Report of the Working Group on Ecosystem Monitoring and Management

(Punta Arenas, Chile, 7 to 18 July 2014)

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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)
ρ = 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[1] 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%

[1] 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^2 (compared to ~0.3 and 3.2 m^2 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 g m^{-2}) interspersed with years (1999–2000, 2004, 2009–2010) of low density (<30 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 CO_2 levels and successful hatching is impaired at CO_2 levels greater than 1 000 μatm. Exposure to elevated 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 CO_2. Krill embryos appear more vulnerable to ocean acidification than other pelagic crustaceans such as copepods. $p\mathrm{CO}_2$ in the Southern Ocean is predicted to rise to above 1 500 μatm 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 $p\mathrm{CO}_2$, 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 $p\mathrm{CO}_2$ 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®, 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-convener). 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 (RSMPA), (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 RSMPA. Four of these seven areas are highlighted as areas for contribution to the East Antarctica RSMPA; 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 RSMPA, 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 RSMPA.

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) 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 circumpolar 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 Straight, 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.[a]
Kai Shun, *Kai Li* (Notification ID_83786)	These vessels have an echosounder, but this appears to be misreported as sonar. Notifying Member to confirm this information.[b]
Insung Ho (Notification ID_84026)	This vessel will install an echosounder in November. Notifying Member to provide detail on the model/frequency.[b]
Sejong (Notification ID_84026)	There appears to be an error in the echosounder model reported. Notifying Member to confirm this information.[b]
Antarctic Sea, *Juvel* (Notification ID_84045)	There appears to be an error in the frequencies used by the echosounders. Notifying Member to confirm this information.[b]

[a] This was confirmed during the meeting.
[b] 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)
	Catch	Fishery	December to August/September	SSMUs ex APDPW, APE	Yes
Predator	CEMP	CEMP – arrival	Summer	CEMP sites/foraging areas	Yes
		CEMP – breeding/foraging	Summer	CEMP sites/foraging areas	Yes
		CEMP – multi-year	Summer	CEMP sites/foraging areas	Yes
Fishery	Catch	Haul by haul	December to August/September	Exact fish location	Yes
	Distribution	Haul location (VMS)	December to August/September		Yes
Environment	SST	Data portal(s) SOOS	Daily	Global (ice)	No
	CTD	National surveys	Month (associated with krill surveys)	SSMUs ex APDPW, APE	No

Appendix A

List of Participants

Working Group on Ecosystem Monitoring and Management
(Punta Arenas, Chile, 7 to 18 July 2014)

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Appendix B

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 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 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 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 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 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 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 R.D. Cavanagh, E.J. Murphy, S.L. Hill and N.M. Johnston (United Kingdom) (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 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. Juáres (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. Juáres (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/A 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. Ovsyanikova, 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 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
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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

Appendix D

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.