 years and was a gap for CCAMLR and a data-poor area. Progress report of performed Research program of Russia was presented and considered at WG-SAM-2014 (Chile, Punta Arenas) and received positive assessment of the Working Group as evidenced by the corresponding entries in the report (WG-SAM-2014, paragraphs 4.6 to 4.12). In the same report on the results of research in Subarea 48.5 presented at WG-FSA-2014 some participants of the Group found insignificant, minor mistakes which in general do not affect the overall result of the studies. In accordance with the procedure discussed mistakes were corrected and placed on the web-site of the Working Group and were marked as revision. But some participants put in doubt the findings, which were reviewed and

discussed at the WG-SAM-2014 (WG-SAM-2014, paragraphs 4.6 to 4.12) and stated that they doubt the results and data presented by us. Then I offered to convene independent working group for discussion of the arisen questions related to the presented by us data using the data submitted by us to the CCAMLR Secretariat, but did not receive general support. As long as the group has not been created and procedure for the consideration of the dispute issue was not complied in accordance with the procedure. Also during the plenary session I did not receive the data from the opponents where they could show the factual differences.

I reserve my opinion on that issue. The research program presented by Russian Federation in document WG-FSA-14/09 must be considered by the Scientific Committee. I believe that it is necessary to continue Russian research programs adopted by the Commission (CCAMLR-XXXI, paragraphs 5.37 to 5.43) at the Thirty-first Meeting, planned for season 2014/15 by us.

I would like to note that we fully support proposal made by the WG-SAM-2014 to open the Subarea 48.5 for exploratory fishing after the stock assessment for toothfish in this area is completed. We are sure that when the Subarea 48.5 will be open for everyone then CCAMLR will get confirmation of our results.'

5.83 Many members noted that:

'The assertion from Dr Petrov, that he "offered to convene independent working group for discussion of the arisen questions related to the presented by us data using the data submitted by us to the CCAMLR Secretariat, but did not receive general support" is not factually accurate.

This offer was not made during the proceedings of WG-FSA-14 to any other participant's knowledge. Dr Petrov did offer to look at the data held by the Secretariat in plenary, but did not offer that opportunity to others. Were it to have been made, the Working Group would have welcomed and fully supported the opportunity to address the questions relative to the data presented. The Working Group had agreed that it would review a revision of the analyses if they were made available for consideration in the subgroup and later in plenary.'

Division 58.4.4a and 58.4.4b (Ob and Lena Banks)

5.84 Papers considered under this item included:

- (i) WG-FSA-14/04 and 14/21, describing plans for research in 2014/15 to support the development of a stock assessment for toothfish in blocks C and D in this division by the *St André* (France) and the *Shinsei Maru No. 3* (Japan)
- (ii) WG-FSA-14/06 and 14/23, describing updated stock assessments using CASAL of the toothfish in blocks C and D.

5.85 The Working Group noted the advice by WG-SAM-14 on refining research plans and preliminary assessments for this division, including reconciling MPD and MCMC estimates of biomass, the impact of IUU fishing on the stock and seeking consistency in the development of input files for CASAL (Annex 5, paragraphs 2.18 to 2.25).

5.86 The Working Group noted that the revised assessments presented have improved relative to those presented at WG-SAM-14. Work undertaken during the meeting, including reweighting data using the Francis (2011) method, estimating IUU fishing of 30–50 tonnes in 2012 and fitting standardised CPUE further improved the robustness of the models conducted, however, this was unable to be progressed to the point of providing management advice using the CCAMLR decision rules. The Working Group recommended that the assessments continue to be refined independently, including:

- (i) development of catch at age and growth based on fish aged from this division
- (ii) estimation of YCS where ageing data is available
- (iii) fitting standardised CPUE
- (iv) investigation of the impact of effective sample size
- (v) alternative assumptions of selectivity (e.g. longline versus gillnet) for IUU fishing
- (vi) runs of simulations to detect sources of bias in the models.

5.87 The Working Group also recommended that an intersessional e-group<sup>1</sup> be convened to progress the items noted above and requested that the Scientific Committee consider the inclusion of a focus topic on the preparation of data for inclusion in integrated assessments at WG-SAM-15.

5.88 Noting the progress towards an assessment in this area and the broad consistency between the expected tag-recapture estimates from WG-FSA-13 (SC-CAMLR-XXXII, Annex 6, Table 13) and those observed, the Working Group recommended that the research fishing proposed by France and Japan in this division proceed in 2014/15, with a catch limit of 25 tonnes in block C and 35 tonnes in block D.

#### Division 58.4.3a (Elan Bank)

5.89 Papers considered under this item included:

- (i) WG-FSA-14/05 and 14/20, describing plans for research in 2014/15 to support the development of a stock assessment for toothfish in this division by the *St André* (France) and the *Shinsei Maru No. 3* (Japan)
- (ii) WG-FSA-14/22, describing an updated stock assessment using CASAL.

5.90 The Working Group noted the advice by WG-SAM-14 on refining research plans for this division, including accounting for tag recaptures in 2014 in updated estimates of biomass, establishment of research blocks, analysis of skate by-catch and facilitating collaborative research (Annex 5, paragraphs 3.32 to 3.38).

5.91 Following review of the scenarios in WG-FSA-14/22, the Working Group agreed that the CASAL assessment was currently not sufficiently robust to provide management advice

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<sup>1</sup> CCAMLR e-groups can be accessed from the [CCAMLR homepage](#) and are available to authorised users.

using the CCAMLR decision rules. It 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. In addition, analysis of the penalties applied to tagging data seen in the stock assessment models should be evaluated.

5.92 In the absence of an assessment using the CCAMLR decision rules, the Working Group agreed that re-estimation of the geometric mean of Petersen biomass estimates be used as the estimate of biomass for this division, including the 24 tags recaptured during research fishing in 2013/14 by the *Shinsei Maru No. 3* and the *St André*. Given this analysis estimated biomass at 386 tonnes, which was similar to the 372 tonnes, the Working Group recommended that the catch limit for this division remain unchanged at 32 tonnes for 2014/15.

5.93 The Working Group reviewed the spatial, vessel- and gear-specific patterns of skate and macrourid by-catch in this division. Patterns of by-catch varied across all of these factors. The Working Group noted the analysis in WG-FSA-14/05 indicating that for soak times of less than 24 hours, soak time did not seem to influence skate by-catch rates on the *St André*, as well as that the great majority of skates caught by that vessel in 2013/14 were deemed likely to survive and were released.

5.94 The Working Group agreed that it was unnecessary to prescribe soak times or spatial locations for the research fishing proposed by France and Japan in this division in 2014/15. However, the Working Group agreed that further analysis of skate condition in relation to soak time and spatial distribution of fishing was needed and requested an updated analysis to be submitted to WG-FSA-15. It welcomed the offer from France to tag and release skates.

#### Divisions 58.4.1 and 58.4.2

5.95 Papers considered under this item included:

- (i) WG-FSA-14/35 and WG-SAM-14/09, describing the results of the depletion experiment conducted by the *Tronio* (Spain) in Division 58.4.1 in 2012/13 and 2013/14, and the proposal to continue this research through to 2017/18
- (ii) WG-FSA-14/18 and 14/19 describing plans for research in 2014/15 by the *Shinsei Maru No. 3* (Japan) to support the development of a stock assessment for toothfish in Divisions 58.4.1 and 58.4.2
- (iii) WG-FSA-14/38 and 14/39 describing plans for research in 2014/15 by the *Kingstar* (Republic of Korea) to support the development of a stock assessment for toothfish in Divisions 58.4.1 and 58.4.2.

5.96 The Working Group noted the advice by WG-SAM-14 on refining research plans for Divisions 58.4.1 and 58.4.2, including the need for evaluation of the CV of the biomass resulting from the depletion experiment and the area to which estimates are applied, the need for a review of the depletion experiment at WG-SAM-15 prior to research continuing and the need for prioritisation of research activities in these proposals, given the large spatial coverage of research activities proposed by Japan and the Republic of Korea across these divisions and Subarea 48.6 (Annex 5, paragraphs 3.25 to 3.31).

5.97 The Working Group noted that Spain had been unable to complete the depletion experiments within SSRU C in 2013/14 within the 42 tonne limit allocated. It noted that Spain had continued the research after discussion with the Secretariat and Japan, and that the research had concluded after 54 tonnes were taken, therefore without exceeding the overall catch limit for this SSRU. It further noted that Spain had requested that 50 tonnes be allocated to reduce the risk that research would be curtailed in 2014/15.

5.98 It requested that the Commission consider a mechanism that would provide the flexibility to the *Tronio* to complete depletion experiments if more than 42 tonnes is required to complete it in 2014/15.

5.99 The Working Group agreed that the priority for the depletion experiment should be to return to locations where depletions had been observed previously in an attempt to recapture tagged fish and to estimate the rate at which toothfish may replenish areas where local depletion has occurred, prior to prospecting outside these areas. It further noted that lines should be set close together to ensure that the variability in CPUE observed can be attributed to local depletion rather than variation in toothfish density across an area. It also encouraged the development of an ageing program by Spain to enhance the information on population dynamics of toothfish in the region.

5.100 The Working Group agreed with the recommendation from WG-SAM-14 that the results from the depletion experiment be reviewed prior to further research fishing in 2015/16. Such a review would consider the following questions:

- (i) How does the precision and magnitude of biomass estimated from Leslie depletion analysis compare with that estimated from tag recaptures?
- (ii) What is the relationship between the initial CPUE in an area and the resulting biomass in an area derived from a depletion experiment?
- (iii) What is the area to which the biomass estimate derived from a Leslie depletion analysis applies?
- (iv) How can the results of depletion experiments be used to develop a stock assessment that uses the CCAMLR decision rules?

5.101 The Working Group noted the revised research proposal by the Republic of Korea detailed in WG-FSA-14/38 and 14/39, which provided additional details on the schedule of work planned over five years of research. The Working Group noted that the proposal included a plan to release one satellite pop-up tag in each of Divisions 58.4.1 and 58.4.2 and Subarea 48.6. The Working Group recommended that, given the reliability of these tags, releasing all tags in one location was more likely to result in useful data on toothfish behaviour, as well as the feasibility of using this technology in areas seasonally covered by sea-ice.

5.102 The Working Group welcomed the development of an ageing program by Korean scientists and encouraged continued correspondence between the Republic of Korea and established toothfish ageing programs such as that undertaken by New Zealand, and developing quality control procedures as described by the Ageing Workshop for *D. eleginoides* and *D. mawsoni* at WG-FSA-12 (SC-CAMLR-XXXI, Annex 7, paragraphs 10.1 to 10.19).

5.103 The Working Group noted that the proposals by Spain, and Japan and the Republic of Korea, both included research blocks located in areas that are periodically covered by sea-ice. It recalled that in 2013, Korea had been unable to complete planned research due to problems with sea-ice encountered during January, and sea-ice had impacted on the ability of the *Tronio* to set lines in 2014.

5.104 Analysis of historical sea-ice conditions using the methods described in WG-FSA-14/54 and 14/55 Rev. 1 indicated that research blocks 5841C\_a and 5841C\_b most reliably have some fishable area clear of sea-ice (Figure 12). In some years, other research blocks were partly or entirely occluded by sea-ice, however, February was consistently the month that sea-ice was at its minimum extent. The Working Group therefore agreed that research be focused on those blocks at times where sea-ice was likely to permit multiyear tag-recapture experiments. Noting that the time window for operating adjacent to the Antarctic coast in Divisions 58.4.1 and 58.4.2 was around one month, this meant that it was unlikely that a single vessel was likely to be able to conduct research in all of the block proposed.

5.105 The Working Group recommended that research by Japan and the Republic of Korea in 2014/15 be focused on those block(s) designated in 2013 that have a high number of tags available for recapture and that are likely to be accessible. Given that no further information on stock status or productivity was available, the Working Group recommended that the same catch limits apply in 2014/15.

5.106 The Working Group acknowledged that sea-ice posed a significant obstacle to progressing stock assessments based on tag recaptures in many exploratory fisheries. It therefore requested that the Scientific Committee task WG-SAM-15 with reviewing research methods to develop stock assessments in these areas, taking into account the experience and data collected from research activities conducted in exploratory toothfish fisheries in areas affected by sea-ice, habitat modelling of toothfish, sea-ice maps and the operational capabilities of fishing vessels.

#### Subarea 88.1 and SSRUs 882A–B

##### Ross Sea sub-adult survey

5.107 Results of the 2014 Ross Sea sub-adult survey were presented in WG-FSA-14/51. The three completed surveys were summarised and showed that the survey was tracking age-class progression of fish of 6–9 years old. The 2014 survey also showed that high catch rates of large toothfish were observed in McMurdo Sound relative to the other survey areas.

5.108 The Working Group noted that the recommendations from WG-SAM (Annex 5, paragraphs 4.24 and 4.25) were incorporated in the updated report and that further progress on including the index of YCS in the stock assessment will be presented at WG-SAM-15. The Working Group also noted that there was no evidence to date that commercial fishing was influencing the survey CPUE data. The Working Group agreed that the age structure and standardised CPUE derived from commercial data do not index the age structure or abundance in the area and that the survey is necessary to collect that information. The Working Group also agreed with WG-SAM that monitoring the size composition in the McMurdo Sound area would be useful in the future (Annex 5, paragraph 4.26).

5.109 The proposal to continue the Ross Sea sub-adult survey in 2015 was presented in WG-SAM-14/25. The proposed survey strata for 2015 include a stratum near Terra Nova Bay, as that area has been identified as an area of high juvenile abundance and fish tagged in the southern Ross Sea may have moved to this area.

5.110 The Working Group endorsed the recommendations from WG-SAM-14 to carry out the survey in 2015 with an exploratory stratum near Terra Nova Bay and recommended that the proposed survey be carried out in 2015. The Working Group also agreed that the survey should be comprised of 60 sets with a catch limit of 68 tonnes.

#### SSRUs 882A–B

5.111 A multinational survey to map bathymetry and collect biological data from toothfish in the northern part of SSRUs 882A–B was proposed in WG-FSA-14/61. The Working Group noted that the proposal was improved by the incorporation of recommendations from WG-SAM-14 (Annex 5, paragraphs 4.16 to 4.23). The Working Group agreed that the proposal would provide information that was relevant both to the development of spatial population models (SPMs) and will also inform the understanding of stock structure in the region. The Working Group encouraged the participating vessels to fish in SSRU 881C adjacent to SSRU 882A using the standardised gear configuration to enhance the comparison between the two areas and also noted that the participating vessels have a good tagging performance history.

5.112 The Working Group recommended the bathymetry mapping and survey go ahead as an effort limited ‘prospecting’ phase research 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 an upper catch limit of 50 tonnes per vessel deducted from the catch limit from the Ross Sea region was appropriate for the scope of the research and recommended that the Scientific Committee consider appropriate options to account for the survey catches, noting that a proposal for this purpose was submitted by New Zealand (SC-CAMLR-XXXIII/09).

5.113 In the southern area of SSRU 882A, an updated proposal to conduct research on the continental slope and shelf was presented in WG-FSA-14/13. Previous versions of the proposal have been discussed in 2013 (see discussion of a previous version of the proposed research in SC-CAMLR-XXXII, paragraphs 3.151 to 3.160), by the Commission (CCAMLR-XXXII, paragraphs 5.33 to 5.37) and by WG-SAM-14 (Annex 5, paragraph 4.17). The objective is to sample a previously fished area to recover tagged toothfish that were either tagged in the area or have moved into the area, hypothesised to be mainly from the Ross Sea slope. The focus area consists of a central box and three smaller areas either to the northwest, southwest or east of the main area (options 1, 2, 3), with the smaller areas fished to be chosen depending on ice conditions.

5.114 The Working Group noted that the proposed design would allow the data to be used by the Ross Sea spatial population model but also noted that it proposed a different life-history hypothesis and stock structure for the fish inhabiting the southern part of SSRU 882A that would entail an eastward migration from the Ross Sea into SSRUs 882C–H (SC-CAMLR-XXXII, paragraph 3.158).

5.115 The Working Group noted that this proposal has been presented under CM 24-01. It agreed that the catch would be taken from the Ross Sea stock. It also noted that the proposal was for the research catches to be taken additional to the catch limit. In view of the catch limit for the Ross Sea stock being set according to the CCAMLR decision rules, then additional catch for the research would mean that the total catch would not satisfy the decision rules. The Working Group agreed that there was no information to complete a review of the implications for the stock of taking a research catch greater than the catch limit set according to the decision rules. It noted that should the catch be taken as part of the catch limit for the Ross Sea stock, then the research need not be undertaken under CM 24-01.

5.116 The Working Group noted that discussions surrounding activities in respect of toothfish in SSRUs 882A–B would be clearer if these SSRUs were more clearly identified with the Ross Sea stock. It recalled the discussion of the Commission in 2013 regarding the rationale for the revision of the boundary between Subareas 88.1 and 88.2 (CCAMLR-XXXIII, paragraphs 5.34 and 5.37). The Working Group also recalled that the Commission had revised boundaries of management areas in the past to more clearly be associated with whole stocks (e.g. Division 58.4.3b; CCAMLR-XX, paragraphs 7.16 to 7.20).

5.117 In reference to whether closed SSRUs represented unexploited areas and that catches in open SSRUs were only applicable to sustainable yields in those SSRUs, the Working Group noted that the Commission has developed spatial management strategies to help improve data collection during exploratory fisheries (CCAMLR-XXII, paragraphs 9.16 to 9.23; CCAMLR-XXIII, paragraphs 10.57, 10.58 and 10.70; CCAMLR-XXIV, paragraphs 10.11 to 10.16). These measures were aimed at concentrating fishing activities but not affecting catch limits for whole divisions and subareas; some SSRUs were closed and the catch limits from those closed SSRUs were added to adjacent SSRUs. This approach was undertaken in the knowledge that the fish were likely to move between SSRUs.

5.118 The Working Group concluded that the issue of the boundaries of Subareas 88.1 and 88.2 is a matter for the Commission but that toothfish inhabiting SSRUs 882A–B are included in the Ross Sea region stock assessment and therefore catch from those areas should be subtracted from the Ross Sea region catch limit to satisfy the CCAMLR decision rules (SC-CAMLR-XXIV, paragraph 4.162; CCAMLR-XXIV, paragraph 11.72).

5.119 The Working Group recommended that if the research proposal was undertaken under the catch limit for the Ross Sea region, then a catch limit of 60 tonnes would be appropriate inside the main box and 40 tonnes in the area outside the box, for a total of 100 tonnes for the SSRU 882A shelf and slope survey.

#### Multiyear research plan

5.120 A multinational multiyear research plan for the Ross Sea was developed in WG-FSA-14/60. The research plan aims to address information needs for management of the Ross Sea region *D. mawsoni* population focusing on improved biological parameters for stock assessment and improved understanding of ecosystem effects of fishing. The Working Group welcomed the plan, encouraged other Members to review and operationally support the plan and looked forward to progress on the topics identified. The Working Group agreed with the

report of WG-EMM (Annex 6, paragraphs 5.21 and 5.22) that work on the ecosystem effects of fishing was important and that future work should consider how the Scientific Committee could use such information in advising the Commission.

#### Summary of advice on the catch limits of exploratory and other fisheries

5.121 The Working Group discussed the results of research fishing in 2013/14 and reviewed the number of recaptures of tagged fish predicted at its 2013 meeting (SC-CAMLR-XXXII, Annex 6, paragraphs 6.26 to 6.28 and Table 13).

5.122 In 2013, the Working Group defined research catch limits that would achieve 10 or more recaptures in 2013/14 without exceeding local exploitation rates of approximately 0.04. Where multiple plausible local biomass estimates were available, the more precautionary option was selected, unless other evidence supported a higher local biomass (SC-CAMLR-XXXII, Annex 6, paragraph 6.26 and Table 13).

5.123 The Working Group recalled that the following criteria had been used in formulating the information and advice contained in SC-CAMLR-XXXII, Annex 6, Table 13:

- (i) Local biomass was estimated using available data (Petersen, CPUE seabed analogy) and the lowest estimate ( $B$ ) was selected.
- (ii) The minimum catch required to catch 10 tags in the next season ( $C_1$ ) was

$$C_1 = \frac{10B}{T}$$

where  $T$  is the estimated number of tagged fish available for recapture.

- (iii) The catch that would result in a local exploitation rate of 0.04 ( $C_2$ ) was

$$C_2 = 0.04B.$$

- (iv) The lower value of  $C_1$  and  $C_2$  as selected as the upper limit of catch for research activities in a given block (i.e. the recommended catch limit).

5.124 The Working Group also recalled that the number of tagged fish available for recapture within each research block was based on a subset of data representing 'effective tag releases'. Only tagged fish from vessels from which at least one of their tagged fish had subsequently been recaptured (from effective tag releases, and excluding tagged fish which had been released and recaptured in the same season) are used for the estimation of local abundance using the Petersen estimator and for subsequent calculations on expected recaptures under different catch limits and in stock assessments (SC-CAMLR-XXXII, Annex 6, paragraph 6.13). This method has been applied to vessels in each subarea where research fishing occurs, pending development of alternative methods.

5.125 The Working Group noted the following points in relation to SC-CAMLR-XXXII, Annex 6, Table 13:

- (i) the boundaries of research blocks in Subarea 48.6 and Divisions 58.4.1, 58.4.2 and 58.4.3a are defined in CMs 41-04, 41-11, 41-05 and 41-06 respectively
- (ii) the boundaries of research block 485\_1 (Subarea 48.5) were defined at WG-FSA-13 (SC-CAMLR-XXXII, Annex 6, paragraph 6.86)
- (iii) the boundaries of research blocks 5844b\_1 and 5844b\_2 (Division 58.4.4b) are 52°45'S–54°00'S and 47°30'E–49°15'E and 54°00'S–54°45'S and 49°15'E–52°00'E respectively
- (iv) estimation methods follow the advice of WG-SAM (SC-CAMLR-XXXII, Annex 4, paragraph 2.7) regarding the framework and approaches for research plans in data-poor fisheries
- (v) the local exploitation rate for *D. mawsoni* in research block 486\_4 was incorrectly reported in Table 13; the correct rate is 0.04–0.06.

5.126 The Working Group also noted that the research blocks used at WG-FSA-13 were renamed by the Commission in 2013 to avoid confusion with SSRU nomenclature (CCAMLR-XXXII, paragraph 7.88) and the mapping of current names to the names used at WG-FSA-13 is as follows:

Current name	Name used at WG-FSA-13
485_1	Option 1-a
486_1	A
486_2	B
486_3	C
486_4	D
486_5	E
5841_1	C-a
5841_2	C-b
5841_3	E-a
5841_4	E-b
5841_5	G
5842_1	E
5843a_1	A
5844b_1	C
5844b_2	D.

5.127 The Working Group estimated the number of tags available for recapture in each research block in 2014 (using only ‘effective tag releases’) and compared the number of observed recaptures in 2014 with the number that would be expected under different assumptions of local biomass estimated using alternate methods (Table 5). The number of tagged fish available in a given season ( $n$ ) was calculated taking into account the number of available tagged fish in the previous season ( $n - 1$ ), tag induced mortality, natural mortality, the number of tagged fish recaptured in season  $n - 1$  and the number of tagged fish released in season  $n - 1$ .

5.128 The Working Group noted that the estimates of local biomass used in the calculations in Table 5 were those estimated by WG-FSA-13, except for the estimates for *D. mawsoni* in research block 486\_2 and *D. eleginoides* in blocks 5843a\_1 and 5844b\_1, which were revised in 2014 (see paragraphs 5.55, 5.86 and 5.90).

5.129 The Working Group agreed that the catch limits in Table 5 are appropriate to achieve the aims of the research programs proposed in exploratory and other fisheries and recommended that these be considered as management advice by the Scientific Committee for catch limits for 2014/15. It is also clarified that those limits are expected to remain for the duration of the proposed research programs, provided that they are reviewed by the Working Groups in light of information derived from research activities and no significant sign of adverse impact on the stock is detected.

5.130 The Working Group also discussed the feasibility of research programs which include a large number of research blocks that are unlikely to be able to be surveyed in a single year by the proposed number of vessels due to the limited time window of access due to sea-ice. The Working Group noted that the inclusion of multiple blocks as proposed increases the feasibility of the research in at least a subset of the proposed research blocks. The Working Group agreed that, with the exception of the proposed research areas in SSRUs A and C in Division 58.4.2, where no research blocks are currently identified, Japan and the Republic of Korea could conduct research fishing in the research blocks designated by the Commission in 2013. In order to advance the research in an efficient manner, the Working Group further agreed that the two programs focus on priority areas and recommended that Japan focus its research in Subarea 48.6 while Korea focus in Division 58.4.1, and schedule research at a time when sea-ice is likely to be at a minimum in the research blocks.

## **Vulnerable marine ecosystems (VMEs)**

### **Review of VMEs notified in 2013/14**

6.1 No notifications of VMEs were made under CM 22-06 in 2014 (SC-CAMLR-XXXIII/BG/01). The VME registry is being developed to be available online via the CCAMLR website. One VME indicator notification was received under CM 22-07 for SSRU 882H, but no new VME Risk Areas were identified.

6.2 The Working Group agreed with the Secretariat's plan to develop a web-based interface to provide an annually updated repository of the VME registry which would include information about currently designated VMEs (defined as both lines and areas), VME Risk Areas and VME fine-scale rectangles. The Secretariat also indicated that VME locations and metadata would be added to the CCAMLR online GIS using the same terminology as in the registry. The web-based interface would provide updated information about the status of VMEs in the Convention Area without the need to update an annual report. The Working Group also agreed that until formal reviews of CMs 22-06 and 22-07 were conducted, the current management advice regarding the management of impacts to VMEs has been compiled and provided in the 2013 Report on Bottom Fisheries and Vulnerable Marine Ecosystems.

6.3 Dr Welsford notified the Working Group of the availability of an extensive final report (WG-FSA-14/P06), entitled ‘Vulnerability of Benthic Habitats to Impact by Demersal Gears’, detailing work on the estimated levels of disturbance to 17 groups of vulnerable benthic organisms within the Australian EEZ in Division 58.5.2. The report will be made available in hard copy to the Scientific Committee. It included a proposed framework for risk categorisation and monitoring of bottom fishing impacts and concluded that the majority of the benthos in Division 58.5.2 were classified as either relatively low vulnerability or relatively high vulnerability but substantially protected in the marine reserve. The authors estimated that less than 1.5% of all the biomass in waters less than 1 200 m are estimated to have been damaged or destroyed by all bottom fishing activities since 1997 in this division. 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 in Division 58.5.2.

### **Scheme of International Scientific Observation (SISO)**

7.1 Data collected by scientific observers on vessels operating in the Convention Area during 2013/14, based on data received by the Secretariat up to 1 October 2014 (WG-FSA-14/01 Rev. 2), were presented by the Secretariat. Points noted were improved data quality through better checking procedures developed by the Secretariat with Member technical coordinators, the publishing of observer names on the CCAMLR website in an honour roll as recommended by the SISO review panel and the requirement of a revision of this paper due to late data submissions.

7.2 The Working Group appreciated the thorough presentation of results and thanked all observers for the data collection, noting specifically the usefulness of by-catch data and the impressive reduction in the seabird by-catch in the French EEZ.

7.3 WG-FSA-14/27 provided a description of the use of an electronic monitoring camera system on board a longline vessel operating in the toothfish fishery in Subarea 48.3. It noted that since the study took place in 2012, some vessels have voluntarily adopted similar systems in the fishery and that these could assist with vessels’ by-catch reporting.

7.4 There was consensus within the Working Group of the potential usefulness of such a system, particularly for reducing the workload on observers or providing more time for additional data collection. Several participants mentioned that similar systems had been, or are currently being, trialled in their national fisheries. The Working Group noted the value of electronic monitoring (EM) in providing a verification record for particular events. The Working Group suggested it would be important to look at including some IT components in observer training and developing infrastructure for archiving EM records. The Secretariat indicated that there was currently no system in place for it to archive EM records but that the portal for uploading photographic material may be modified to do this.

7.5 Dr Petrov presented a paper commenting on the SISO review (SC-CAMLR-XXXIII/BG/18). The following statement was provided:

‘Whilst Russia supports changes to logbook forms, we do not see the necessity for an accreditation scheme, and would like to seek the opinion of the Scientific Committee

and the Commission. Institute VNIRO held a two-day workshop (29 and 30 September 2014) specifically for the preparation of scientific observers, for work in a zone of Convention CCAMLR. The workshop program includes such questions as observance of measures on conservation, correct filling of CCAMLR forms, a directory of the scientific observer and tagging module and many other questions connected with work of scientific observers in the Convention zone. Thirty-seven research assistants of profile Russian institutes have taken part in a workshop. Following the results of a workshop, certificates on the work right in CCAMLR zone on systems the international scientific observer are given out to 24 research assistants.'

7.6 The Working Group thanked Russia for its response. The coordinator of the e-group for the CCAMLR SISO review presented a table which broke down responsibilities of decision-making for each recommendation in the report, noting that the only relevant section for WG-FSA was the prioritisation of observer data collection.

7.7 The Working Group discussed the SISO review (SC-CAMLR-XXXII/07 Rev. 1) relevant to WG-FSA and:

- (i) recommended that all recommended revisions detailed in Annex 1 be accepted and adopted in 2014
- (ii) noted that much of the data collection done by observers is not done independently from the vessel, and should therefore be removed from observer tasks and logbook reporting requirements
- (iii) agreed that development of new logbooks and the cruise report to reflect the proposed changes detailed in Appendices 2 and 3 will be progressed further intersessionally through the Scheme of International Scientific Observation e-group, for adoption in 2015
- (iv) noted the importance of observers collecting independent conversion factor data, however, variability in conversion factor calculation between vessels has been identified (WG-FSA-13/68 Rev. 1)
- (v) requested that the Secretariat undertake an analysis of the factors that influence variability in the product to green-weight conversion factors used in the toothfish fishery
- (vi) noted the discussion regarding the recommendation requiring observer data to be submitted one month after the end of fishing and considered that operational and practical constraints for vessels operating in areas both inside and outside the Convention Area were a major impediment to meeting this recommendation and concluded to keep the current submission deadlines
- (vii) sought clarification from the Scientific Committee as to the utility of the observer data collected on board vessels for which data had been quarantined (see paragraph 3.10).

## Non-target catch in CCAMLR fisheries

### Fish by-catch

8.1 The Secretariat summarised recent catches from the CCAMLR area (SC-CAMLR-XXXIII/BG/01). Fish by-catch reported in landings data included sleeper shark (*Somniosus* spp.), skates (Rajiformes), morid cods (*Antimora rostrata*) and various species of grenadier (Macrouridae) and icefish (Nototheniidae). Fish species landed only in small quantities (<1 tonne) included occasional sharks (*Lamna nasus*, *Etmopterus* spp.) and a range of teleosts (e.g. Muraenolepididae, Myctophidae, Channichthyidae, Liparidae and Zoarcidae).

8.2 The Secretariat also analysed commercial catch data (2006–2013) for one research fishery (South Sandwich Islands, Subarea 48.4) and seven exploratory toothfish fisheries: Bouvet (Subarea 48.6), Ross Sea (Subareas 88.1 and 88.2), East Antarctica (Divisions 58.4.1 and 58.4.2), Elan Bank (Division 58.4.3a) and BANZARE Bank (Division 58.4.3b) (WG-FSA-14/16). Data on by-catch quantity (kilograms and numbers) were standardised as a proportion of toothfish catch (hauls with either no toothfish or no by-catch were excluded). Toothfish were the main catch component (by biomass), but by-catch species were numerically dominant. Subareas 48.4, 88.1 and 88.2 and Division 58.4.2 showed significant differences in by-catch landings per haul between years and a general decline by weight. In Subarea 48.6 and Division 58.4.1, by-catch levels in 2013 were similar to those observed in 2006, but lower in intervening years. In Division 58.4.3b by-catch landings per haul generally increased over time. The ratio of macrourids or skates to target catch varied between years and areas. Subareas 48.4 and 88.2 had the highest ratio of macrourids to target catch. The proportion of skates to target catch was lower than for macrourids and the area with the highest ratio of skate to target catch was Division 58.4.3a.

8.3 The Working Group welcomed this preliminary study and encouraged that further studies be undertaken. Such studies could usefully involve (i) further analyses to examine data quality, (ii) comparisons between observer data and C2 catch data reported by vessels, and (iii) finer-scale analyses (e.g. between vessels operating within the same area; between areas fished by the same vessels).

8.4 WG-FSA-14/47 Rev. 1 investigated factors affecting the by-catch of skates and grenadiers in the longline fishery in Subarea 48.3. Reported by-catch was greater for vessels using autolines than for those using the Spanish line system, which may relate to proximity of the gear to the seabed, bait type and other factors. In the years 1996–1999, prior to the change of the start of the fishing season to the beginning of May, skate by-catch was higher in February and March, and grenadier by-catch lower in July and August. Grenadier by-catch was higher along the southern slope of South Georgia to Shag Rocks and skate by-catch was generally greater along the northern slope of South Georgia. Bathymetric variation in the by-catch of skates and grenadiers was noted, with grenadier catches highest in waters 600–1 400 m deep, and skate by-catch greater in shallower and deeper zones.

8.5 The Working Group encouraged further studies examining the influence of gear, bait, fishing location and bottom topography on the CPUE of by-catch species to be undertaken. Studies examining the rates at which different species were attracted to bait may help in the interpretation of species-specific CPUE.

8.6 WG-FSA-14/25 provided information for the improved identification of four grenadier species (*M. caml*, *M. carinatus*, *M. holotrachys* and *M. whitsoni*) that are a by-catch in longline fisheries in Subareas 48.3 and 48.4.

8.7 The Working Group recognised that the taxonomy and identification of some by-catch species remains problematic. The development of user-friendly keys to improve the accuracy of species-specific data recording is encouraged and could be undertaken intersessionally (see paragraph 8.18).

8.8 The Working Group noted other national initiatives to improve identification in the field, including the recently completed ‘Fishes of the Ross Sea region: a field guide to common species caught in the longline fishery’ (McMillan et al., 2014) and welcomed such initiatives.

8.9 The Secretariat summarised the commercial catch and observer data available for skates and held in the CCAMLR database (WG-FSA-14/12). These data relate to seven species, one variant species and three higher taxonomic groups (RAJ, SRX and BHY). The highest catches (by number) occurred in the early 2000s. Reported landings have declined since 2005 as more skates have been released in recent years. Overall, 78% of landed skates have come from Kerguelen (Division 58.5.1) and Crozet (Subarea 58.6). Biological data held by CCAMLR were also summarised. Tagging data show that of the skates tagged ( $n = 17\ 004$ ), 333 (2%) have been recaptured. Most were recaptured within a few kilometres of the release position. Correct species identification remains problematic, and 31% of the recaptures had different taxonomic codes between tagging and recapture. The spatial distributions were mapped for all species and higher taxa. Two species that are considered endemic to the Kerguelen Plateau showed records from other areas, which warrant further investigation. Morphometric data also showed some inconsistencies.

8.10 The Working Group noted that CCAMLR data is a valuable source of information for Southern Ocean skates. Given recent changes in skate taxonomy, improved guidance as to which three-letter codes should be used could usefully be circulated. In order to minimise incorrect data being submitted, data should only be collected and submitted at the lowest taxonomic level possible. Observer data should provide the best data on species composition, with vessel catch data probably better collected at a higher taxonomic level (e.g. SRX) (Table 8).

8.11 The Working Group noted that further quality checks of skate data are required to improve data quality. Improved quality-check routines for data submitted in the future could also usefully be developed. The Working Group recognised the need to (i) conduct further checks of skate data, (ii) improve taxonomic knowledge and field identification guides for skates, and (iii) provide information to the Secretariat on the differences between *Amblyraja georgiana* (SRR) and *A. georgiana* (var.) (SR2). It was agreed that this work should be undertaken intersessionally (see paragraph 8.18).

8.12 WG-FSA-14/48 presented results from a preliminary stock assessment for skates (species complex) based on the Petersen method. Over the period 2006–2014, a total of 7 866 skates were tagged and released. Of the 167 recaptures analysed, most were recaptured within two years (maximum time at liberty was 6.9 years). Most were taken within 20 km of the release position. The assessment suggested a relatively stable population, albeit with large confidence intervals. This study also showed a preponderance of males in surveys.

8.13 The Working Group encouraged further studies of this nature. The significant difference in sex ratio was intriguing and, while sexual segregation is reported widely in elasmobranchs, further investigations on this were suggested, including more detailed analyses by depth, area and observer.

8.14 The Working Group noted that this preliminary assessment of skate by-catch was to provide information on the population dynamics of the skate complex, from which by-catch is taken in the Subarea 48.3 toothfish fishery. This is in support of the evaluation of the ecosystem effects of the toothfish fishery and there is no intention to develop a skate fishery.

8.15 Further data on the condition of skates were also presented (WG-FSA-14/05). Catches of two species (*Bathyraja eatonii* and *B. irrasa*;  $n = 4\ 174$ ) from 91 longline sets from around the Kerguelen Islands indicated that <3% were classed as condition 1 or 2 (dead or poor health). Similar results were also obtained from the Elan Bank area, where about 3% of *A. taaf* ( $n = 6\ 625$ ) were classified as condition 1 or 2. This study did not find any effect of depth or soak time on condition, but soak times were of limited duration on the latter survey (ca. 24 hours) (paragraph 5.93).

8.16 Additional biological data on skates were also collected during the Australian trawl survey around Heard Island (WG-FSA-14/41). This survey caught *B. eatonii* (659 kg; 315–1 115 mm total length), *B. irrasa* (254 kg; 235–1 185 mm) and *B. murrayi* (92 kg; 125–545 mm) and skate egg cases. Skate abundance was slightly higher than the 2006–2013 average.

8.17 Options for updating CCAMLR skate maturity keys were also presented (WG-FSA-14/33) and this is commented on under Item 9 and paragraph 8.18.

8.18 The Working Group recommended that the following work could usefully be undertaken by an intersessional group:

- (i) Photographic identification guides: while identification guides have been developed for problematic taxa by various nations, intersessional work could usefully compare these guides (including their consistency), collate representative photographs and develop a draft guide that could be used across the CCAMLR area. Initial work should focus on one taxonomic group (e.g. skates), before including further taxa in the future.
- (ii) Photographic maturity key for skates: photographs of the different maturity stages of Antarctic skates could also usefully be collated.
- (iii) Develop a targeted program to facilitate the collection of relevant identification material and samples for skates (e.g. photos of diagnostic characters and tissue samples) to allow for improved taxonomic studies in the future.
- (iv) Checking of morphometric and other biological data for skates on the CCAMLR database: given the discrepancies on the CCAMLR database, an intersessional group should work with the Secretariat to identify (and correct where possible) errors and suggest ways of improving data checks in the future.

Members were asked to send relevant photographs and any regional/national guides to the Secretariat ([observer.scheme@ccamlr.org](mailto:observer.scheme@ccamlr.org)).

8.19 The Working Group considered WG-FSA-14/66, which documented the history of discussion of fish by-catch in the krill fishery and included a proposal to examine the fish by-catch in the krill fishery, in order to review the potential for that fishery to impact fish populations.

8.20 The Working Group agreed that the issue of fish by-catch in the krill fishery had been considered periodically for the past 25 years and remained a concern that had not been adequately addressed. However, the Working Group recognised that the increased coverage and scientific observer data collection in the krill fishery, including fish by-catch (e.g. WG-EMM-14/31 Rev. 1), meant that CCAMLR was in a better position to address this issue than previously.

8.21 The Working Group requested that the Secretariat work with SISO technical coordinators to improve awareness of the sampling methods and data reporting for observers collecting fish by-catch data, including the collection of photographs to confirm species identification in the by-catch, and encouraged summary analyses of fish by-catch in the krill fishery (e.g. as presented in WG-EMM-14/31 Rev. 1) to be presented to WG-FSA as well as to WG-EMM.

#### Marine mammal and seabird by-catch

8.22 WG-FSA-14/28 reported a single seabird mortality event in the Subarea 48.3 toothfish longline fishery, when 74 white-chinned petrels (*Procellaria aequinoctialis*) were caught on a single longline on 13 April (during the season extension period 6 to 16 April). The paper highlighted a number of potential contributing factors, including the setting time (close to and just after dawn), time of year and gear type (Spanish system). As a result of this incident, and in accordance with CM 41-02, the season in 2014/15 will commence on 16 April. The authors of WG-FSA-14/28 suggested that future season extensions would require careful consideration and potentially extra mitigation measures.

8.23 The Working Group reflected that the seasonal closure of the toothfish fishery in Subarea 48.3 was introduced to reduce the overlap in the period of high risk for seabirds such as white-chinned petrels) (during the November to April period). Although the incident occurred at dawn, the extent to which this was a contributory factor was questioned, as white-chinned petrel feeding is not limited to daylight. The Working Group recalled that albatrosses feed predominantly during daylight and that night setting requirements were introduced primarily in response to this risk factor. The Working Group recognised that while this incident was very unfortunate, the fact that it was a single incident highlighted the effectiveness of existing mitigation measures in comparison to the risk to seabirds that still existed in areas where mitigation measures were not fully implemented.

8.24 WG-FSA-14/40 reported on trials of daytime fishing during a pre-season extension in the *D. eleginoides* longline fishery in Division 58.5.2. Two vessels fished during this period but no daytime setting was carried out. No seabirds were caught. Any fishing that occurs in the post-season extension period (1 to 14 November) or in April 2015 will be reported to WG-FSA-15.

8.25 The Working Group congratulated France on the significant reductions in incidental seabird mortality in their national EEZs in Subarea 58.6 and Division 58.5.1.

8.26 WG-FSA-14/24 addressed a comment highlighted in the SISO review (SC-CAMLR-XXXII/07 Rev. 1) regarding the effectiveness of bottle tests. The paper concluded that bottle tests (which check line sink rates) are no longer necessary due to the line-weighting specification set out in CM 25-02. The paper also recommended a review of elements of CMs 41-02 to 41-11 to improve their clarity with regard to night-setting requirements.

8.27 The Working Group recommended that:

- (i) The general requirement for night setting in CM 25-02 should be removed and replaced with specific night-setting requirements where necessary in CMs 41-02 to 41-11.

The Working Group noted that this revision would remove the need for vessels to meet the requirements of CM 24-02 for daytime setting in CMs 41-02 to 41-11 and in any area where night-time setting is required, this will need to be included in the relevant conservation measure.

- (ii) Vessels using gear types not included in CM 24-02 should be required to demonstrate gear sink rates of 0.3 m/s or greater using the methods set out in CM 24-02.

- (iii) To simplify this process, the Secretariat will enhance the 'gear library' to include validated sink-rate data for each gear type recorded.

- (iv) To facilitate these changes, when vessels notify their intention to fish, they will be required to describe their gear type and confirm that it meets the requirement of CM 25-02. Where a vessel intends to use gear not currently specified in CM 25-02, it should provide documentation which indicates that this gear will meet the minimum sink rates set out in CM 24-02.

8.28 The Working Group noted that these changes will necessitate alterations to CMs 41-02 to 41-11 and are an opportunity to increase the clarity of these conservation measures with regard to night-setting requirements.

## Marine debris

8.29 Data on surveys of beached debris, marine debris associated with seabird colonies, marine mammal entanglements and hydrocarbon soiling of seabirds (WG-FSA-14/68) were presented by the Secretariat. The Working Group noted that the types of marine debris collected have remained fairly constant over time, and although marine mammal entanglement has declined since records were first collected, over the last decade numbers have remained static. Members are requested to also provide additional data sets from other sites for comparison with the limited number of CCAMLR sites.

## Biology, ecology and interactions in fish-based ecosystems

9.1 Fifteen papers were submitted for consideration by the Working Group under this agenda item. They dealt with *D. mawsoni* (6), *D. eleginoides* (2), surveys (2), macrourids (2) and rajiformes (3). In addition, one paper from WG-EMM-14 was presented.

9.2 The Working Group noted that a fish identification guide for the Ross Sea has been developed by New Zealand and hard copies are available from the Secretariat. Electronic copies have been made available to the Secretariat for use by Members.

### *Dissostichus mawsoni*

9.3 WG-FSA-14/02 provided detailed information on the reproduction of *D. mawsoni* collected from around the Antarctic continent. Reproductive parameters such as gonadosomatic index (GSI) and absolute and relative fecundity were remarkably similar in all areas. Larger fish tend to live in deeper water and were in more advanced stages of gonad development than smaller fish. The similar reproductive state of fish in all areas indicated that spawning takes place in all areas at about the same time of the year. Relative fecundity was comparable to its congener *D. eleginoides*.

9.4 WG-FSA-14/15 described the technique utilised in VNIRO (Moscow) to prepare otoliths for age reading and how annular structures on polished otolith sections are interpreted. The method used appears to underestimate age of fish by up to 4 or 5 years. The paper noted that it seems unlikely that fish grow up to 50 cm in the first two years while the congener *D. eleginoides* grows at most 10 cm per year (Evseenko et al., 1995). Observations on pelagic juveniles suggest that the pelagic phase is similar to that of *D. eleginoides* (Yukhov, 1970, 1971). Resulting values of  $L_{\infty}$  and  $K$  are comparable to those obtained by other age readers.

9.5 The Working Group recommended that comparative age readings between labs should be continued to verify age readings.

9.6 WG-FSA-14/53 described results of a New Zealand–Russia experiment of comparative age reading for *D. mawsoni*. The resulting four-way comparison enabled differences in preparation method to be distinguished from differences in interpretation of otolith banding patterns. Results suggest broad agreement in ages determined by each reader and with each method. However, there remained enough inconsistency in preparation technique and in interpretation of the break and burn preparation method to warrant further coordination and comparisons before merging data. The Working Group noted that the experiment highlighted the importance of monitoring and comparing ageing protocols within and between fish ageing programs.

9.7 The paper recommended four criteria to determine if significant differences existed between the readings compared for Antarctic toothfish. These were a paired  $t$ -test of the differences in age readings, no more than 25% of comparisons being greater than two years apart, a linear regression slope of the age bias plot statistically equal to 1 and an overall CV of less than 10%. The Working Group agreed that it is important to monitor for consistency and age drift in generating age data.

9.8 The Working Group stressed the importance of these inter-calibration experiments in order to identify the most reliable method of ageing and develop more precise age estimates as one of the bases for assessments. It encouraged New Zealand and Russia to continue and expand such experiments.

9.9 The Working Group noted that the Republic of Korea was actively collaborating with New Zealand to develop its *D. mawsoni* ageing program and looked forward to further analysis of age composition from its research program.

9.10 WG-FSA-14/64 reported on the retrieval of an archival tag on *D. mawsoni* deployed in the Ross Sea in January 2013 and recovered 335 days later on 24 December 2013, providing data (temperature, depth, acceleration and magnetic field strength) archived at 10-minute intervals. Summaries of raw data show contrasting patterns in the variables throughout the time series, with several periods containing distinct behavioural profiles suggesting significant activity throughout the winter period. Current efforts focus on developing a Bayesian modelling approach to fit the most likely movements of the tagged fish during its time at liberty based on the environmental variables recorded by the tag compared with spatial environmental data.

9.11 Similar data as those recorded from toothfish are also recorded from elephant seals, which conduct long-term migrations from sub-Antarctic islands to the Antarctic continent and back. The Working Group suggested that the analytical processes to analyse the elephant seal data may be applicable to the similar data types recorded by the toothfish tags.

9.12 The Working Group noted that a number of nations were considering deploying archival tags and recommended international collaboration on that topic.

### *Dissostichus eleginoides*

9.13 WG-FSA-14/49 and 14/50 presented analyses of data gained from tagging *D. eleginoides* in Subareas 48.3 and 48.4 respectively, including spatial movements and regional connectivity. Information on the tagging procedure, biology, growth and local movement had been presented in WG-SAM-14/35. The characterisation of tag-recapture data shows that the tagging program has been successful in providing substantial information for the stock assessment. It can provide a first indication of areas of particular biological interest, such as potential spawning and nursery grounds. It also showed evidence for movement between the South Sandwich Islands and South Georgia and hypothesised that *D. eleginoides* in the South Sandwich Islands may be a non-spawning portion of the population living around South Georgia (no gonad maturation has been observed in these fish). The Working Group agreed that while there is uncertainty in the stock structure of toothfish in this area, the approach of managing fish in each area separately is considered precautionary.

9.14 Analysis of catch data from a deepwater trawl survey conducted at South Georgia and Shag Rocks in 2003 indicated that depth and region have a marked influence over demersal fish assemblage structure (WG-FSA-10/26). Three distinct depth-stratified fish assemblages were identified. The demersal fish assemblage found on the shelf to depths of around 400 m is dominated by nototheniids and channichthyids. It is comprised largely of species endemic to the Southern Ocean. At increasing depths (400–600 m), diversity increases with the presence

of many benthopelagic species. Below 600 m, the demersal fish community is dominated by gadiform fishes, including members of the Macrouridae and Moridae families and endemism was reduced compared with shallower areas. Clear regional differences in the shelf assemblage are apparent with differences observed between South Georgia and Shag Rocks to depths of around 400 m. The biogeographic patterns observed in demersal fishes show similar trends to those seen in a range of other taxa, such as crustaceans.

## Surveys

9.15 WG-FSA-14/07 reported on results from three surveys conducted in the northern part of the Kerguelen Plateau (POKER 1, 2006; POKER 2, 2010; POKER 3, 2013) with the chartered trawler FV *Austral* repeating the same 202 random and stratified sampling stations in the bathymetric range 100–1 000 m. Estimated fish biomass ranged from 247 000 to 268 000 tonnes for a bottom area of about 183 000 km<sup>2</sup>. *Dissostichus eleginoides* was the dominant species, with up to 40% of the total biomass in the depth range 100–1 000 m. Juvenile individuals of up to 60 cm occur primarily in the 100–500 m depth range, where commercial fishing is prohibited. Other species (*Notothenia rossii*, *C. rhinoceratus*, *Zanclorhynchus spinifer*, *L. squamifrons*, *C. gunnari*, *B. eatonii*) formed the bulk of the remaining biomass. Previously overexploited species, such as *N. rossii* and *C. gunnari*, show clear and recent strong recovery. The drivers of changes in biomass of unexploited species (i.e. *C. rhinoceratus*), unrelated to fishery impacts, remain unclear. The Working Group noted that the study was rare in that it analysed all the fish species encountered in a large surveyed area in the Southern Ocean.

9.16 The paper noted a strong recovery of *N. rossii* in the last decade resulting in hauls up to 20 tonnes/15 min during the surveys. The recovery paralleled the recovery of *N. rossii* at South Georgia which was apparent from regular surveys by the UK during the last decade.

9.17 The importance of the depths shallower than 500 m was stressed as a nursery ground for juvenile *D. eleginoides*, which appears to be similar at South Georgia and Kerguelen Islands.

9.18 Changes have occurred over the last two to three decades, such as the recovery of stocks of species such as *N. rossii* and *C. gunnari* (at different time scales) and the substantial increase in the number of fur seals at South Georgia. The Working Group noted that extensive surveys, such as the POKER survey series, may help to inform the processes and time frames required for the recovery of particular species and may be informative to the Commission in meeting its objectives under Article II of the Convention.

9.19 The Working Group recommended that detailed descriptions of the trawl configurations and standard survey procedures be submitted to the CCAMLR gear library, which so far only holds descriptions of longline gear used in the Convention Area.

## Macrourids

9.20 Automated acoustic analysis methods were developed (WG-FSA-14/62) to estimate grenadier distribution and abundance in parts of the Ross Sea based on single echo

identification and tracking. Trials using data from SSRU 881I showed positive correlations between acoustic targets and longline catches of grenadiers and toothfish. Single targets revealed consistent spatial patterns in density and in height off the bottom. The acoustic target strength distribution of single targets was similar to that predicted, based on the expected size range of grenadiers. Variability in spatial coverage between years meant that it was not possible to obtain a consistent time series of relative abundance estimates for grenadiers from acoustic data collected opportunistically by New Zealand vessels in SSRU 881I. The next step in the development will be to apply these methods to data spanning the Ross Sea region. The Working Group noted that increased coverage could be achieved if other vessels recorded such data.

9.21 Two species of grenadier are predominantly taken as by-catch in the Ross Sea region, *M. whitsoni* and *M. caml* (WG-FSA-14/62). A linear function of fish total length (cm), depth of the whole otolith (depth, mm) and maximum cross-sectional area of the otolith (area, mm<sup>2</sup>) gave 92% discrimination between the two species. This work suggested that historic otolith collections may be used to examine the ratio of the two species in the catch from previous years where most macrourids were identified as *M. whitsoni*. The Working Group noted that it may also be possible to use DNA collected from various tissues, including otoliths, to retrospectively determine species.

#### Rajiformes

9.22 WG-FSA-14/33 provided suggestions for updating the maturity keys used by CCAMLR for skates. Currently, CCAMLR observers use a three-stage maturity key (immature, maturing and mature). Reproductively active stages are not recorded separately, but such data can be useful in identifying areas important for reproduction. The inclusion of a fourth stage ('active') in the maturity scale would allow such data to be collected. It was also indicated that the current scale has potential ambiguity between 'maturing' and 'mature' stages, which could be resolved by replacing 'maturing' with 'developing'.

9.23 The Working Group did not consider that the skate maturity scales used in the *Scientific Observers Manual* should be changed at the present time. The Working Group noted that improved user-friendly maturity keys could usefully be developed and that modifications to maturity keys should be introduced only after appropriate supporting information and training is available. The Working Group suggested that photographic maturity keys could be developed intersessionally (see paragraph 8.27).

#### Modelling approaches

9.24 WG-EMM-14/51 described the development of a spatially explicit minimum realistic model of demersal fish population dynamics, predator-prey interactions and fishery removals based on the spatial population model (SPM) for toothfish in the Ross Sea. The model includes *D. mawsoni* as well as macrourids and channichthyids, the two groups that make up ~50% of *D. mawsoni* prey. The model indicates that channichthyids, with a relatively high productivity, would be expected to substantially increase in abundance within fished locations

as predation pressure by toothfish is decreased, particularly in SSRU 881H where historical fishery removals have been most concentrated. Macrourids would be expected to show a modest increase in biomass.

9.25 The Working Group noted that WG-EMM-14/51 was discussed by WG-EMM-14 with recommendations in Annex 6, paragraphs 2.97 to 2.100 and 5.22. The Working Group endorsed the recommendations from WG-EMM. It further noted that CCAMLR currently has no framework to manage large changes in abundance of non-target species due to the effects of fishing on other ecosystem components. The Working Group recommended that the Scientific Committee consider future work items to include a consideration for how these types of potential effects could be monitored, evaluated and managed.

## **Future work**

### Steepness and stock-recruit relationship

10.1 The Working Group considered the analyses presented in WG-FSA-14/32 and 14/P05 on the importance to stock assessments of assumptions about the productivity of a stock (as reflected in the steepness parameter in stock-recruitment relationships), yet the sensitivity of the outcomes of stock assessments to these assumptions was rarely tested.

10.2 The Working Group noted that in the hypothetical distribution of steepness parameters, based on expected life-history characteristics presented in WG-FSA-14/P05, most estimates were higher than 0.75, the value used in toothfish assessments, and therefore CCAMLR was likely to be using a conservative steepness parameter.

10.3 The Working Group agreed that while a change in the steepness parameter would not have a large impact on the historical stock status it would influence projections of yield into the future and that it was important to periodically review information about stock status and productivity to ensure that the assumptions are consistent with the ecosystem-based approach adopted by CCAMLR. Members were encouraged to present analyses of the influence of productivity on toothfish stock assessments, in particular on the influence of density-dependent mortality and the influence of assumptions about stock-status and stock-recruit relationships in the projection of yields used by CCAMLR to WG-SAM-15.

### External review of assessments

10.4 The Working Group recalled discussion last year on the desire for periodic external review of CCAMLR assessments and endorsed the recommendations of WG-SAM (Annex 5, paragraphs 2.31 to 2.33) on the adoption of an assessment benchmarking process similar to the one used by ICES. For a biennial assessment, such a review would take place early in a non-assessment year in order that the outcomes of the review could be considered by WG-SAM and recommendations agreed by the Scientific Committee for the assessment in the following year.

## Communication of the work of WG-FSA

10.5 The Working Group noted that the amount and complexity of information considered at its meetings meant that there was a need to find a mechanism for increasing engagement and understanding of the work of WG-FSA and CCAMLR in general and requested that the Scientific Committee give consideration to how this might be addressed.

10.6 The Working Group discussed the development of a 'data dashboard' that could be used to summarise information about CCAMLR fisheries and associated management advice and provide this in an interactive format using the CCAMLR website.

## Prioritisation of future work

10.7 The Working Group agreed that next year there would be a particularly heavy workload, including the biennial assessments and the review of research programs in data-poor exploratory fisheries, and requested that the Scientific Committee consider how this workload could be effectively managed. This includes a process to develop a more efficient prioritisation and allocation of tasks to the respective agendas of WG-SAM and WG-FSA.

10.8 The Working Group noted the following priorities for its work related to:

- (i) tagging programs – including the history of tagging, movement of tagged fish, the degree of spatial overlap of the fishery with tagged fish and the need to determine how to incorporate these data into new assessments. The Working Group suggested a focused workshop might be an appropriate mechanism to progress such a complex topic
- (ii) research reviews – there are a number of multiyear research programs that will require review after 3 years in 2015 (paragraphs 5.23 and 5.106)
- (iii) preparation of data for input into CASAL assessments (paragraph 5.87)
- (iv) advice on the use of mark-recapture estimators.

## CASAL course

10.9 The Working Group noted that a CASAL course had taken place at the CCAMLR Secretariat prior to the meeting of WG-FSA (SC-CAMLR-XXXII, Annex 6, paragraph 11.1, SC CIRCs 14/41 and 14/46) and had been attended by a total of 12 participants from Chile/Australia, Japan, Republic of Korea, New Zealand, Spain, UK, USA and the Secretariat. All participants of the course agreed that the course had helped them make substantial progress in understanding the assessment process using CASAL.

10.10 The Working Group extended its thanks to Dr A. Dunn (New Zealand) for running the course (and to NIWA for making his time available) and agreed that similar courses, potentially focusing on the preparation of data for input into CASAL, would be helpful in increasing capacity in fishery assessments in CCAMLR.

## Advice to the Scientific Committee and its working groups

11.1 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.

11.2 The Working Group provided advice to the Scientific Committee and other working groups on the following topics:

- (i) Information requirements –
  - (a) quarantined data (paragraph 3.8, see also paragraph 7.7)
  - (b) evaluation of fishery notifications (paragraphs 5.6 and 5.10)
  - (c) vessel sightings (paragraph 3.14)
  - (d) tag overlap statistic (paragraphs 3.25 and 3.26).
- (ii) Assessed fisheries –
  - (a) *C. gunnari* in Subarea 48.3 (paragraph 4.45)
  - (b) *C. gunnari* in Division 58.5.1 (paragraph 4.49)
  - (c) *C. gunnari* in Division 58.5.2 (paragraph 4.54)
  - (d) *D. eleginoides* in Subarea 48.3 (paragraph 4.2)
  - (e) *Dissostichus* spp. in Subarea 48.4 (paragraphs 4.8 to 4.11)
  - (f) *D. eleginoides* in Division 58.5.1 (paragraph 4.37)
  - (g) *D. eleginoides* in Division 58.5.2 (paragraph 4.32)
  - (h) *D. eleginoides* at Crozet Islands (paragraph 4.41)
  - (i) *D. eleginoides* at Prince Edward and Marion Islands (no advice)
  - (j) *Dissostichus* spp. in Subarea 88.1 (paragraph 5.13)
  - (k) *Dissostichus* spp. in Subarea 88.2 SSRU 882C–G (paragraphs 5.41 to 5.44)
  - (l) *Dissostichus* spp. in Subarea 88.2 SSRU 882H (paragraph 5.32).
- (iii) Data-poor fisheries for *Dissostichus* spp. –
  - (a) development and revision of research plans (paragraphs 5.60, 5.105, 5.106 and 5.130)
  - (b) by-catch in research blocks (paragraph 5.94)

- (c) research catch limits for *Dissostichus* spp. (paragraphs 5.23, 5.88, 5.92, 5.98, 5.110, 5.112, 5.118, 5.119, 5.129 and Table 5).
- (iv) Research fishing in other areas –
  - (a) *Dissostichus* spp. in Subarea 48.2 (paragraph 5.48)
  - (b) *Dissostichus* spp. in Subarea 48.5 (no advice)
  - (c) *Dissostichus* spp. in Divisions 58.4.4a and 58.4.4b (paragraph 5.88 and Table 5).
- (v) Scheme of International Scientific Observation –
  - (a) recommendations from the SISO review (paragraph 7.7)
  - (b) utility of observer data from vessels where fishery data have been quarantined (paragraph 7.7).
- (vi) By-catch –
  - (a) intersessional work on skates (paragraph 8.18)
  - (b) requirements for night setting and longline sink rates (paragraph 8.27).
- (vii) Other matters –
  - (a) submission of trawl configurations and survey procedures to the gear library (paragraph 9.19)
  - (b) development of spatially explicit minimum realistic models (paragraph 9.25)
  - (c) communicating the work of WG-FSA (paragraph 10.5).
- (viii) Future work –
  - (a) priorities for future work (paragraph 10.7).

## **Adoption of the report**

12.1 The report of the meeting was adopted.

## **Close of meeting**

13.1 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 issues. He also thanked the rapporteurs and the Secretariat for their support to the work of WG-FSA.

13.2 On behalf of the Working Group, Drs Ellis and Reid thanked Dr Belchier for his leadership in steering the Working Group through a large, and at times challenging, work program.

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Table 1: Total reported catches (tonnes) of target species in fisheries in the Convention Area in 2013/14 (to 20 September 2014 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	
<i>Champscephalus gunnari</i>	48.3	42-01	4 635	4	<1
	58.5.2	42-02	1 267	1 123	89
<i>Dissostichus eleginoides</i>	48.3	41-02	2 400	2 180	91
	48.4	41-03	45	44	98
	58.5.1 French EEZ <sup>a</sup>	n/a	5 100	3 017	-
	58.5.2	41-08	2 730	1 909	70
	58.6 French EEZ <sup>a</sup>	n/a	700	401	57
	58 South African EEZ <sup>b</sup>	n/a	450	178	40
<i>Dissostichus mawsoni</i>	48.4	41-03	24	24	100
<i>Dissostichus</i> spp.	48.6	41-04	538	154	59
	58.4.1	41-11	724	101	29
	58.4.2	41-05	35	no fishing	-
	58.4.3a	41-06	32	32	100
	58.4.3b	41-07	0	no fishing	-
	88.1	41-09	3 001 <sup>c</sup>	2 900	97
	88.2	41-10	390	426	109
<i>Euphausia superba</i>	48.1, 48.2, 48.3, 48.4	51-01	620 000	291 370	47
	58.4.1	51-02	440 000	no fishing	-
	58.4.2	51-03	452 000	no fishing	-

<sup>a</sup> Reported in fine-scale data to July 2014.

<sup>b</sup> Whole EEZ.

<sup>c</sup> Excluding the limit and catch from the research survey.

n/a Not specified by CCAMLR.

Table 2: Landings of *Dissostichus eleginoides* (estimated live weight) reported in Catch Documentation Scheme (CDS) fisheries operating outside the Convention Area in the calendar years 2012 to 2014 (to September 2014; refer to the *Statistical Bulletin* for previous years).

Ocean sector	FAO area	Estimated live weight (tonnes)		
		2012	2013	2014
Southwest Atlantic	41	7 579	8 004	4 942
Southeast Atlantic	47	126	60	26
Western Indian	51	298	324	77
Eastern Indian	57	-	-	-
Southwest Pacific	81	377	423	424
Southeast Pacific	87	5 685	4 211	1 998
Total		14 066	13 021	7 467

Table 3: Notifications for exploratory fisheries for *Dissostichus* spp. in 2014/15.

Vessel name	Member	Subarea 88.1	Subarea 88.2	Division 58.4.3a	Subarea 48.6	Division 58.4.1	Division 58.4.2
<i>Antarctic Chieftain</i>	Australia	N	N				
<i>St André</i>	France			N			
<i>Shinsei Maru No. 3</i>	Japan	N		N	N	N	N
<i>Kingstar</i>	Korea, Republic of				N	N	N
<i>Hong Jin No. 701</i>	Korea, Republic of	N	N				
<i>Kostar</i>	Korea, Republic of	N	N				
<i>Sunstar</i>	Korea, Republic of	N	N				
<i>San Aspiring</i>	New Zealand	N	N				
<i>Janas</i>	New Zealand	N	N				
<i>San Aotea II</i>	New Zealand	N	N				
<i>Seljevaer</i>	Norway	N	N		W	W	
<i>Mys Marii</i>	Russia	N	N				
<i>Palmer</i>	Russia	N	N				
<i>Yantar 31</i>	Russia	N	N				
<i>Yantar 35</i>	Russia	N	N				
<i>Sparta</i>	Russia	W	W				
<i>Ugulan</i>	Russia	W	W				
<i>Yantar 33</i>	Russia	N	N				
<i>Tarpon</i>	Russia	W	W				
<i>Tomkod</i>	Russia	W	W				
<i>Koryo Maru No. 11</i>	South Africa				N		
<i>Tronio</i>	Spain	N	N			N	N
<i>Simeiz</i>	Ukraine	N	N				
<i>Koreiz</i>	Ukraine	W	W				
<i>Polus 1</i>	Ukraine	N	N				
<i>Argos Froyanes</i>	United Kingdom	N	N				
<i>Argos Georgia</i>	United Kingdom	N	N				
Total Members		9	8	2	4	4	3
Total vessels		24	23	2	4	4	3
Total fished							
Total withdrawn		5	5		1	1	

Legend: N = notified  
W = withdrawn  
F = fished

Table 4: Latitude and longitude (dd.00) of the corner coordinates of the areas shown in Figure 7.

Area	Latitude	Longitude
1	73.8°S	108.0°W
	73.8°S	105.0°W
	75.0°S	105.0°W
	75.0°S	108.0°W
2	73.3°S	119.0°W
	73.3°S	111.5°W
	74.2°S	111.5°W
	74.2°S	119.0°W
3	72.2°S	122.0°W
	70.8°S	115.0°W
	71.7°S	115.0°W
	73.2°S	122.0°W
4	72.6°S	140.0°W
	72.6°S	128.0°W
	74.7°S	128.0°W
	74.7°S	140.0°W

Table 5: Local biomass estimation methods and recommended research catch limits (from SC-CAMLR-XXXII, Annex 6, Table 13) for *Dissostichus eleginoides* (TOP) and *D. mawsoni* (TOA) in research blocks, catch reported in 2014, number of tagged fish available and the expected and observed recaptures.

Subarea/ SSRU	Research block	Species	Estimation method	Local biomass (tonnes)	Tagged fish in 2013			Recommended catch limit (tonnes)	Local exploitation rate	Catch in 2014		Tagged fish in 2014			Tagged fish in 2015		
					Available number	Recaptures				(tonne)	% limit	Available number	Recaptures		Available number	Recaptures expected number	
						Expected number	Observed number						Expected number	Observed Number			% expected
<b>Subarea 48.5*</b>																	
<b>Subarea 48.6</b>																	
486AG	486_1 + 486_2	TOP	Petersen	351	257	2.9	3	14	0.040	9	64	366	14.6	1	7	325	13.0
486AG	486_1 + 486_2	TOP	CPUE 484N	697	257	1.5	3	28	0.040	9	32	366	14.7	1	7	325	13.0
486AG	486_2	TOA	CPUE 882H	7221**	947	8.7	6	170	0.023	95	56	1079	26.6	11	41	1006	23.1
486D	486_3	TOA	CPUE 882H	3624	621	8.4	2	50	0.014	50	100	752	10.4	1	10	589	8.3
486E	486_4	TOA	CPUE RSR	2515	343	15.3	0	100–150	0.040–0.060	-	-	743	29.5–44.3			582	23.3–34.9
486BC	486_5	TOA	CPUE RSR	6622	405			190	0.029	-	-	352	10.1			276	8.0
<b>Subarea 58.4</b>																	
5841C	5841_1	TOA	CPUE RSR	3140	131			125	0.040	-	-	114	4.5			89	3.6
5841C	5841_2	TOA	CPUE RSR	2337	687			90	0.039	-	-	598	23.0			663	25.9
5841E	5841_3	TOA	CPUE RSR	7061	259			280	0.040	-	-	226	9.0			177	7.1
5841E	5841_4	TOA	CPUE RSR	930	83			35	0.038	-	-	72	2.7			56	2.1
5841G	5841_5	TOA	CPUE RSR	674	424			26	0.039	-	-	369	14.2			289	11.3
5841C	n/a	TOA	depletion	n/a				42	n/a	54	-						
5841D	n/a	TOA	depletion	n/a				42	n/a	6	-						
5841G	n/a	TOA	depletion	n/a				42	n/a	24	-						
5841H	n/a	TOA	depletion	n/a				42	n/a	17	-						
5842E	5842_1	TOA	CPUE RSR	877	227	1.0	0	35	0.040	-	-	214	8.5			168	6.7
5843aA	5843a_1	TOP	Petersen	386**	349	15.0	11	32	0.083	32	100	318	30.4	24	79	304	25.2
5843aA	5843a_1	TOP	CPUE 484N	2798	349	2.0	11	32	0.011	32	100	318	4.0	24	600	304	3.3
5844bC	5844b_1	TOP	CASAL	705**	215	6.8	3	25	0.035	12	48	216	8.5	5	59	219	7.8
5844bD	5844b_2	TOP	CPUE 5844-C	786**	73	0.8	0	35	0.045	15	43	39	1.6	4	250	93	4.1

\* See discussion in paragraphs 5.61 to 5.83.

\*\* Local biomass updated during WG-FSA-14.

Table 6: The total catch and number of sets for vessels for which the peak of the frequency distribution of CPUE was greater than 0.75 kg/hook (in an analysis of all vessels fishing in the Convention Area (see paragraph 5.70)). The frequency distributions for each vessel are shown in Figure 9.

Season	Management area	Vessel	Catch (tonnes)	N (sets)
1996	58.6	<i>Alida Glacial</i>	10	2
1997	58.6	<i>Alida Glacial</i>	12.64	2
1996	58.7	<i>Alida Glacial</i>	234.87	20
1997	58.7	<i>Alida Glacial</i>	8.48	1
1996	58.6	<i>American Champion</i>	75.48	26
1996	58.7	<i>American Champion</i>	247.66	113
2009	48.6	<i>Insung No. 22*</i>	172.65	20
2011	48.6	<i>Insung No. 7*</i>	43.32	6
1996	58.7	<i>Koryo Maru No. 11</i>	80.45	12
2012	88.1	<i>San Aspiring</i>	474.82	84
2012	58.6	<i>Ship 7</i>	102.18	26
2013	88.2	<i>Sunstar</i>	7.4	2
2012	88.1	<i>Tronio</i>	523.42	47
2006	88.2	<i>Yantar</i>	29.08	3
2013	48.5	<i>Yantar 35</i>	59.53	8
2014	48.5	<i>Yantar 35</i>	228.6	34

\* Data is quarantined.

Table 7: Summary of the number and proportion of sets where the hauling rate was more than 1 fish per minute (fpm) for all autoline vessels fishing in management areas 88.1, 88.2 and 48.5 in 2012–2014.

Vessel	Management area	N (sets)	sets >1fpm	% >1 fpm
<i>Antarctic Chieftain</i>	88.1	36	2	5.6
<i>Antarctic Chieftain</i>	88.2	271	0	0.0
<i>Argos Froyanes</i>	88.1	201	3	1.5
<i>Argos Froyanes</i>	88.2	169	2	1.2
<i>Argos Georgia</i>	88.1	386	21	5.4
<i>Argos Georgia</i>	88.2	12	0	0.0
<i>Janas</i>	88.1	193	2	1.0
<i>Janas</i>	88.2	93	0	0.0
<i>Mys Marii</i>	88.1	23	0	0.0
<i>Palmer</i>	88.1	45	0	0.0
<i>Palmer</i>	88.2	78	0	0.0
<i>San Aotea II</i>	88.1	384	2	0.5
<i>San Aspiring</i>	88.1	241	14	5.8
<i>Seljevaer</i>	88.1	371	11	3.0
<i>Seljevaer</i>	88.2	30	1	3.3
<i>Yantar 31</i>	88.1	239	0	0.0
<i>Yantar 31</i>	88.2	7	3	42.9
<i>Yantar 35</i>	48.5	42	22	52.4
<i>Yantar 35</i>	88.1	106	1	0.9
<i>Yantar 35</i>	88.2	5	0	0.0

Table 8: Taxonomic ranking of skates indicating which higher taxonomic codes should be used when accurate species-specific data cannot be provided. Skates (Order Rajiformes, SRX) are broadly divided into soft-nose skates (Family Arhynchobatidae; Genus *Bathyraja*, BHY) and hard-nose skates (Family Rajidae, RAJ).

Order	Code	Genus or family	Code	Species	Code
Rajiformes	SRX	<i>Bathyraja</i> spp.	BHY	Eaton's skate	BEA
				<i>Bathyraja eatonii</i>	
				Kerguelen sandpaper skate	BYR
				<i>Bathyraja irrasa</i>	
				McCain's skate	BAM
				<i>Bathyraja maccaini</i>	
				Dark-belly skate	BYE
				<i>Bathyraja meridionalis</i>	
				Murray's skate	BMU
		<i>Bathyraja murrayi</i>			
		Rajidae	RAJ	Antarctic starry skate	SRR
				<i>Amblyraja georgiana</i>	
				Antarctic starry skate (variant)	SR2
				<i>Amblyraja georgiana</i> (var)	
				Whiteleg skate	RFA
				<i>Amblyraja taaf</i>	

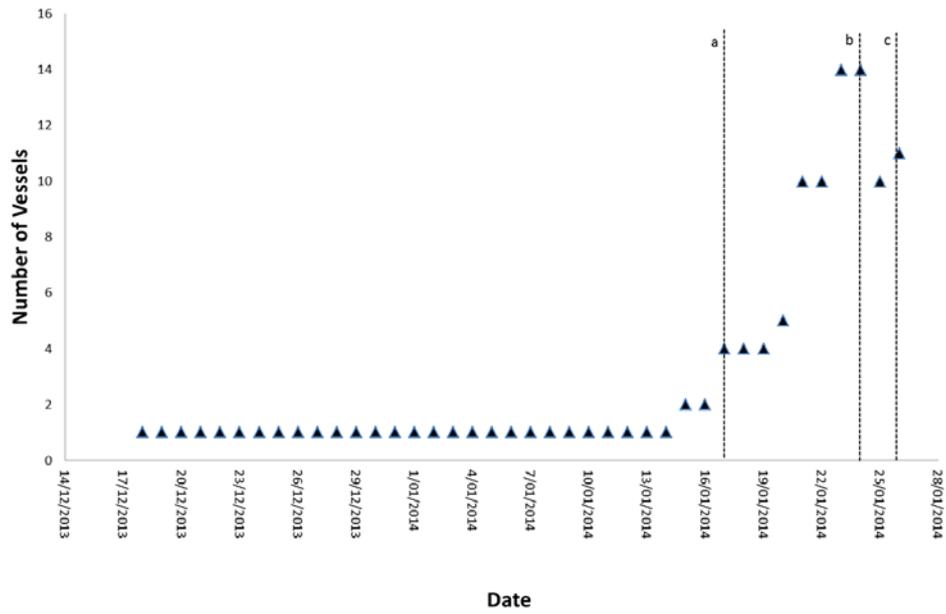


Figure 1: Number of vessels fishing in Subarea 88.2 in 2013/14; the vertical dotted lines indicate the closure dates in: (a) Subarea 88.1 (17 January), (b) SSRU 882H (24 January) and (c) SSRUs 882C–G (26 January).

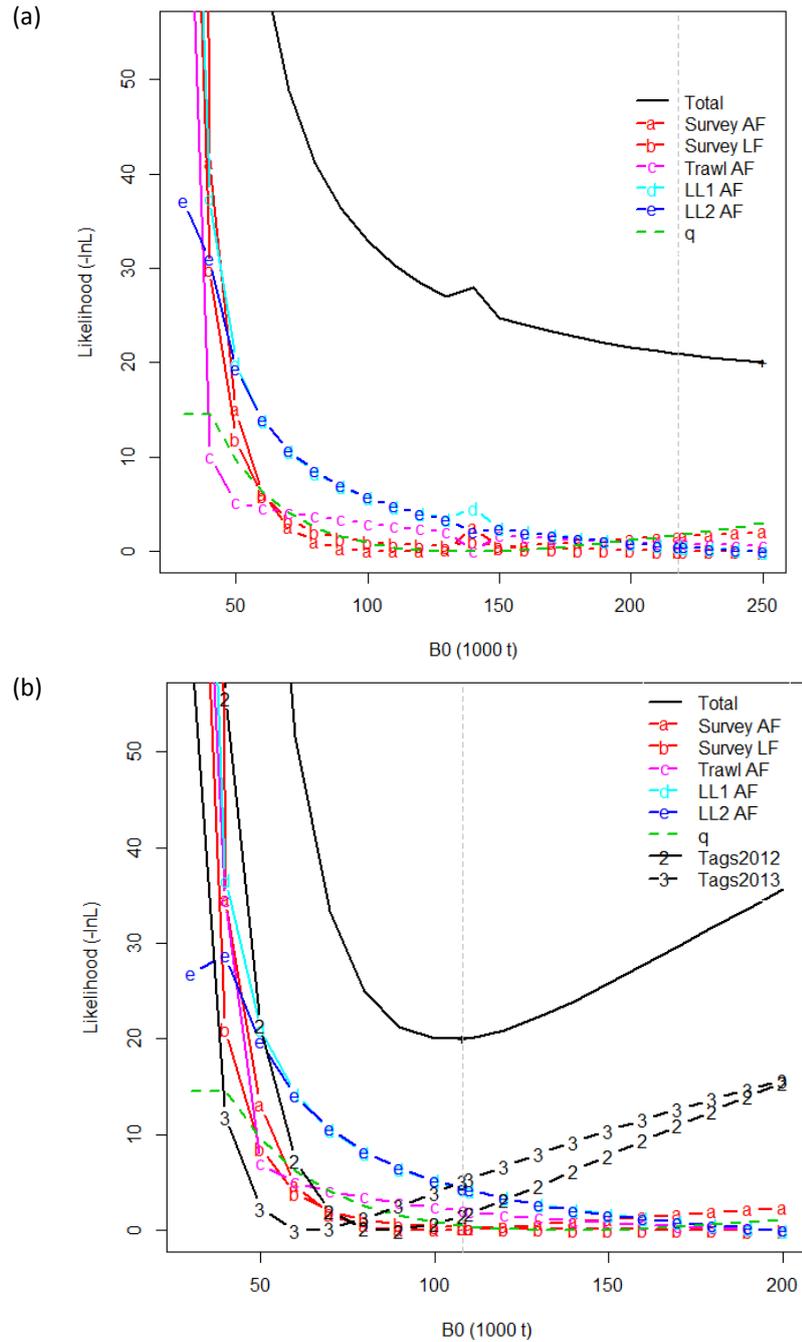


Figure 2: Likelihood profiles ( $-2 \log$ -likelihood) across a range of  $B_0$  values for (a) 'Model 13' (estimated year-class strength (YCS) 1986–2009) and (b) 'Model 14' (estimated YCS 1986–2009 and tag releases 2012 and 2013). Shown are the total objective function (Total) and contributions to the total objective function from survey abundance-at-age (Survey AF), abundance-at-length (Survey LF), trawl catch-at-age (Trawl AF), longline catch-at-age in depths shallower than 1 500 m (LL1 AF) and deeper than 1 500 m (LL2 AF), survey catchability  $q$  ( $q$ ), tag releases in 2012 (Tags 2012) and tag releases in 2013 (Tags 2013). To create these profiles,  $B_0$  values were fixed while the remaining parameters were estimated. Values for each dataset were rescaled to have a minimum of 0, while the total objective function was rescaled to 20. The dotted grey line indicates the MPD estimate.

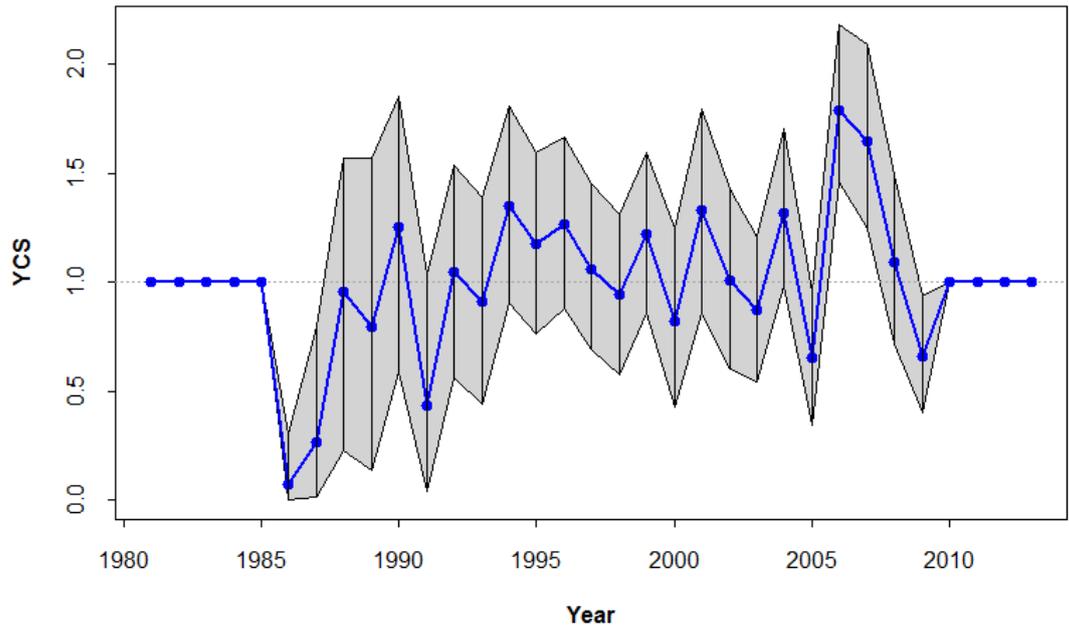


Figure 3: Year-class strength (YCS) estimates (median and 95% CI from MCMC sampling) for 'Model 14' (estimated YCS 1986–2009 and tag releases 2012 and 2013).

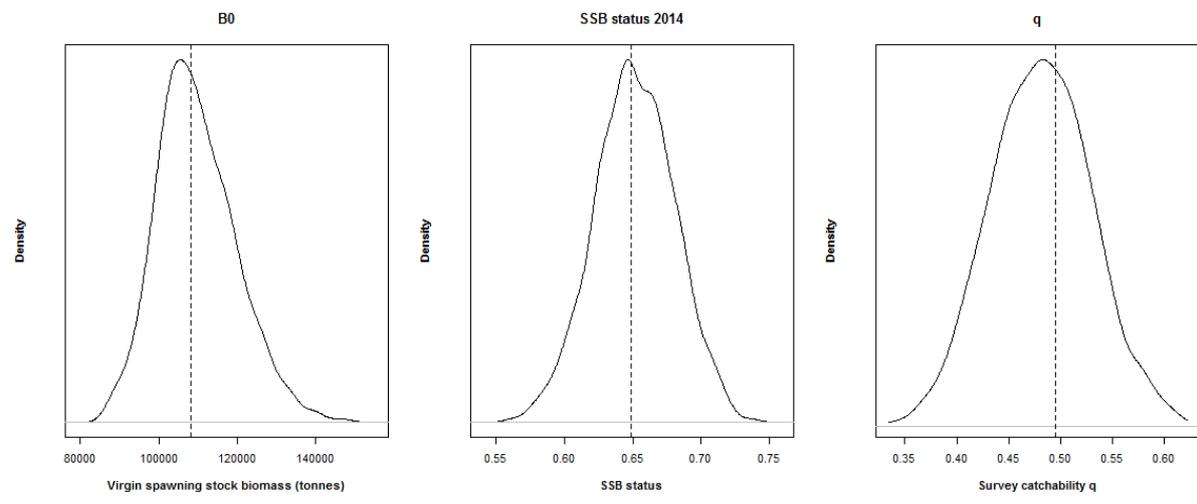


Figure 4: MCMC posterior distribution of  $B_0$ , SSB status in 2014 and survey catchability  $q$  for 'Model 14' (estimated year-class strength (YCS) 1986–2009 and tag releases 2012 and 2013). Vertical line is the MPD estimate.

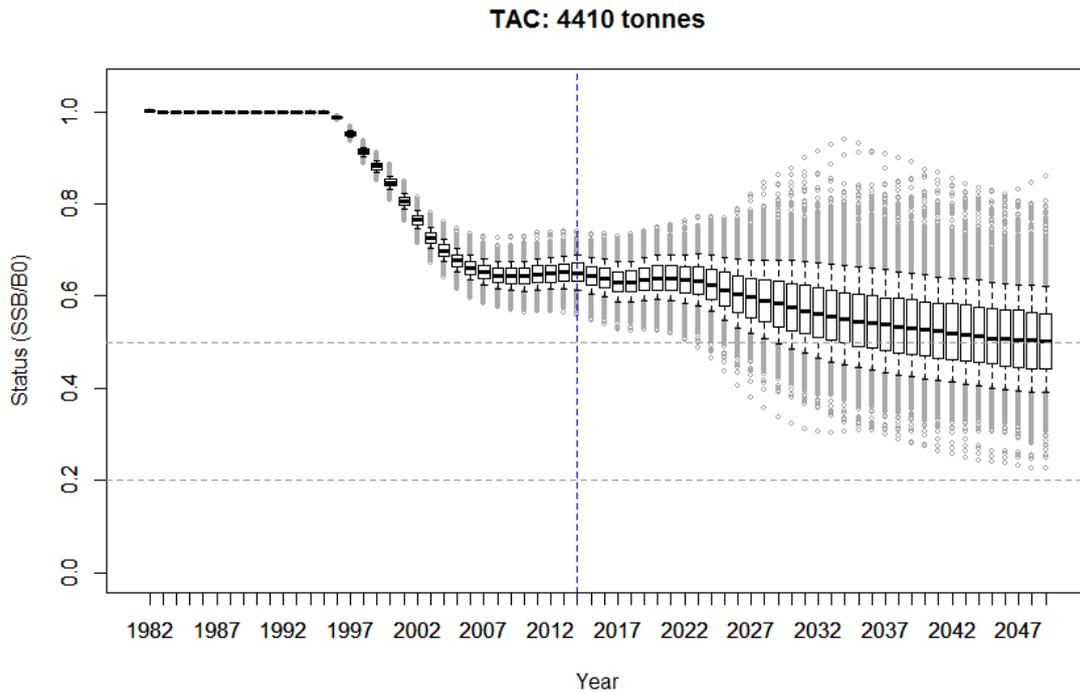


Figure 5: Projected SSB status relative to  $B_0$  for 'Model 14' (estimated year-class strength (YCS) 1986–2009 and tag releases 2012 and 2013) using MCMC samples and random lognormal recruitment from 2011–2049 with annual constant catches. Boxplots represent the distribution of the estimates across 1 000 projection trials. Dotted lines show the 50% and 20% status levels used in the CCAMLR decision rules.

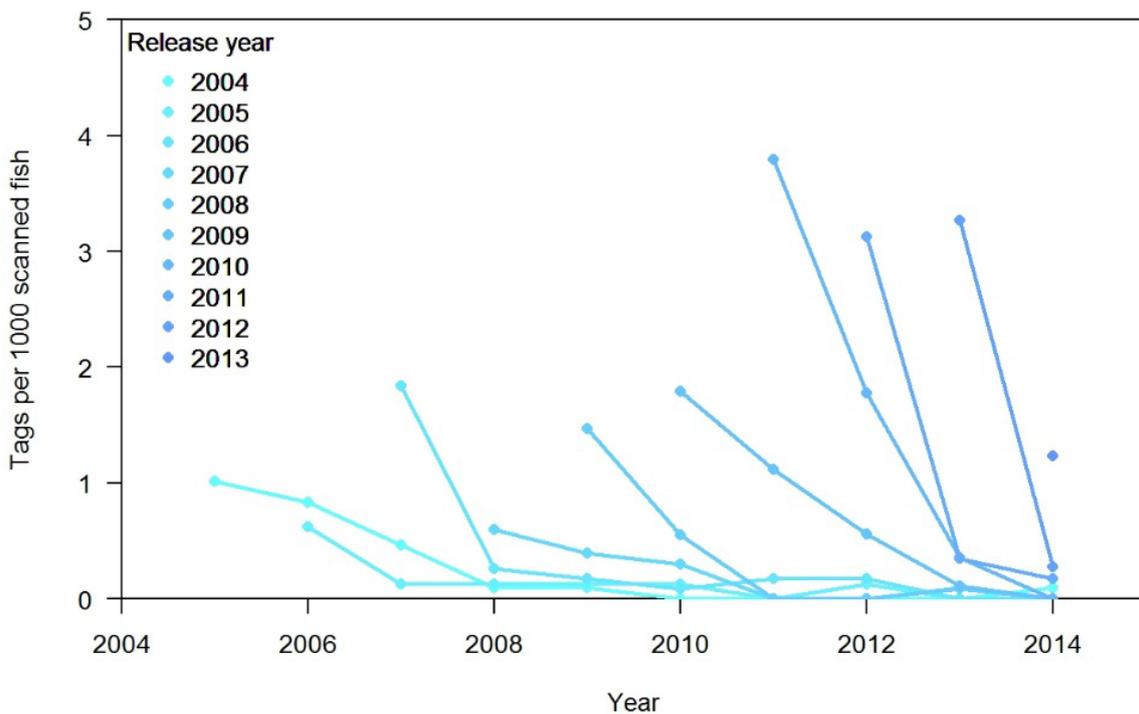


Figure 6: Observed tag-recapture rate for each tag-release cohort (by year, colour) over time in SSRU 882H.

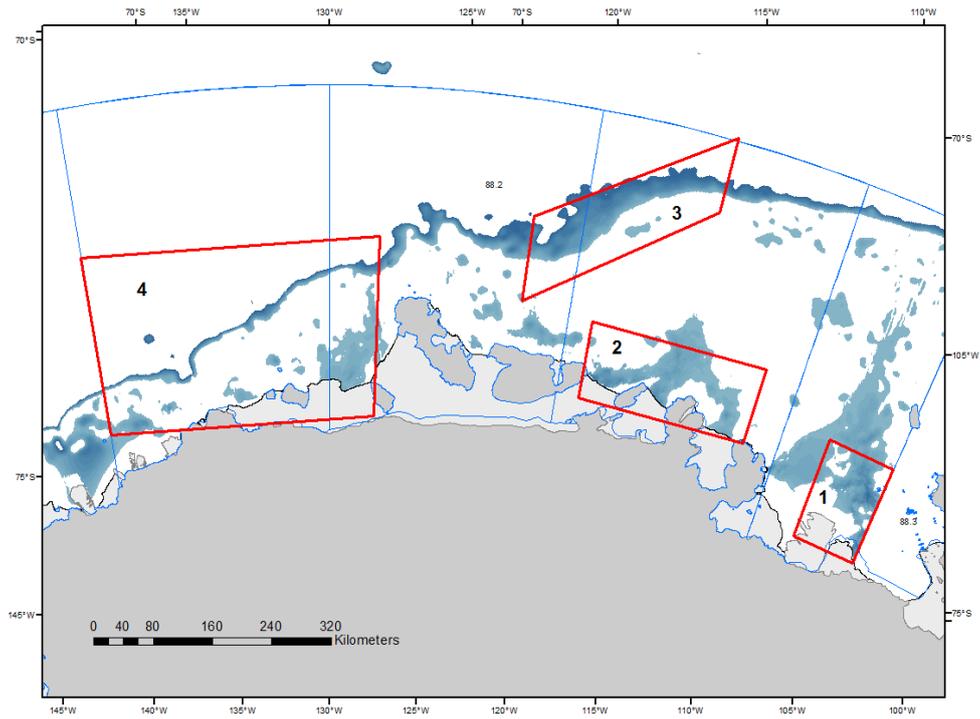


Figure 7: The main fishing grounds (1–4) fished in SSRUs 882C–G since 2006 (WG-FSA-14/59). The depth strata from 600 to 1 800 m are coloured in blue. Coordinates for these polygons are provided in Table 4.

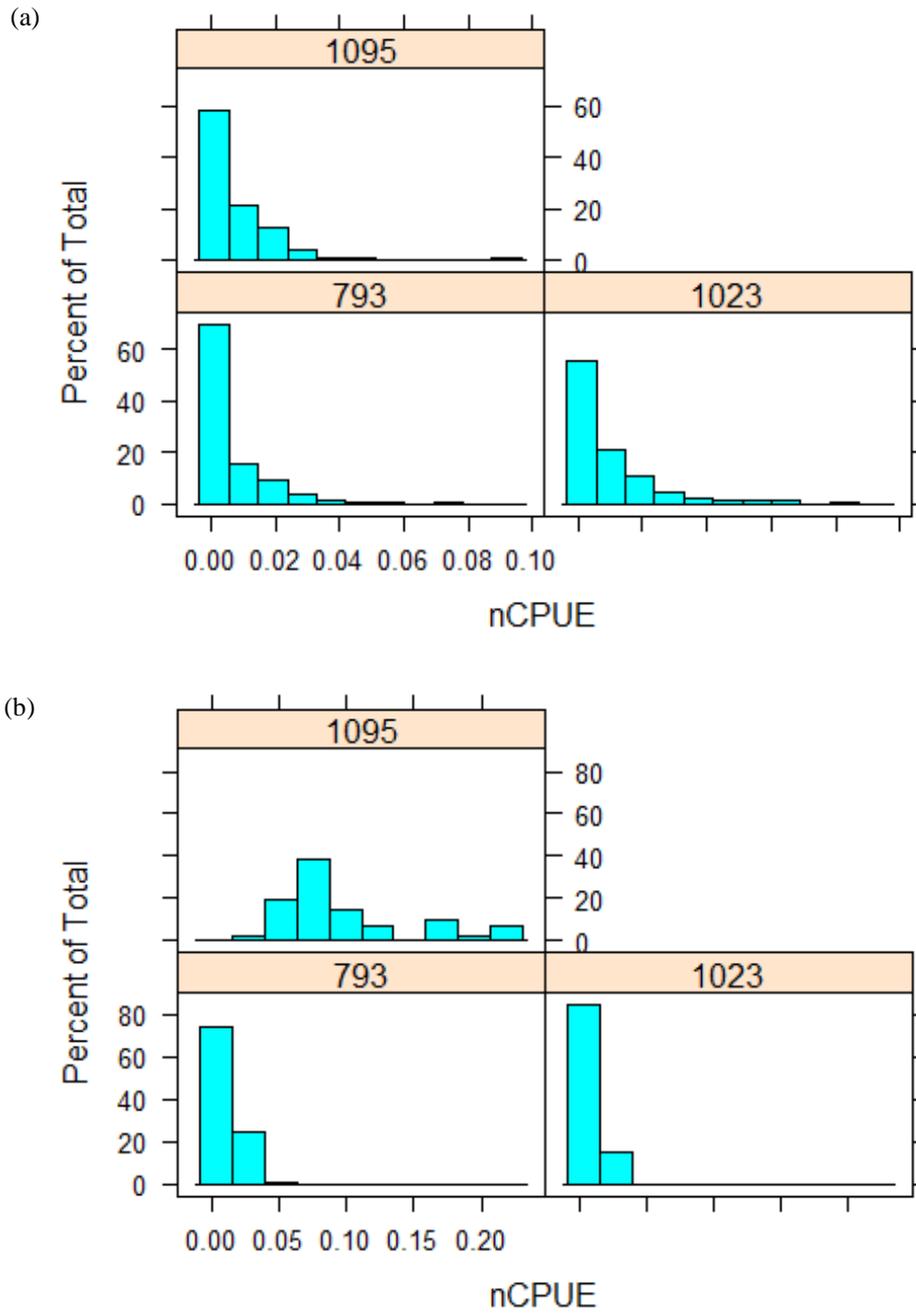


Figure 8: CPUE (numbers of fish per hook) for (a) by-catch and (b) *Dissostichus mawsoni* from the *Koryo Maru No. 11* (1 023) and *Shinsei Maru No. 3* (793) using trotlines in the southern SSRUs in Subarea 48.6 and *Yantar 35* (1 095) in Subarea 48.5 using autolines. These are the only vessels to have fished in those areas.

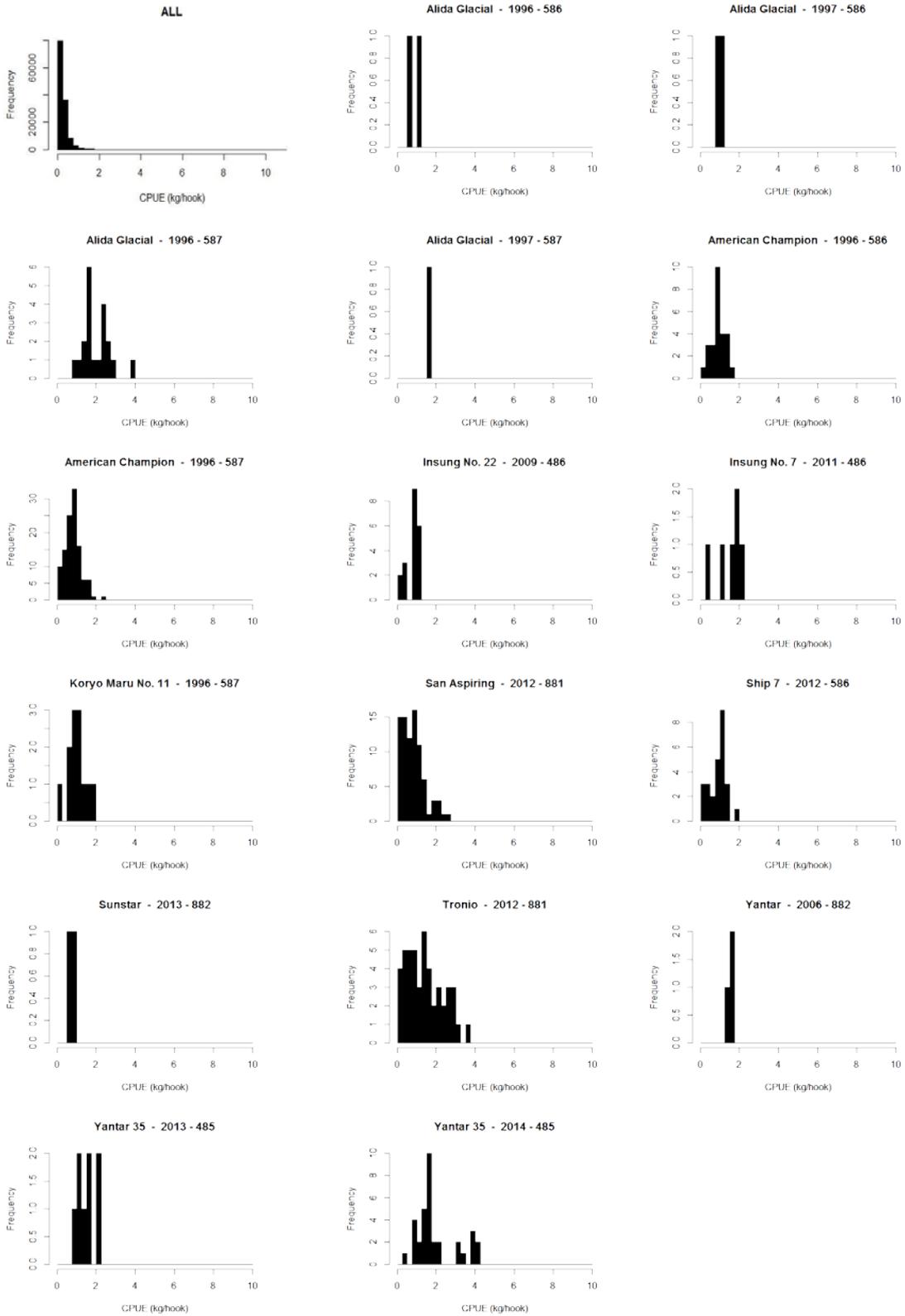


Figure 9: Distribution of CPUE values for sets for longline vessels from Table 6.

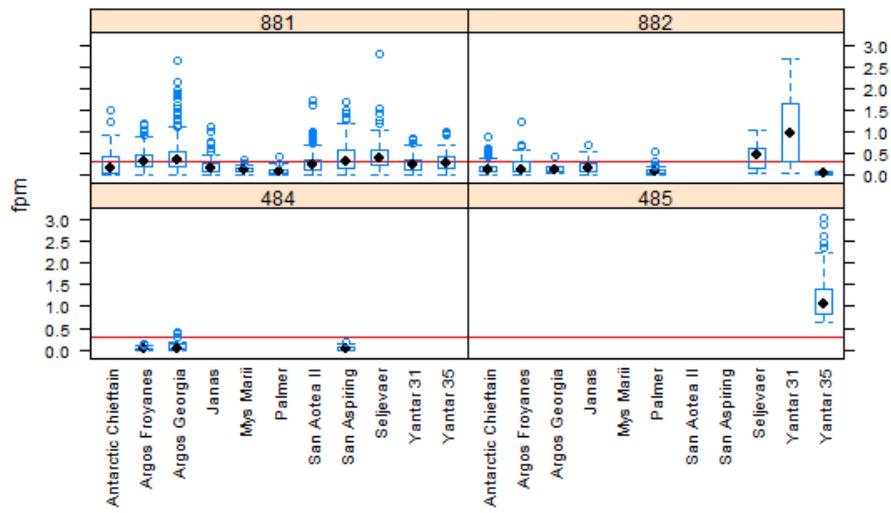


Figure 10: Box-whisker plots of the distribution of hauling rates, fish per minute (fpm), for individual autoline vessels fishing in management areas 88.1, 88.2, 48.4 and 48.5 (2012–2014). The horizontal red line indicates the overall mean for all vessels.

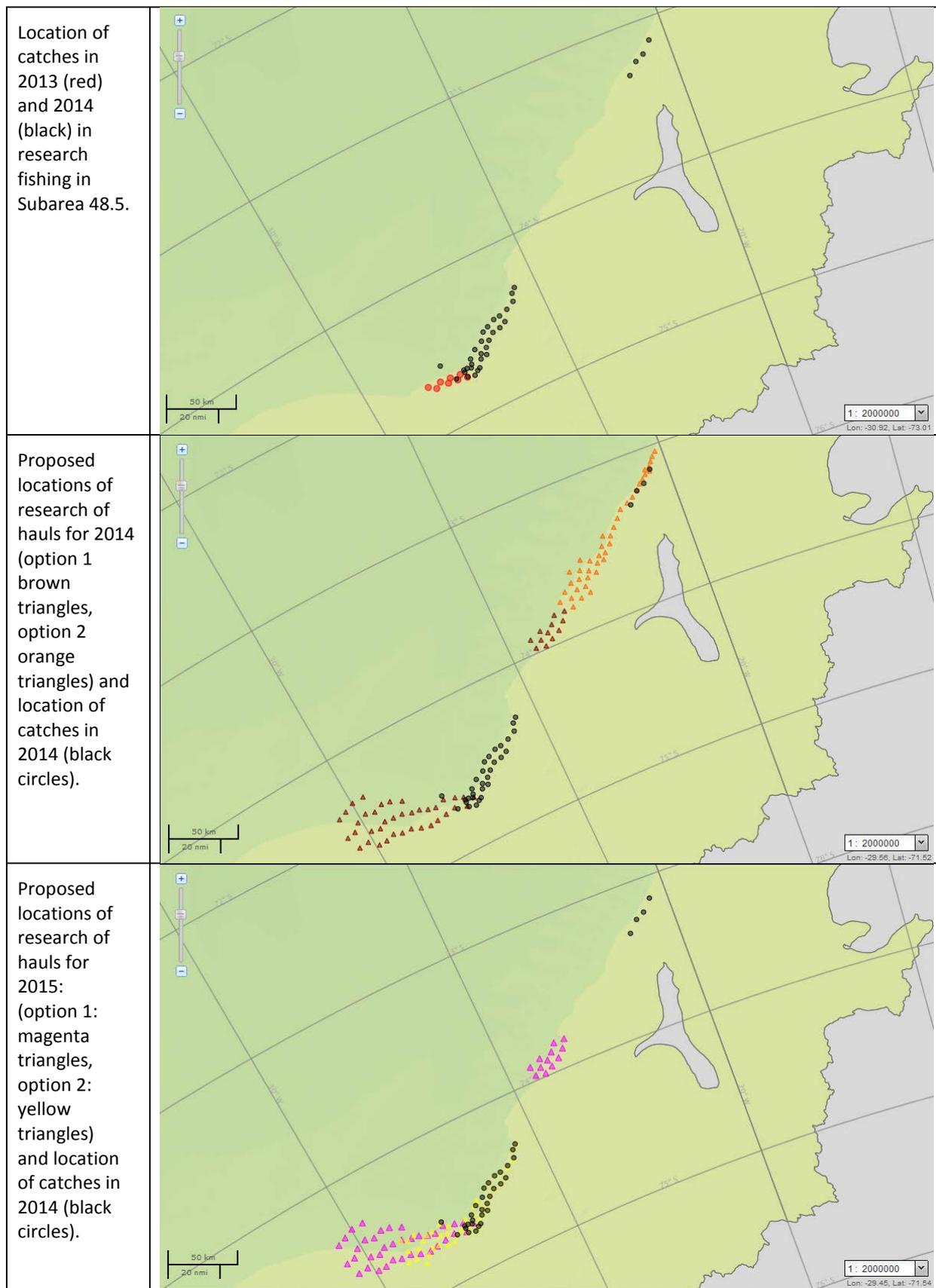


Figure 11: Proposed and actual locations of fishing activities in Subarea 48.5 in 2013, 2014 and 2015.

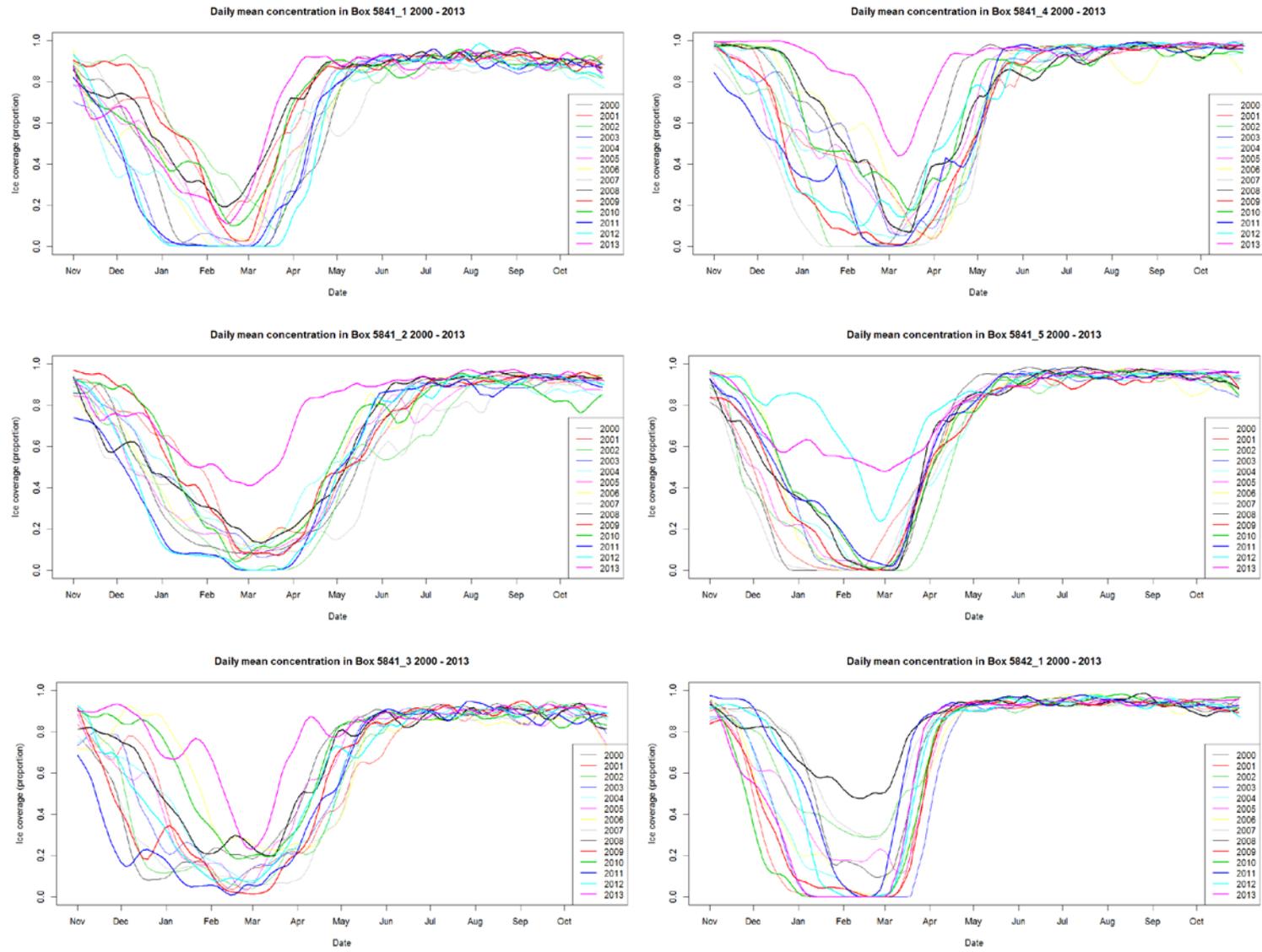


Figure 12: Mean daily sea-ice concentrations in research blocks in Divisions 58.4.1 and 58.4.2 (see paragraph 3.18).

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(Hobart, Australia, 6 to 17 October 2014)

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## Agenda

### Working Group on Fish Stock Assessment (Hobart, Australia, 6 to 17 October 2014)

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 data
4. Established fisheries
  - 4.1 Review of preliminary assessments
    - 4.1.1 *Dissostichus eleginoides* Division 58.5.2
    - 4.1.2 *Dissostichus eleginoides* Division 58.5.1 and Subarea 58.6
    - 4.1.3 *Dissostichus eleginoides* and *D. mawsoni* Subarea 48.4
    - 4.1.4 *Champsocephalus gunnari* Divisions 58.5.1 and 58.5.2
    - 4.1.5 *Dissostichus* spp. Subarea 88.2
  - 4.2 Assessments and management advice
  - 4.3 Update Fishery Reports for established fisheries
    - 4.3.1 *Champsocephalus gunnari* Subarea 48.3
    - 4.3.2 *Champsocephalus gunnari* Division 58.5.2
    - 4.3.3 *Dissostichus eleginoides* Subarea 48.3
    - 4.3.4 *Dissostichus eleginoides* Division 58.5.2
    - 4.3.5 *Dissostichus eleginoides* Division 58.5.1
    - 4.3.6 *Dissostichus eleginoides* Subarea 58.6 (French EEZ)
    - 4.3.7 *Dissostichus eleginoides* Subarea 58.6 and 58.7 (South African EEZ)
5. Exploratory and other fisheries
  - 5.1 Exploratory fisheries
    - 5.1.1 Exploratory fisheries in 2013/14
    - 5.1.2 Exploratory fisheries notified for 2014/15
  - 5.2 Research to inform current or future assessments
    - 5.2.1 Subareas 48.2, 48.5 and 48.6
    - 5.2.2 Subarea 58.4
    - 5.2.3 Subareas 88.1 and 88.2

- 5.3 Update Fishery Reports for exploratory fisheries
  - 5.3.1 *Dissostichus* spp. Subareas 88.1 and 88.2
  - 5.3.2 *Dissostichus* spp. Subarea 48.4
  - 5.3.3 *Dissostichus* spp. Subarea 48.6
  - 5.3.4 *Dissostichus* spp. Division 58.4.1
  - 5.3.5 *Dissostichus* spp. Division 58.4.2
  - 5.3.6 *Dissostichus* spp. Division 58.4.3a
  - 5.3.7 *Dissostichus* spp. Division 58.4.3b
  - 5.3.8 *Dissostichus* spp. Division 58.4.4
6. Bottom fishing activities and vulnerable marine ecosystems (VMEs)
  - 6.1 Review of VMEs notified in 2013/14
  - 6.2 Report on Bottom Fisheries and VMEs
7. Scheme of International Scientific Observation
8. Non-target catch in CCAMLR fisheries
  - 8.1 Fish 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
  - 10.2 Notification of Scientific Research
11. Other business
12. Advice to the Scientific Committee
13. Adoption of the report
14. Close of the meeting.

### List of Documents

Working Group on Fish Stock Assessment  
(Hobart, Australia, 6 to 17 October 2014)

- |                     |  |
|---------------------|--|
| WG-FSA-14/01 Rev. 2 | Summary of scientific observer data collected in the CAMLR Convention Area during 2014<br>Secretariat  |
| WG-FSA-14/02        | Analytical data on determination of reproductive potential of Antarctic toothfish <i>D. mawsoni</i> in the Pacific (SSRUs 88.1, 88.2, 88.3), Indian Ocean (SSRUs 58.4.1 и 58.4.2) and Atlantic (SSRU 48.6, 48.5) Antarctic areas<br>S.V. Piyanova and A.F. Petrov (Russia) |
| WG-FSA-14/03 Rev. 2 | Progress report on the Weddell Sea Research Program Stage II<br>A.F. Petrov, I.I. Gordeev, S.V. Pianova and E. F. Uryupova (Russia)  |
| WG-FSA-14/04        | Research plan for the exploratory longline fishery for <i>Dissostichus</i> spp. in 2014/15 in Division 58.4.4<br>Delegation of France  |
| WG-FSA-14/05        | Revised research plan for the exploratory longline fishery for <i>Dissostichus</i> spp. in 2014/15 in Division 58.4.3a<br>Delegation of France   |
| WG-FSA-14/06        | Revised stock assessment of the Patagonian toothfish, <i>Dissostichus eleginoides</i> , in research block C of Division 58.4.4 (Ob and Lena Banks) using CASAL<br>A. Rélot-Stirnemann (France)   |
| WG-FSA-14/07        | 2006–2013 fish distribution and biomass in the Kerguelen EEZ (CCAMLR Division 58-5-1) for the bathymetric range 100–1 000 m<br>G. Duhamel, M. Hauteœur and R. Sinigre (France)   |
| WG-FSA-14/08        | Revised plan of research program of the Ukraine in Subarea 48.2 in 2015<br>Delegation of Ukraine   |
| WG-FSA-14/09        | Plan of research program of the Russian Federation in Subarea 48.5 (Weddell Sea) in season 2014/2015<br>Delegation of the Russian Federation   |

WG-FSA-14/10	Comparison of two methods to assess fish losses due to depredation by killer whales and sperm whales on demersal longline N. Gasco, P. Tixier, G. Duhamel and C. Guinet (France)
WG-FSA-14/11	Stock assessment of mackerel icefish ( <i>Champsocephalus gunnari</i> ) in the vicinity of Kerguelen Islands (Division 58.5.1) after the 2013 POKER Biomass survey R. Sinegre and G. Duhamel (France)
WG-FSA-14/12	Review of skate (Rajiformes) by-catch in CCAMLR toothfish fisheries Secretariat
WG-FSA-14/13	Research program on resource potential and life cycle of <i>Dissostichus</i> species from the Subarea 88.2 A in 2014–2017 Delegation of the Russian Federation
WG-FSA-14/14 Rev. 1	Stock assessment and proposed TAC for Antarctic toothfish (TOA) in the Subarea 88.2 H in the season 2014–2015 S.M. Goncharov and A.F. Petrov (Russia)
WG-FSA-14/15	Comparative data on size–age composition and growth of Antarctic toothfish <i>Dissostichus mawsoni</i> in Ross Sea, Amundsen Sea and Weddell Sea A.F. Petrov, E.N. Kyznetsova, S.V. Piyanova and I.I. Gordeev (Russia)
WG-FSA-14/16	A review of by-catch in CCAMLR exploratory toothfish fisheries E. McClure, K. Reid (Secretariat)
WG-FSA-14/17	Revised research plan for the exploratory fisheries for <i>Dissostichus</i> spp. in Subarea 48.6 in 2014/15 Delegation of Japan
WG-FSA-14/18	Revised research plan for the exploratory fisheries for <i>Dissostichus</i> spp. in Division 58.4.1 in 2014/15 Delegation of Japan
WG-FSA-14/19	Revised research plan for the exploratory fisheries for <i>Dissostichus</i> spp. in Division 58.4.2 in 2014/15 Delegation of Japan
WG-FSA-14/20	Revised research plan for the exploratory fisheries for <i>Dissostichus</i> spp. in Division 58.4.3a in 2014/15 Delegation of Japan

WG-FSA-14/21	Revised research plan for toothfish in Division 58.4.4 b by <i>Shinsei maru No. 3</i> in 2014/15 Delegation of Japan
WG-FSA-14/22	Assessment models for Patagonian toothfish in research block 5843a_1 of Division 58.4.3a, Elan Bank K. Taki (Japan)
WG-FSA-14/23	Revised assessment models for Patagonian toothfish in research block C of Division 58.4.4, Ob and Lena Banks K. Taki (Japan)
WG-FSA-14/24	Reviewing the need for bottle test for specified longline gear configurations Secretariat
WG-FSA-14/25	Macrourus ID guide for observers for CCAMLR Subareas 48.3 and 48.4 J. McKenna, K.A. Ross and M. Belchier (United Kingdom)
WG-FSA-14/26	The demersal fish communities of the shelf and slope of South Georgia and Shag Rocks (CCAMLR Subarea 48.3) S. Gregory, M.A. Collins and M. Belchier (United Kingdom)
WG-FSA-14/27	The use of electronic monitoring camera system for the toothfish fishery in CCAMLR Subarea 48.3: a study case to help CCAMLR R.A. Benedet (United Kingdom)
WG-FSA-14/28	White-chinned petrel incidental mortality event in the Subarea 48.3 Patagonian toothfish fishery during the season extension period in the 2013/14 season M.A Collins, M. Soffker, C. Darby, K. Ross and P.N. Trathan (United Kingdom)
WG-FSA-14/29 Rev. 1	A preliminary CASAL population assessment of Patagonian toothfish in CCAMLR Subarea 48.4 based on data for the 2009–2014 fishing seasons V. Laptikhovsky, R. Scott, M. Söffker and C. Darby (United Kingdom)
WG-FSA-14/30 Rev. 1	A Petersen tag-recapture preliminary population assessment of Antarctic toothfish in CCAMLR Subarea 48.4 based on data for the 2009–2014 fishing seasons V. Laptikhovsky, R. Scott, M. Söffker, T. Earl and C. Darby (United Kingdom)

- WG-FSA-14/31 A false positive in the CCAMLR tag overlap statistic arising from low catch volume and consequent limited sample size  
C. Darby (United Kingdom)
- WG-FSA-14/32 Steepness for Antarctic toothfish (*Dissostichus mawsoni*) based on life history  
M. Mangel, J. Brodziak and G.M. Watters (USA)
- WG-FSA-14/33 Maturity stages for skates (Rajiformes)  
J.R. Ellis, S.R. McCully Phillips and V. Laptivovsky (United Kingdom)
- WG-FSA-14/34 An integrated stock assessment for the Heard Island and the McDonald Islands Patagonian toothfish (*Dissostichus eleginoides*) fishery (Division 58.5.2)  
P. Ziegler, D. Welsford, W. de la Mare and P. Burch (Australia)
- WG-FSA-14/35 Results of the Spanish exploratory longline fishery for *Dissostichus* spp. in Divisions 58.4.1 and 58.4.2 in the two previous seasons  
R. Sarralde, L.J. López-Abellán and S. Barreiro (Spain)
- WG-FSA-14/36 Rev. 1 Updated and revised stock assessments of Patagonian toothfish (*Dissostichus eleginoides*) in the vicinity of Kerguelen Islands (Division 58.5.1) and Crozet Islands (Subarea 58.6)  
S. Romain and G. Duhamel (France)
- WG-FSA-14/37 Revised research plan for the exploratory longline fishery for *Dissostichus* spp. in Subarea 48.6 in 2014/15  
Delegation of the Republic of Korea
- WG-FSA-14/38 Revised research plan for the exploratory longline fishery for *Dissostichus* spp. in Division 58.4.1 in 2014/15  
Delegation of the Republic of Korea
- WG-FSA-14/39 Revised research plan for the exploratory longline fishery for *Dissostichus* spp. in Division 58.4.2 in 2014/15  
Delegation of the Republic of Korea
- WG-FSA-14/40 Report on season extension trials in the Patagonian toothfish longline fishery in CCAMLR Statistical Division 58.5.2  
T. Lamb (Australia)
- WG-FSA-14/41 The 2014 annual random stratified trawl survey in the waters of Heard Island (Division 58.5.2) to estimate the abundance of *Dissostichus eleginoides* and *Champscephalus gunnari*  
G.B. Nowara, T.D. Lamb and D.C. Welsford (Australia)

- WG-FSA-14/42 Updated models of the habitat use of Patagonian toothfish (*Dissostichus eleginoides*) on the Kerguelen Plateau around Heard Island and the McDonald Islands (Division 58.5.2)  
C. Péron and D.C. Welsford (Australia)
- WG-FSA-14/43 Development of the Patagonian toothfish (*Dissostichus eleginoides*) tagging program in Division 58.5.2, 1997–2014  
D.C. Welsford, C. Péron, P.E. Ziegler and T.D. Lamb (Australia)
- WG-FSA-14/44 A preliminary assessment of mackerel icefish (*Champsocephalus gunnari*) in Division 58.5.2, based on results from the 2014 random stratified trawl survey  
D.C. Welsford (Australia)
- WG-FSA-14/45 An update of the ageing program for Patagonian toothfish (*Dissostichus eleginoides*) at the Australian Antarctic Division, including a summary of new data available for the Integrated Stock Assessment for the Heard Island and the McDonald Islands fishery (Division 58.5.2)  
B.M. Farmer, E.J. Woodcock and D.C. Welsford (Australia)
- WG-FSA-14/46 Investigating the uncertainty of age determinations for Patagonian toothfish (*Dissostichus eleginoides*) and the implications for stock assessment  
P. Burch, P. Ziegler, W. de la Mare and D. Welsford (Australia)
- WG-FSA-14/47 Rev. 1 Bycatch of skates (Rajiformes) and grenadiers (Macrouridae) in longline fisheries in Subarea 48.3  
V. Laptikhovsky, M. Soeffker, M. Belchier, J. Roberts, C. Darby, J. Ellis and R. Scott (United Kingdom)
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- WG-FSA-14/60 Medium-term research plan for the Ross Sea toothfish fishery Delegations of New Zealand, Norway and the United Kingdom

- WG-FSA-14/61 Proposal for a longline survey of toothfish in the northern Ross Sea region (SSRUs 88.2 A and B)  
Delegations of New Zealand, Norway and the United Kingdom
- WG-FSA-14/62 Using acoustic echo counting to estimate grenadier abundance in the Ross Sea (SSRU88.1I)  
Y. Ladroit, R.L. O’Driscoll and S. Mormede (New Zealand)
- WG-FSA-14/63 Discrimination of two species of grenadier (Gadiformes, Macrouridae), *Macrourus whitsoni* and *M. caml*, in the Ross Sea region of the Southern Ocean (CCAMLR Subareas 88.1 and 88.2) on the basis of otolith morphometrics  
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Secretariat



**Feedback management pro forma**



## Feedback management pro forma

General points to be addressed in the FBM proposal:

1. General concept of the FBM.
2. Data required for the proposed FBM and their source.
3. How catch limits and their distribution are to be determined and adjusted:
  - (i) spatial and temporal scale
  - (ii) decision rules
  - (iii) temporal sequential requirements, if any.
4. Details of implementation.

Specific questions:

1. How often catch limits and their distribution may change?
2. Does this involve structured fishing and if so, does it include a reference area?
3. What are the data and activity requirements from the fishery?
4. What are the data and activity required of a scientific survey at sea?
5. What are the data and activity required by CEMP?
6. What is the plan for additional data collection during stage 2 and how will it contribute to move to stage 3?
  - (i) How long do we need to collect this data to be useful?
  - (ii) How can data collection requirements be sustained?
  - (iii) What impact will failure to collect the required data have on the first specific question? i.e. the trade-off between data collection, uncertainty and setting catch limits.
7. Are there specific scientific questions to address before undertaking the transition from stage 2 to stage 3? e.g. what effects might fishing have on the foraging success of predators?



**Glossary of acronyms and abbreviations  
used in SC-CAMLR reports**



**Glossary of acronyms and abbreviations  
used in SC-CAMLR reports**

AAD	Australian Government Antarctic Division
ACAP	Agreement on the Conservation of Albatrosses and Petrels
ACAP BSWG	ACAP Breeding Sites Working Group (BSWG)
ACC	Antarctic Circumpolar Current
ACW	Antarctic Circumpolar Wave
ADCP	Acoustic Doppler Current Profiler (mounted on the hull)
ADL	Aerobic Dive Limit
AEM	Ageing Error Matrix
AFMA	Australian Fisheries Management Authority
AFZ	Australian Fishing Zone
AIS	Automatic Identification System
AKES	Antarctic Krill and Ecosystem Studies
ALK	Age-length Key
AMD	Antarctic Master Directory
AMES	Antarctic Marine Ecosystem Studies
AMLR	Antarctic Marine Living Resources
AMSR-E	Advanced Microwave Scanning Radiometer – Earth Observing System
ANDEEP	Antarctic Benthic Deep-sea Biodiversity
APBSW	Bransfield Strait West (SSMU)
APDPE	Drake Passage East (SSMU)
APDPW	Drake Passage West (SSMU)
APE	Antarctic Peninsula East (SSMU)
APEC	Asia-Pacific Economic Cooperation
APECS	Association of Polar Early Career Scientists

APEI	Elephant Island (SSMU)
APEME Steering Committee	Steering Committee on Antarctic Plausible Ecosystem Modelling Efforts
APIS	Antarctic Pack-Ice Seals Program (SCAR-GSS)
APW	Antarctic Peninsula West (SSMU)
ARK	Association of Responsible Krill harvesting companies
ASE	Assessment Strategy Evaluation
ASI	Antarctic Site Inventory
ASIP	Antarctic Site Inventory Project
ASMA	Antarctic Specially Managed Area
ASOC	Antarctic and Southern Ocean Coalition
ASPA	Antarctic Specially Protected Area
ASPM	Age-Structured Production Model
ATCM	Antarctic Treaty Consultative Meeting
ATCP	Antarctic Treaty Consultative Party
ATME	Antarctic Treaty Meeting of Experts on the Impacts of Climate Change for Management and Governance of the Antarctic region
ATS	Antarctic Treaty System
ATSCM	Antarctic Treaty Special Consultative Meeting
AVHRR	Advanced Very High Resolution Radiometry
BAS	British Antarctic Survey
BED	Bird Excluder Device
BICS	Benthic Impact Camera System
BIOMASS	Biological Investigations of Marine Antarctic Systems and Stocks (SCAR/SCOR)
BROKE	Baseline Research on Oceanography, Krill and the Environment
BRT	Boosted Regression Trees
CAC	Comprehensive Assessment of Compliance

cADL	calculated Aerobic Dive Limit
CAF	Central Ageing Facility
CAML	Census of Antarctic Marine Life
CAMLR Convention	Convention on the Conservation of Antarctic Marine Living Resources
CAML SSC	CAML Scientific Steering Committee
CAR	Comprehensiveness, Adequacy, Representativeness
CASAL	C++ Algorithmic Stock Assessment Laboratory
CBD	Convention on Biodiversity
CCAMLR	Commission for the Conservation of Antarctic Marine Living Resources
CCAMLR-2000 Survey	CCAMLR 2000 Krill Synoptic Survey of Area 48
CCAMLR-IPY- 2008 Survey	CCAMLR-IPY 2008 Krill Synoptic Survey in the South Atlantic Region
CCAS	Convention on the Conservation of Antarctic Seals
CCEP	CCAMLR Compliance Evaluation Procedure
CCSBT	Commission for the Conservation of Southern Bluefin Tuna
CCSBT-ERS WG	CCSBT Ecologically Related Species Working Group
CDS	Catch Documentation Scheme for <i>Dissostichus</i> spp.
CDW	Circumpolar Deep Water
CEMP	CCAMLR Ecosystem Monitoring Program
CEP	Committee for Environmental Protection
CF	Conversion Factor
CircAntCML	Circum-Antarctic Census of Antarctic Marine Life
CITES	Convention on International Trade in Endangered Species
CM	Conservation Measure
CMIX	CCAMLR's Mixture Analysis Program
CMP	Conservation Management Plan

CMS	Convention on the Conservation of Migratory Species of Wild Animals
COFI	Committee on Fisheries (FAO)
COLTO	Coalition of Legal Toothfish Operators
CoML	Census of Marine Life
COMM CIRC	Commission Circular (CCAMLR)
COMNAP	Council of Managers of National Antarctic Programs (SCAR)
CON	CCAMLR Otolith Network
COTPAS	CCAMLR Observer Training Program Accreditation Scheme
CPD	Critical Period–Distance
CPPS	Permanent Commission on the South Pacific
CPR	Continuous Plankton Recorder
CPUE	Catch-per-unit-effort
CQFE	Center for Quantitative Fisheries Ecology (USA)
CS-EASIZ	Coastal Shelf Sector of the Ecology of the Antarctic Sea-Ice Zone (SCAR)
CSI	Combined Standardised Index
CSIRO	Commonwealth Scientific and Industrial Research Organisation (Australia)
CT	Computed Tomography
CTD	Conductivity Temperature Depth Probe
CV	Coefficient of Variation
C-VMS	Centralised Vessel Monitoring System
CVS	Concurrent Version System
CWP	Coordinating Working Party on Fishery Statistics (FAO)
DCD	<i>Dissostichus</i> Catch Document
DMSP	Defense Meteorological Satellite Program
DPM	Dynamic Production Model

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 <i>Dissostichus</i> spp.
ECOPATH	Software for construction and analysis of mass-balance models and feeding interactions or nutrient flow in ecosystems (see <a href="http://www.ecopath.org">www.ecopath.org</a> )
ECOSIM	Software for construction and analysis of mass-balance models and feeding interactions or nutrient flow in ecosystems (see <a href="http://www.ecopath.org">www.ecopath.org</a> )
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 <i>Polarstern</i> Study
EPRM	Erasable Programmable Read-Only Memory
eSB	Electronic version of CCAMLR's <i>Statistical Bulletin</i>
ESS	Effective Sample Size(s)
FAO	Food and Agriculture Organization of the United Nations
FEMA	Workshop on Fisheries and Ecosystem Models in the Antarctic
FEMA2	Second Workshop on Fisheries and Ecosystem Models in the Antarctic
FFA	Forum Fisheries Agency

FFO	Foraging–Fishery Overlap
FIBEX	First International BIOMASS Experiment
FIGIS	Fisheries Global Information System (FAO)
FIRMS	Fishery Resources Monitoring System (FAO)
FMP	Fishery Management Plan
FOOSA	Krill–Predator–Fishery Model (previously KPFM2)
FPI	Fishing-to-Predation Index
FRAM	Fine Resolution Antarctic Model
FV	Fishing Vessel
GAM	Generalised Additive Model
GATT	General Agreement on Tariffs and Trade
GBIF	Global Biodiversity Information Facility
GBM	Generalised Boosted Model
GCMD	Global Change Master Directory
GDM	Generalised Dissimilarity Modelling
GEBCO	General Bathymetric Chart of the Oceans
GEOSS	Global Earth Observing System of Systems
GIS	Geographic Information System
GIWA	Global International Waters Assessment (SCAR)
GLM	Generalised Linear Model
GLMM	Generalised Linear Mixed Model
GLOBEC	Global Ocean Ecosystems Dynamics Research
GLOCHANT	Global Change in the Antarctic (SCAR)
GMT	Greenwich Mean Time
GOOS	Global Ocean Observing System (SCOR)
GOSEAC	Group of Specialists on Environmental Affairs and Conservation (SCAR)

GOSSOE	Group of Specialists on Southern Ocean Ecology (SCAR/SCOR)
GPS	Global Positioning System
GUI	Graphical User Interface
GRT	Gross Registered Tonnage
GTS	Greene et al., (1990) linear TS versus length relationship
GYM	Generalised Yield Model
HAC	A global standard being developed for the storage of hydroacoustic data
HCR	Harvest Control Rule
HIMI	Heard Island and McDonald Islands
IA	Impact Assessment
IAATO	International Association of Antarctica Tour Operators
IASOS	Institute for Antarctic and Southern Ocean Studies (Australia)
IASOS/CRC	IASOS Cooperative Research Centre for the Antarctic and Southern Ocean Environment
IATTC	Inter-American Tropical Tuna Commission
ICAIR	International Centre for Antarctic Information and Research
ICCAT	International Commission for the Conservation of Atlantic Tunas
ICED	Integrating Climate and Ecosystem Dynamics in the Southern Ocean
ICES	International Council for the Exploration of the Sea
ICESCAPE	Integrating Count Effort by Seasonally Correcting Animal Population Estimates
ICES WGFASST	ICES Working Group on Fisheries Acoustics Science and Technology
ICFA	International Coalition of Fisheries Associations
ICG-SF	Intersessional Correspondence Group on Sustainable Financing
ICSEAF	International Commission for the Southeast Atlantic Fisheries
ICSU	International Council for Science
IDCR	International Decade of Cetacean Research

IFF	International Fishers' Forum
IGBP	International Geosphere-Biosphere Programme
IGR	Instantaneous Growth Rate
IHO	International Hydrographic Organisation
IKMT	Isaacs-Kidd Midwater Trawl
IMAF	Incidental Mortality Associated with Fishing
IMALF	Incidental Mortality Arising from Longline Fishing
IMBER	Integrated Marine Biogeochemistry and Ecosystem Research (IGBP)
IMO	International Maritime Organization
IMP	Inter-moult Period
IOC	Intergovernmental Oceanographic Commission
IOCSOC	IOC Regional Committee for the Southern Ocean
IOFC	Indian Ocean Fisheries Commission
IOTC	Indian Ocean Tuna Commission
IPHC	International Pacific Halibut Commission
IPOA	International Plan of Action
IPOA-Seabirds	FAO International Plan of Action for Reducing Incidental Catch of Seabirds in Longline Fisheries
IPY	International Polar Year
IRCS	International Radio Call Sign
ISO	International Organization for Standardization
ISR	Integrated Study Region
ITLOS	International Tribunal for the Law of the Sea
IUCN	International Union for the Conservation of Nature and Natural Resources – the World Conservation Union
IUU	Illegal, Unreported and Unregulated
IW	Integrated Weight

IWC	International Whaling Commission
IWC-IDCR	IWC International Decade of Cetacean Research
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)
<i>M</i>	Natural Mortality
MARPOL Convention	International Convention for the Prevention of Pollution from Ships
MARS	Multivariate Adaptive Regression Splines
MAXENT	Maximum Entropy modelling
MBAL	Minimum Biologically Acceptable Limits
MCMC	Markov Chain Monte Carlo
MCS	Monitoring Control and Surveillance
MDS	Mitigation Development Strategy

MEA	Multilateral Environmental Agreement
MEOW	Marine Ecoregions of the World
MFTS	Multiple-Frequency Method for in situ TS Measurements
MIA	Marginal Increment Analysis
MIZ	Marginal Ice Zone
MLD	Mixed-layer Depth
MODIS	Moderate Resolution Imaging Spectroradiometer
MoU	Memorandum of Understanding
MP	Management Procedure
MPA	Marine Protected Area
MPD	Maximum of the Posterior Density
MRAG	Marine Resources Assessment Group (UK)
MRM	Minimum Realistic Model
MSE	Management Strategy Evaluation
MSY	Maximum Sustainable Yield
MV	Merchant Vessel
MVBS	Mean Volume Backscattering Strength
MVP	Minimum Viable Populations
MVUE	Minimum Variance Unbiased Estimate
NAFO	Northwest Atlantic Fisheries Organization
NASA	National Aeronautical and Space Administration (USA)
NASC	Nautical Area Scattering Coefficient
NCAR	National Center for Atmospheric Research (USA)
NEAFC	North East Atlantic Fisheries Commission
NGO	Non-Governmental Organisation
NI	Nearest Integer

NIWA	National Institute of Water and Atmospheric Research (New Zealand)
nMDS	non-Metric Multidimensional Scaling
NMFS	National Marine Fisheries Service (USA)
NMML	National Marine Mammal Laboratory (USA)
NOAA	National Oceanic and Atmospheric Administration (USA)
NPOA	National Plan of Action
NPOA-Seabirds	FAO National Plans of Action for Reducing Incidental Catch of Seabirds in Longline Fisheries
NRT	Net Registered Tonnage
NSF	National Science Foundation (USA)
NSIDC	National Snow and Ice Data Center (USA)
OBIS	Ocean Biogeographic Information System
OCCAM Project	Ocean Circulation Climate Advanced Modelling Project
OCTS	Ocean Colour and Temperature Scanner
OECD	Organisation for Economic Cooperation and Development
OM	Operating Model
PaCSWG	Population and Conservation Status Working Group (ACAP)
PAR	Photosynthetically Active Radiation
PBR	Permitted Biological Removal
PCA	Principal Component Analysis
PCR	Per Capita Recruitment
pdf	Portable Document Format
PF	Polar Front
PFZ	Polar Frontal Zone
PIT	Passive Integrated Transponder
PRP	CCAMLR Performance Review Panel
PS	Paired Streamer Line

PTT	Platform Terminal Transmitter
RES	Relative Environmental Suitability
RFB	Regional Fishery Body
RFMO	Regional Fishery Management Organisation
RMT	Research Midwater Trawl
ROV	Remotely-Operated Vehicle
RPO	Realised Potential Overlap
RTMP	Real-Time Monitoring Program
RV	Research Vessel
RVA	Register of Vulnerable Areas
SACCB	Southern Antarctic Circumpolar Current Boundary
SACCF	Southern Antarctic Circumpolar Current Front
SAER	State of the Antarctic Environment Report
SAF	Sub-Antarctic Front
SBDY	Southern Boundary of the ACC
SBWG	Seabird Bycatch Working Group (ACAP)
SCAF	Standing Committee on Administration and Finance (CCAMLR)
SCAR	Scientific Committee on Antarctic Research
SCAR-ASPECT	Antarctic Sea-Ice Processes, Ecosystems and Climate (SCAR Program)
SCAR-BBS	SCAR Bird Biology Subcommittee
SCAR-CPRAG	Action Group on Continuous Plankton Recorder Research
SCAR-EASIZ	Ecology of the Antarctic Sea-Ice Zone (SCAR Program)
SCAR-EBA	Evolution and Biodiversity in Antarctica (SCAR Program)
SCAR-EGBAMM	Expert Group on Birds And Marine Mammals
SCAR-GEB	SCAR Group of Experts on Birds
SCAR-GOSEAC	SCAR Group of Specialists on Environmental Affairs and Conservation

SCAR-GSS	SCAR Group of Specialists on Seals
SCAR-MarBIN	SCAR Marine Biodiversity Information Network
SCAR/SCOR-GOSSOE	SCAR/SCOR Group of Specialists on Southern Ocean Ecology
SCAR WG-Biology	SCAR Working Group on Biology
SC-CAMLR	Scientific Committee for the Conservation of Antarctic Marine Living Resources
SC CIRC	Scientific Committee Circular (CCAMLR)
SC-CMS	Scientific Committee for CMS
SCIC	Standing Committee on Implementation and Compliance (CCAMLR)
SC-IWC	Scientific Committee for IWC
SCOI	Standing Committee on Observation and Inspection (CCAMLR)
SCOR	Scientific Committee on Oceanic Research
SCP	Systematic Conservation planning
SD	Standard Deviation
SDWBA	Stochastic Distorted-wave Born Approximation
SEAFO	South East Atlantic Fisheries Organisation
SeaWiFS	Sea-viewing Wide Field-of-view Sensor
SG-ASAM	Subgroup on Acoustic Survey and Analysis Methods
SGE	South Georgia East
SGSR	South Georgia–Shag Rocks
SGW	South Georgia West (SSMU)
SIBEX	Second International BIOMASS Experiment
SIC	Scientist-in-Charge
SIOFA	Southern Indian Ocean Fisheries Agreement
SIR Algorithm	Sampling/Importance Resampling Algorithm
SISO	Scheme of International Scientific Observation (CCAMLR)

SMOM	Spatial Multispecies Operating Model
SNP	Single Nucleotide Polymorphism
SO-CPR	Southern Ocean CPR
SO GLOBEC	Southern Ocean GLOBEC
SOI	Southern Oscillation Index
SO JGOFS	Southern Ocean JGOFS
SOMBASE	Southern Ocean Molluscan Database
SONE	South Orkney North East (SSMU)
SOOS	Southern Ocean Observing System
SOPA	South Orkney Pelagic Area (SSMU)
SOS Workshop	Southern Ocean Sentinel Workshop
SOW	South Orkney West (SSMU)
SOWER	Southern Ocean Whale Ecology Research Cruises
SPA	Specially Protected Area
SPC	Secretariat of the Pacific Community
SPGANT	Ocean Colour Chlorophyll- <i>a</i> 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
SST	Sea-Surface Temperature
STC	Subtropical Convergence

SWIOFC	Southwest Indian Ocean Fisheries Commission
TASO	ad hoc Technical Group for At-Sea Operations (CCAMLR)
TDR	Time Depth Recorder
TEWG	Transitional Environmental Working Group
TIRIS	Texas Instruments Radio Identification System
TISVPA	Triple Instantaneous Separable VPA (previously TSVPA)
ToR	Term of Reference
TrawlCI	Estimation of Abundance from Trawl Surveys
TS	Target Strength
TVG	Time Varied Gain
UBC	University of British Columbia (Canada)
UCDW	Upper Circumpolar Deep Water
UN	United Nations
UNCED	UN Conference on Environment and Development
UNCLOS	UN Convention on the Law of the Sea
UNEP	UN Environment Programme
UNEP-WCMC	UNEP World Conservation Monitoring Centre
UNFSA	the United Nations Fish Stock Agreement is the 1995 United Nations Agreement for the Implementation of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks
UNGA	United Nations General Assembly
UPGMA	Unweighted Pair Group Method with Arithmetic Mean
US AMLR	United States Antarctic Marine Living Resources Program
US LTER	United States Long-term Ecological Research
UV	Ultra-Violet
UW	Unweighted

UWL	Unweighted Longline
VME	Vulnerable Marine Ecosystem
VMS	Vessel Monitoring System
VOGON	Value Outside the Generally Observed Norm
VPA	Virtual Population Analysis
WAMI	Workshop on Assessment Methods for Icefish (CCAMLR)
WC	Weddell Circulation
WCO	World Customs Organization
WFC	World Fisheries Congress
WCPFC	Western and Central Pacific Fisheries Convention
WG-CEMP	Working Group for the CCAMLR Ecosystem Monitoring Program (CCAMLR)
WG-EMM	Working Group on Ecosystem Monitoring and Management (CCAMLR)
WG-EMM-STAPP	Subgroup on Status and Trend Assessment of Predator Populations
WG-FSA	Working Group on Fish Stock Assessment (CCAMLR)
WG-FSA-SAM	Subgroup on Assessment Methods
WG-FSA-SFA	Subgroup on Fisheries Acoustics
WG-IMAF	Working Group on Incidental Mortality Associated with Fishing (CCAMLR)
WG-IMALF	ad hoc Working Group on Incidental Mortality Arising from Longline Fishing (CCAMLR)
WG-Krill	Working Group on Krill (CCAMLR)
WG-SAM	Working Group on Statistics, Assessments and Modelling
WMO	World Meteorological Organization
WOCE	World Ocean Circulation Experiment
WSC	Weddell–Scotia Confluence
WS-Flux	Workshop on Evaluating Krill Flux Factors (CCAMLR)

WS-MAD	Workshop on Methods for the Assessment of <i>D. eleginoides</i> (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)