Report of the Working Group on Ecosystem Monitoring and Management
(Buenos Aires, Argentina, 10 to 14 July 2017)

Content

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Introduction

Opening of the meeting

1.1 The 2017 meeting of WG-EMM was held in the Palacio San Martín, Buenos Aires, Argentina, from 10 to 14 July 2017. The meeting Convener, Dr M. Korczak-Abshire (Poland), welcomed the participants (Appendix A). Mr Maximo Gowland, the Argentinian Commissioner to CCAMLR and Director of the Dirección Nacional de Política Exterior Antártica welcomed all participants to the meeting and wished them every success in their meeting and an enjoyable stay in Buenos Aires.

Adoption of the agenda and organisation of the meeting

1.2 At the invitation of Dr Korczak-Abshire, the Chair of the Scientific Committee (Dr M. Belchier, UK) provided a summary of the outcomes of the Scientific Committee Symposium, held in 2016, and the subsequent deliberations of the Scientific Committee on the priorities and work plans for the Working Group. He noted that the priorities identified by the Scientific Committee in 2016 for the work of WG-EMM this year (as outlined in SC-CAMLR-XXXV, Table 1) were:

- approaches to the operationalising of feedback management (FBM) in the krill fishery in Subarea 48.1
- data layers used in the risk assessment for krill fisheries and the Domain 1 planning process
- Domain 1 marine protected area (MPA) process, including the integration of CCAMLR Ecosystem Monitoring Program (CEMP) monitoring and monitoring as part of the Domain 1 MPA process.

1.3 Dr Belchier also noted that events that had occurred after the meeting of the Scientific Committee, such as the adoption of the Ross Sea region MPA, meant that there were additional items that required consideration. He acknowledged the reduced time available and the considerable number of papers tabled to the meeting, however, while hoping that all papers could receive appropriate consideration, he urged the Working Group to focus on the priorities provided by the Scientific Committee.

1.4 The meeting agenda was adopted (Appendix B).

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

1.6 In this report, paragraphs that provide advice to the Scientific Committee and its other working groups have been indicated in grey. A summary of these paragraphs is provided in Item 7.

1.7 The Working Group used the Secretariat's online meeting server to support its work and facilitate the preparation of the meeting report.

1.8 The report was prepared by M. Belchier (Chair of the Scientific Committee), C. Cárdenas (Chile), C. Darby (UK), L. Emmerson (Australia), D. Freeman (New Zealand), O.R. Godø (Norway), S. Grant and S. Hill (UK), J. Hinke and E. Klein (USA), P. Koubbi (EU), K. Reid (Secretariat), M. Santos (Argentina), M. Söffker (UK) and D. Welsford (Australia).

The krill-centric ecosystem and issues related to management of the krill fishery

2.1 WG-EMM-17/48 described how accuracy of catch reporting at two-hourly intervals can be improved on continuous fishing system vessels, by:

(i) monitoring holding tank fullness more accurately and defining the relationship between tank fullness and krill wet weight

(ii) correcting the estimates at the end of each day with daily catch.

2.2 WG-EMM-17/48 outlined a calibration process for more accurate two-hourly catch reporting, whereby the sum of two-hourly catch estimated in the holding tank over 24 hours is compared to the actual catch measured for this period over the flow scale, and the two-hourly catch data subsequently corrected by the relationship between them:

$$C_{ic} = C_i * C_{tot}/\sum C_i$$

where C_i is the catch reported at two-hourly intervals and C_{ic} is the compensated two-hour catch, $\sum C_i$ is the sum of two-hour catches over one 24-hour period and C_{tot} is total daily reported catch for that period.

2.3 The paper presented calibration results of a trial period in May 2017, and the authors considered that fine-scale recording of catch cannot be improved beyond the improvement suggested by this paper until instrumented recording of krill influx through the trawl opening can be recorded. The Working Group requested that vessels using the continuous fishing system carry out the calibration process regularly and frequently throughout the fishing season to better understand the variability expected with this proposed way of catch reporting.

2.4 The Working Group recalled the discussions at WG-EMM-16 (SC-CAMLR-XXXV, Annex 6, paragraphs 2.18 to 2.22), noting that due to the current inability of continuous fishing system vessels to record catches accurately at the time intervals required by Conservation Measure (CM) 21-03, there is still a mismatch between where catch was taken and where it was reported. The Working Group also noted the discussions around WS-SISO-17/11, detailing how observer samples are taken on continuous fishing system vessels, and recalled that the Workshop on the Scheme of International Scientific Observation (WS-SISO) concluded that there is a need to find a way of reconciling observer samples and data with corresponding C1 data, as well as gaining accurate spatial and temporal locations for these samples.

2.5 The Working Group requested that the Scientific Committee review whether the catch and effort data submitted from the continuous fishing system is consistent with CMs 21-03 and 23-06.

2.6 The Working Group requested that Norway analyse historic catch data and catch reporting, including the following analyses to assist in the interpretation of this issue:

(i) whether there is a systematic factor in the delay of catch location and volume reporting that could further improve the accuracy of catch data, and to investigate if any such relationships could also rectify previously collected data

(ii) investigate the variability associated with the time delay from when a vessel begins fishing on a new swarm and that first catch being recorded in the holding tank

(iii) investigate the spatial uncertainty associated with historic catch reporting locations

(iv) compare acoustic data and catch reported to understand the spatial variability associated with the delay.

2.7 The Working Group noted that other means of obtaining accurate information on catch and location, such as monitoring of trawl opening and codend and pump flow rate, may potentially be available in the future and encouraged Norway to consider how these could improve catch location reporting in the future.

Krill fishery update

2.8 The Krill Fishery Report for Area 48 is available on the CCAMLR website (www.ccamlr.org/node/93212). The Working Group noted that the krill fishery had operated in Subarea 58.4 in the 2016/17 season and that it would be appropriate to provide a separate report for krill fishing in East Antarctica in the future.

2.9 The catch by subarea and month in the 2016/17 season indicated that fishing occurred later and with fewer vessels in Subarea 48.1 than in previous seasons, and the trigger level was not reached until July 2017. The Working Group noted that fishing vessels remained in Subarea 48.2 for a longer period than in recent years with a contingent delay in the movement of fishing operations to Subarea 48.1. This appeared to be a consequence of more favourable fishing conditions in Subarea 48.2 during February and March.

2.10 The Working Group reviewed notifications of intention to fish for krill in 2018 using the information on notifications, vessel and gear details that are provided on the CCAMLR website (www.ccamlr.org/en/fishery-notifications/notified/krill). The Working Group noted that following the advice of the Scientific Committee, these data are no longer presented as a summary in a paper to WG-EMM (SC-CAMLR-XXXV, paragraph 3.168). The Working Group noted that 13 vessels from five Members had notified their intention to fish for krill, and two vessels withdrew from the fishery in all areas and one vessel withdrew from Area 58. It recalled that records of withdrawn vessels remain in the notification table, as this information provides important background to understanding how interest in the krill fishery changes over time.

Scheme of scientific observation

2.11 The key recommendations from WS-SISO-17 to WG-EMM-17 were as follows:

(i) Krill sampling – krill carapace measurements

(a) WS-SISO considered the suggestion for the addition of a field in the SISO observer logbook for recording krill carapace lengths during measurement of krill: Request to WG-EMM to review the utility, methods and sample size

(b) review the number of carapace measurements and the number of total length measurements.

(ii) Fish by-catch in the krill fishery

(a) WS-SISO-17 considered an analysis of the relative number of fish found in subsamples – 98% of all fish reported came from the 25 kg samples. WS-SISO-17 recommended that subject to review by WG-EMM, the krill by-catch sampling regime undertaken by observers only requires a 25 kg sample

(b) extend by-catch monitoring to address more than fish, e.g. include other invertebrates, such as salps

(c) consider molecular approaches that may be appropriate for identifying by-catch species in krill by-catch samples, as well as visual guides that could be drawn from existing guides and information from Members.

(iii) Interactions between fishery and air-breathing krill predators

(a) WS-SISO-17 noted that in several thousand trawl-warp strike observation periods, there have been three seabird strikes since 2010, evidence of the low impact the krill fishery had on bird mortalities, and the success of mitigation measures in CCAMLR. With these mitigation measures in place, WS-SISO suggested to retain the methods and forms currently in use, but to further consider how electronic monitoring in warp strike observations could be used to allow changing the frequency of observations, which would permit observers to focus on other high-priority tasks

(b) WS-SISO-17 asked WG-EMM-17 to consider the suggested design of a sampling regime to record air-breathing predators observed around krill vessels during fishing operations and during acoustic surveys carried out by the krill fishery (Annex 4, paragraphs 4.1 and 4.2), how krill fishing vessels could be used as ‘platforms of opportunity’ to collect broader marine mammal and seabird abundance data, and how these data would progress the work of WG-EMM. The Working Group noted such an approach is exemplified in WG-EMM-17/05.

2.12 The Working Group considered the recommendations of WS-SISO-17 as set out below.

Carapace measurements and observer krill sample size

2.13 In addition to the recommendations from WS-SISO-17, the Working Group discussed WG-EMM-17/28 in this context. WG-EMM-17/28 examined the variability in krill length caught by different vessels fishing in the Bransfield Strait in April and May 2014 and 2015, in the context of the need for accurate observer data on krill length for stock status and fishery selectivity, for the development of FBM and as an integral part of acoustic monitoring from commercial krill vessels. The study found that while the mean krill lengths were comparable between vessels, there was a significant difference in krill length distributions caught by different vessels operating in the same area, which was not determined by the type of fishing gear. The study concluded that it is important to maintain a krill sample size that is sufficiently large to capture the whole range of krill length distribution in a sample.

2.14 The Working Group noted that there can be some variance between observers measuring the same sample (Watkins et al., 1986), but also that there can be noticeable variance in krill length distribution between swarms and different depths, and over different spatial and temporal scales. These are likely important for results found in WG-EMM-17/28, and the Working Group suggested that some of that variability could be addressed by comparing observer data on krill lengths to scientific hauls, where conditions are standardised and acoustic data is available on the same transects. The Working Group also noted that there are statistical methods available to include and address such uncertainties (Annex 5, paragraph 4.39).

2.15 The Working Group recalled that for biomass estimation from acoustic surveys, the important measure is the range of krill lengths in an associated biological sample, where the distribution between vessels was very similar.

2.16 The Working Group concluded that the measure of krill carapaces is important (Tarling et al., 2016) to understand sex-dependent growth dynamics of krill. The Working Group agreed that an optimal sampling design be developed that both captures the spatial variety observed in krill sampling (WG-SAM-16/39, WS-SISO-17/11), and provides sufficient sample size to represent krill length-frequency distribution in the catch. The Secretariat offered to support Members in the development of these methods.

By-catch in the krill fishery

2.17 The Working Group noted the discussions at WS-SISO on by-catch in the krill fishery, particularly around the successful collective development of observer guides for fish by-catch. The Working Group noted that 98% of all fish had been recovered from the 25 kg samples and agreed to the changes to the instructions to remove the need for further subsampling the 25 kg samples.

2.18 The Working Group also noted the potential value of expanding by-catch data from the krill fishery to include invertebrates and noted that, currently, the only field guide for invertebrates potentially caught in the krill fisheries is dated and relies on black and white line drawings.

2.19 The Secretariat encouraged all Members to submit any identification guides on potential invertebrate by-catch in Antarctic krill (*Euphausia superba*) fisheries to the Secretariat, who would compile the information and make it available on the SISO sections of the website, similarly to the compiled finfish by-catch guides provided by Members.

Air-breathing krill predators

Trawl warp strikes

2.20 The Working Group considered the recommendation by WS-SISO to retain the methods and forms currently in use, but to further consider how electronic monitoring in warp strike observation could be used to allow changing the frequency of observations, which would permit observers to focus on other high-priority tasks.

2.21 The Working Group recalled that while globally warp strikes in trawl fisheries are regular causes of seabird deaths caused by fisheries, the characteristics of the krill fishery within CCAMLR, combined with the mitigation measures in place, result in fishing activity of relatively low warp strike danger, with only three white-chinned petrels (*Procellaria aequinoctialis*) recorded in warp strikes during thousands of warp observation periods.

2.22 In view of this, the Working Group supported the reduction of the warp strike observation frequency, subject to evaluation of appropriate observation frequency, and encouraged the development of electronic monitoring, which could include infrared and night-vision cameras, to collect data to support this particular task.

Marine mammal and seabird distribution and abundance

2.23 The Working Group discussed the recommendation by WS-SISO to consider the suggested design of a sampling regime to record air-breathing predators observed around krill vessels during fishing operations and during acoustic surveys carried out by the krill fishery (Annex 4, paragraphs 4.1 to 4.3), and how these data would progress the work of WG-EMM. WS-SISO-17/05 was also considered in this context.

2.24 The Working Group recalled that the recommendation addressed two separate questions: the potential interactions and competition of the krill fishery with krill-dependent predators during fishing operations (SC-CAMLR-XXXV, Annex 7, paragraphs 6.14 and 8.25, see also SC-CAMLR-XXXV, paragraphs 3.84 and 3.108), and the wider ecosystem monitoring through transect and survey work, and acknowledged that these two activities would need different approaches to data collection. The Working Group discussed the utility of marine mammal and seabird observations during surveys on acoustic transects by commercial fishing vessels, noting previous initiatives to use acoustic data to evaluate marine mammal presence (WG-EMM-16/P01), and the opportunity that the current (WG-EMM-17/08) and planned acoustic transects by the commercial fleet provide to collect planned survey data on marine mammals in regions where the krill fleet operates.

2.25 The Working Group agreed that for questions such as the krill risk assessment framework, collection of predator abundance, presence and absence during fishing operations and during survey transects it was important to understand the probability of direct interaction between predators and vessels and potential competition for the same resource. The Working Group noted that the two sets of information are required for the further development of the krill risk assessment framework as well as wider ecosystem studies, and that WS-SISO had drafted two data collection methods, one for observations during fishing operations, and one for commercial vessels in survey transect mode.

2.26 The Working Group recommended that the Scientific Committee consider whether and how data collection on air-breathing predators, both during fishing operations and during survey transects carried out by the commercial krill fishery, could form part of the regular SISO duties.

Observer coverage

2.27 The Working Group discussed the different ways that observer coverage has been defined in the past (SC-CAMLR-XXXV, Annex 6, paragraphs 2.41 to 2.43), and noted that the current CM 51-06 refers to the coverage of vessels, rather than coverage of number of days or number of hauls observed.

2.28 The Working Group noted the agreement by the Commission to transition to 100% observer coverage in the krill fishery by 2020, and that this allowed the Working Group to focus its discussion on observer deployment in terms of sampling and representative data collection, which addresses specific scientific questions, rather than the coverage of vessels by observers, which is specified in the conservation measure.

2.29 The Working Group thanked all the scientific observers in the krill fishery that provided valuable data to the work of CCAMLR and this Working Group in particular.

Operationalising feedback management (FBM) in the krill fishery in Subarea 48.1

Net monitoring cables

3.1 WG-EMM-17/47 presented the challenges and some results from using a net monitoring cable to inform crew and scientists of the real-time performance of a krill trawl. The difficulties encountered when monitoring two different continuous gear types are outlined and discussed. One system requires a separate net monitoring cable, the second solves the problem of adding a third cable by attaching the net cable to other operational cables of the trawl system. The trials demonstrated the potential to observe the trawl in real time, as well as the real-time density distribution of krill entering the trawl.

3.2 Norway had intended to conduct a systematic trial on board the FV *Saga Sea* during the 2016/17 fishing season but due to logistical difficulties it was not completed. Norway is therefore seeking to extend the trial period to the 2017/18 fishing season.

3.3 The Working Group welcomed the development of the net monitoring system, noting that it would be beneficial to establish the links between the monitoring observations recorded by the vessel and the density of krill observed by the vessel acoustics. Also, as the krill entering the net would not all be selected by the gear, investigating the relationship between inflow and eventual catches would be beneficial.

3.4 The Working Group discussed the proposal and recommended that the trials be continued under the conditions agreed previously (SC-CAMLR-XXXV, paragraphs 4.10 and 4.11).

3.5 The Working Group noted that the use of net monitoring cables would also be beneficial for the collection of scientific data associated with actual fishing operations (SC-CAMLR-

XXXV, Annex 6, paragraph 2.24). The Working Group noted that the prohibition on net monitoring cables that currently also applied to the krill fishery was introduced after evidence from other fisheries was presented in CCAMLR that the cables that were thinner than trawl warps represented a high risk of bird strike.

3.6 The Working Group discussed a range of options and agreed that if Members wished to trial such systems, a full research proposal, similar to that presented by Norway (WG-FSA-16/38), would be required and requested that the Scientific Committee provide advice on the most appropriate procedure to review such proposals.

3.7 The Working Group discussed the potential use of the data from real-time monitoring of krill entering the vessel nets, noting that it would help in the determination of the density of krill in the water column which could be used to further examine the daily and seasonal migration of krill similar to the modelling reported in WG-EMM-17/41.

Data for the spatial management of krill

3.8 WG-EMM-17/50 Rev. 1 provided a review of information on openly available data and metadata that could be used as input to the krill risk assessment, developed by WG-EMM and WG-FSA in 2016, and which was used to provide management advice to the Scientific Committee and Commission. The Scientific Committee had requested that the development of the model and datasets continue (SC-CAMLR-XXXV, paragraph 3.64). The paper highlighted where gaps in the available data occur, particularly where the krill fishery is occurring but information on predators is lacking, and where the collection of additional information would help contribute to the development of the risk assessment approach in the management of the krill fishery and also CCAMLR's commitment of applying FBM.

3.9 Several participants noted that datasets currently not available through CEMP would fill some of the gaps noted, but these have not been released for general use to date, due to analyses still being conducted on them. The Working Group encouraged broad engagement in the review process.

3.10 The Working Group discussed the communication and availability of data and recommended that the Developing practical approaches to feedback management for krill e-group outline a proposal for a database setup to contain metadata for regional datasets. The database could be populated by Members collecting data within Subareas 48.1 and 48.2 and which could then be used as a reference.

3.11 Such a database would be similar to that discussed at WS-RMP-17 (WS-RMP-17/09). WS-RMP considered that for the development and monitoring of MPAs, the Secretariat could provide a transparent mechanism to catalogue and share metadata collected for providing advice. WS-RMP-17 considered that the Ross Sea region MPA data repository would be accessible to all Members under the Rules for Access and Use of CCAMLR Data.

3.12 The Working Group noted that such a repository could be used by CCAMLR Members collecting data throughout Antarctica and used for the provision of advice to the Commission by the Scientific Committee and its working groups.

3.13 The Working Group noted that in order to progress the krill risk assessment framework in Area 48 as requested by the Scientific Committee (SC-CAMLR-XXXV, paragraph 3.108), it requires:

(i) further collaborative parameterisation of the conceptual model for the region
(ii) identification of the required data components
(iii) coordination of research effort to collate and/or collect any additional data identified to progress the risk assessment framework.

3.14 The Working Group noted that the suggested schedule of working group meetings, outlined by the Chair of the Scientific Committee (WG-EMM-17/02), included a joint workshop between SG-ASAM, WG-EMM and WG-SAM to further develop FBM of the krill fishery. The Working Group recognised that:

(i) the development and population of a database of biological information

(ii) an analysis of spatial information that can be used to formulate management advice

(iii) identification of information gaps

(iv) the further development of the krill risk analysis and FBM models

would each benefit the 2019 joint meeting, as would the establishment of a steering committee, to ensure that preparatory work was conducted in the build-up to the discussions. The Working Group also noted that the work of the Southern Ocean Observing System (SOOS) and other such collaborative projects would also provide a useful input to the meeting discussions.

Krill biology, ecology and population dynamics

Swarm analysis

3.15 WG-EMM-17/40 described an analysis of abundance and distribution, as well as swarm characteristics and diel vertical migration which were studied using acoustic data from the Chinese krill fishing vessel *Fu Rong Hai* operating in the Bransfield Strait from late austral summer (February) to autumn (March to May).

3.16 The analysis indicated a major shift in krill distribution in mid-April, which included: increased biomass; increased vertical distribution of the swarms; a change in the diel vertical migration, from upward migration during daytime in February–March to downward migration during daytime in May; and also a change in the length distribution of krill. The results strongly support the hypothesis of an inshore krill migration from summer to winter (Siegel, 1988; Trathan et al., 1993) and indicate that the migration is also followed by a gradual shift in swarming behaviour. The catching efficiency of the vessel increased over the season and was positively related to both krill packing density and acoustic biomass, but negatively related to the central depth of gravity of the krill swarms.

3.17 The Working Group congratulated the authors on their research that allowed krill dynamics to be identified from the catch rates recorded by the conventional commercial trawl vessel. The findings, along with those described in WG-EMM-17/41 and 17/45, have demonstrated that the fishery data can be used to make inferences about krill seasonal dynamics and the responses in vessel behaviour. The Working Group noted that the model does not include spatial interaction terms and also that log transformations had been applied to the data. It would be useful to evaluate whether including spatial patterns and changing the distribution assumption made any differences to the analysis.

3.18 The Working Group noted the changes apparent in the krill dynamics in April, which may be related to migration and which also correspond to the time at which some krill predators leave the area. Given the high catch rates at this time, it would be useful to repeat the analysis for other years of data to establish whether this is a time when the condition of krill is good and there is less conflict with predators. The results of such studies would be useful in the development of FBM in the area.

3.19 The Working Group also noted that an extension of this work to analyse catches from other vessels in the area and other gear types would be interesting, however, given the doubts about the utility of the catch rates from the continuous fishing gears this may require further analysis before the data can be used in this approach (paragraphs 3.102 to 3.104).

3.20 The Working Group noted that analyses such as those presented in WG-EMM-17/40, 17/41 and 17/45 have shown that fishing vessel data can be used to evaluate the dynamics of krill and vessels behaving as predators, and that the work of SG-ASAM in standardising the vessel data would be critical to combining information across platforms. The Working Group also noted that data from acoustic moorings could additionally be used in interpreting the seasonal patterns. Such analyses would also be important in determining the role of the flow of krill resulting from water movements (flux) on the replenishment of the krill population, both throughout the season and as catches are removed by the fishery.

3.21 Dr S.-G. Choi (Republic of Korea) noted that Korea had been conducting standardised acoustic transects in Bransfield Strait, using the protocol set out by SG-ASAM, and would be repeating these in future years, including by month to examine the dynamics of krill.

3.22 The Working Group thanked Dr Choi, noting that it was encouraging that the ideas for utilising fishing vessels to conduct research, as set out in WG-EMM and SG-ASAM, were starting to be taken up by the industry.

KRILLBASE

3.23 WG-EMM-17/P03 described KRILLBASE, a circumpolar database of *E. superba* and salp numerical densities, from 1926 to 2016, which is now available online. The database includes fine-scale information on adult krill distribution in Subareas 48.1 and 48.2 and Divisions 58.4.1 and 58.4.2, which have been used in Domain 1 planning (paragraph 4.6) and could provide input to risk assessments for the krill fishery in the Scotia Sea and East Antarctica.

Hydrographic modelling

3.24 WG-EMM-17/30 described the development of regional models for water movements across the South Georgia and South Orkney Islands shelves and surrounding regions, and the results of preliminary analyses. The models simulate key physical processes of relevance to the local ecosystems, including tides, atmospheric forcing from reanalysis, glacial melt and with sea-ice processes incorporated using Louvain-la-Neuve sea-ice model (LIM3). The models have been used to generate 20-year hind-cast time series of oceanographic flows and water mass properties.

3.25 The model in WG-EMM-17/30 provided simulations of the underlying physical environment for detailed examinations of the controls on the distribution of krill and fish life-stage distributions around the islands, their interactions with predators and availability to fisheries. Insight from such studies will help inform WG-EMM activities aimed at developing spatial and FBM procedures. The program is currently being used to investigate the spawning and recruitment of Patagonian toothfish (*Dissostichus eleginoides*).

3.26 The Working Group noted the series of papers presented to the meeting on the dynamics of krill, as estimated from fishing vessels, particularly in the area covered by the model in WG-EMM-17/30, and suggested to combine the current predictions with observed dynamics of krill.

3.27 The Working Group noted that the model allowed predictions to be made in localised fine-scale areas, and that predictions had been evaluated using conductivity temperature depth probe (CTD) data. The model also includes freshwater input from glaciers. The sea-ice predictions show some discrepancy with satellite observations, whilst the seasonal cycle is reproduced by the model, there is a tendency for sea-ice to extend too far north and west in winter, and to retreat too far south in summer; these are thought to arise because of the open boundary forcing from the global Nucleus for European Modelling of the Ocean (NEMO) model.

Krill life-history parameters

3.28 WG-EMM-17/29 analysed Euphausiid larvae (*E. superba*, *Thysanoessa macrura* and *E. frigida*), collected during the summer of 2011 in the Weddell–Scotia confluence region, during 2012 in the western Antarctic Peninsula (WAP) and Scotia Sea and during 2014 on the South Orkney Islands. A strong decrease in the abundance of *E. superba* larvae and an increase in *T. macrura* was recorded between 2011 and 2012 with a strong increase in the abundance of *E. superba* in 2014. In 2011, *T. macrura* dominated the species composition with all stages present, and *E. superba* was found in lowest proportion of the three species. In 2012, the three species had very low numbers, but also *T. macrura* had the highest proportion. In 2014, *E. superba* dominated the sampling with calyptopis larvae stages.

3.29 The geographical distribution of krill larvae was in accordance with previously recorded data for these species, and oceanographic conditions did not show any significant differences to historical information. The analysis also reviewed possible causes of the variability of observed species density and proportions, in relation with physical variables with no clear relationships. Comparison of the data for the recent three years with the physical data obtained in 1995 indicated a decrease in salinity and an increase in the maximum and the minimum temperatures, but the values remain well within the physiological limits of Euphausiid larvae.

3.30 The Working Group thanked the authors for their paper and noted that studies of the dynamics of larval krill are an important contribution to its understanding of the species dynamics, particularly, the transition of year classes in the length distribution of larvae transitioning into, and through, the adult stock.

3.31 The authors noted that there was no linkage between the krill abundance in the fishery and the subsequent larvae abundance; measuring the length distribution of the larvae was currently being conducted.

3.32 The Working Group noted the value of research surveys providing long-term monitoring of the regional density and variability of both larval krill and physical oceanographic parameters so as to understand the possible impacts of climate change on Euphausiid life-history distributions.

Krill assessment models

3.33 No documents were presented for this agenda item. However, the Working Group noted the discussions at WG-SAM-17 (Annex 5, paragraphs 2.1 to 2.5) during which recent developments in the krill assessment model for Subarea 48.1 were considered. WG-SAM noted that there was a need to consider the population dynamics of the krill stock in the area as a whole, as there was confounding between natural mortality and emigration resulting from water flows (flux) within the model.

3.34 In addition, WG-SAM noted that there are no plans for further US AMLR surveys in the same form as in previous years (paragraphs 6.7 to 6.9). The surveys are currently used as an important source of calibration data within the model. The importance of making the best use possible of data from other science surveys and that provided by commercial fishing vessels, such as the transects identified by SG-ASAM, needs to be developed as a high priority in order to allow WG-SAM, WG-EMM, WG-FSA and the Scientific Committee to provide future advice on the trends in stock dynamics of the krill stock covered by the US AMLR surveys (Annex 5, paragraph 2.5).

3.35 The Working Group noted that defining the temporal and spatial scale of the krill assessment process is key to determining the requirements for data that would be used to provide management advice, particularly in relation to the importance of flux. Assessments conducted at a fine scale, which evaluate the localised impact of catches on a small-scale area over a short time period, could be conducted using localised data collected by fishing vessels, as outlined by WG-EMM and SG-ASAM. The impact of fishing at a regional scale and over a longer time period (e.g. annually) would be affected by emigration from, and immigration to, the area. The scale of the data collection and analysis would also affect the evaluation of the fishery impact on predators within FBM.

3.36 The Working Group noted that within the South African small pelagic fishery management system, a series of open and closed areas around islands on which predators are located are defined, and that these are rotated on a fixed time scale in a factorial design (Pichegru et al., 2010, 2012). Such experimental designs may be suited to the evaluation of the localised impact of the krill fishery on predators (paragraph 3.59). The CEMP data would form an important part of such a design process.

3.37 The Working Group noted that the risk assessment framework developed at WG-EMM and WG-FSA allows advice to be provided to the Scientific Committee on where interactions between the fishery and predators are increasing or decreasing and where there is a need for more information to be collected and analysed. The risk assessment framework allows spatial data or its absence to be integrated in a simple format that can be used to provide advice, and while the staged approach for the development of FBM is still being implemented, the Working Group agreed that the continued development of the risk assessment is important in order to progress the precautionary management of the krill fishery.

3.38 The Working Group discussed the availability of a range of data that is being analysed that could contribute to the risk analysis and FBM development and encouraged Members to make this data available in a readily accessible form (paragraph 3.10). The data descriptions, the methods used to collect the data and the quality/uncertainty in the data should form part of the analysis in order to allow the Working Group and the Scientific Committee to assess the utility of the results of analysis for the provision of management advice.

Ecological interactions: predators

Ross Sea

3.39 The Working Group considered WG-EMM-17/06 that reported recent monitoring of an Adélie penguin (*Pygoscelis adeliae*) colony at Cape Hallett in the northern Ross Sea. The colony is adjacent to the newly designated Ross Sea region MPA. The main results presented in the paper from initial field sampling suggest an increasing population over the last decade, up to 53 450 pairs from 47 169 (reported in 2013) and foraging ranges and durations consistent with short-range trips during the breeding season. Census methods using both ground and aerial images obtained from unmanned aerial vehicles (UAVs) suggest counting may benefit from UAV systems when colonies are so large.

3.40 The Working Group welcomed the paper, noting that the diet of Adélie penguins in the Ross Sea region may be quite different from those around the Antarctic Peninsula, and that the Republic of Korea has plans to undertake DNA analysis of penguin guano as part of its future studies in the Ross Sea region. The Working Group also welcomed the intent for monitoring of this penguin colony in the Ross Sea region to continue.

Diet and consumption estimates

3.41 The Working Group reviewed several papers on predator diet and methods to estimate total consumption. WG-EMM-17/P02 reported on diet content of gentoo penguins (*P. papua*) at Bird Island, South Georgia. The Working Group noted that gentoo penguin diets are characterised by fish and krill mixtures, with krill or fish assuming the dominant proportion in most years. Despite mixed diets, reproductive performance was best modelled based on the mass of krill in the diet. The Working Group noted that the sensitivity of breeding success to krill availability, even for species that consistently rely on multiple prey types, supports inference of the importance of krill for these predators.

3.42 The Working Group considered WG-EMM-17/13, which provided results from recent work using the extraction of prey DNA from penguin faecal samples as a non-invasive procedure to complement CEMP Standard Method A8. Primary results suggested that the method is able to identify interannual variability in diet and the identification of soft-bodied prey (e.g. Scyphozoa, Ctenophora and Siphonophora) that are not typically identified in standard stomach lavage studies. WG-EMM-17/13 outlined a pilot study to compare the prey DNA approach with stomach lavage from simultaneous samples collected from Adélie penguins.

3.43 The Working Group noted the potential importance of the method presented in WG-EMM-17/13 as an alternative to more invasive sampling methods, noting that in some cases non-destructive sampling methods can also be more cost effective. It was also noted that it was important to further validate the approach and consider the purpose of the data collection and requirements for particular sampling methods, and to also consider how changes in sampling methodology over time may affect data utility. The Working Group also noted that opportunistic data collection on diet could be a useful addition to ongoing diet studies. For example, the Working Group noted that the collection of stomach samples from flying seabirds incidentally killed by ship collision and during fishing operations may provide a potential source of data on krill consumption by these species.

3.44 The Working Group considered two papers based on the bioenergetics model of Southwell et al. (2015) to estimate consumption rates for Adélie penguins. WG-EMM-17/32 adapted the model to a Signy Island population and extrapolated results across breeding populations throughout Subareas 48.1 and 48.2 from abundance data collated by the mapping application for penguin populations and projected dynamics (MAPPPD) program. The Working Group noted that per capita consumption estimates ranged from 0.6 to 1.1 kg of krill and fish (approx. 96% of which is krill) and that translates to 293 815 tonnes of krill in Subarea 48.1 and 51 215 tonnes of krill in Subarea 48.2. The Working Group noted that these estimates are comparable, but more comprehensive, estimates of consumption reported by Lishman in 1983.

3.45 The Working Group noted that additional analysis on macaroni penguins (*Eudyptes chrysolophus*) was conducted last year and that analysis of chinstrap (*P. antarctica*), and potentially gentoo penguin, consumption was planned by the authors of WG-EMM-17/32 for the near future, highlighting the continued efforts to improve data on prey consumption by penguins.

3.46 WG-EMM-17/12 extended the bioenergetics analysis to examine consumption of the penguin population that includes breeders and non-breeders present in the colony and the component of the population that is not present at the breeding colony (including juveniles, pre-breeders and non-breeding individuals that remain at sea). The non-breeding component of the population can be large, and the authors reported that the size of the non-breeder population at Béchervaise Island may be approx. 76% of the entire breeding population. The Working Group welcomed this important analysis and agreed that estimating the consumption by the whole population must be considered to appropriately estimate predator demand for krill, taking into account the spatial foraging range of breeders and non-breeders (WG-EMM-17/07).

3.47 The Working Group noted that work to update estimates of krill consumption by flying seabirds is another priority of the Working Group and that estimating krill consumption of flying seabirds remains a data gap. Toward filling that gap, WG-EMM-17/11 provided an update on progress to estimate abundance for flying seabirds (including Antarctic petrels

(*Thalassoica antarctica*), Cape petrels (*Daption capense*), southern fulmars (*Fulmarus glacialoides*), snow petrels (*Pagodroma nivea*) and Wilson's storm petrels (*Oceanites oceanicus*)) from east Antarctic Divisions 58.4.1 and 58.4.2. The paper suggested that published counts of breeder abundance may be an order of magnitude lower than true population sizes, particularly given results that 2% of the potential flying seabird breeding habitat in Divisions 58.4.1 and 58.4.2 has been surveyed.

3.48 The Working Group welcomed these studies on updating consumption and abundance data for important krill predators and noted that the detailed description of ongoing search and census methods for snow petrels described in WG-EMM-17/11 may provide a model for improving abundance estimates of other flying seabird species. The Working Group further noted that complementary research in Subarea 48.1 to track understudied demographic groups, including male fur seals, juvenile and non-breeding penguins, will help to better understand the ecological role of krill predators in the Antarctic ecosystem.

3.49 Whales represent important krill predators in the Southern Ocean and WG-EMM-17/14 provided an analysis of minke whale (*Balaenoptera acutorostrata*) feeding habits and prey consumption. Data were collected from lethal sampling in International Whaling Commission (IWC) Antarctic management Areas III, IV, V and VI-West that occurred between 1989 and 2014 and was permitted by the Japanese whale research programs JARPA and JARPA II. The paper estimated daily prey consumption of 207 to 397 kg, depending on maturity stage and sex of the whale. The authors extrapolated krill consumption based on minke whale population estimates and suggested a total consumption of 6.1 million tonnes.

3.50 Regarding WG-EMM-17/14, some technical and analytical issues were raised with the paper. Thus, the Working Group was unable to comment further.

3.51 The Working Group noted that a general understanding of the ecological role of whales in the Antarctic ecosystem was important in an ecosystem-based approach to fishery management, and that the planned workshop between SC-CAMLR and the IWC SC would provide an opportunity to discuss this, including the technical issues raised at this meeting (paragraphs 5.20 to 5.23).

Habitat modelling

3.52 The Working Group considered a number of papers about penguin foraging behaviour and foraging habitats. WG-EMM-17/P01 reported on the foraging behaviours of chinstrap penguins at King George Island during the transition from incubation to chick-rearing period.

3.53 The Working Group welcomed this paper, noting that analyses of long-term monitoring of interannual variability in foraging behaviour in this colony will be presented at future WG-EMM meetings.

3.54 The Working Group considered WG-EMM-17/33 and17/34 that presented habitat models for chinstrap penguins. The models are based on at-sea tracking data. WG-EMM-17/33 developed the habitat model for chinstrap penguins breeding in the South Orkney Islands (Subarea 48.2) using global positioning system (GPS) and time depth recorder (TDR) telemetry data and WG-EMM-17/34 extended the models to Subarea 48.1 to predict suitable foraging habitat for penguins breeding in the South Shetland Islands using both GPS and Argos platform terminal transmitter (PTT) telemetry data. This modelling work was supported by the CEMP Fund.

3.55 Key results from WG-EMM-17/33 suggested that birds from all colonies tended to dive throughout the trip rather than commuting to specific foraging areas and that models built from location-only data performed as well as models that combined location and diving behaviour data. Selection of the model identified geometric covariates of distance from, and bearing to, the colony as the most informative habitat predictors. The models predicted a high probability of occurrence of chinstrap penguin habitats in shallow areas around the South Orkney Islands, including in areas that overlap with the main fishing grounds northwest of the South Orkney Islands.

3.56 WG-EMM-17/34 described the adaptation of the model described in WG-EMM-17/33 to the South Shetland Islands. This paper provided a validation for the use of raw tracking data derived from Argos location estimates as an input into habitat models, greatly expanding the utility of numerous tracking datasets. Models built with different underlying datasets showed comparable results highlighting chinstrap affinity for shallow coastal zones with slow-moving water, but with birds moving towards, and spending time in, the faster-flowing water beyond the shelf break. The analyses highlighted several hotspots of chinstrap penguin density in the western Bransfield Strait and north of King George Island. The results suggested that chinstrap penguins preferentially occupy habitats that are also important to the krill fishery, but for which we have little understanding of krill retention, depletion or replenishment rates, particularly on the spatial scales that are important to predators.

3.57 The Working Group welcomed these papers, noting that they address important gaps in understanding the distribution of predator demand in Subarea 48.1 and the foraging ecology of penguins in general.

3.58 The Working Group recalled previous work to explain the locations of large colonies of chinstrap penguins and the potential influence of sea-ice dissipation (Ichii et al., 1996). The Working Group noted that sea-ice variables and other environmental covariates were considered in the models, but that the coarse spatial resolution of available satellite data, relative to the fine-scale movements of predators from breeding colonies, limited their utility as covariates in this analysis.

3.59 The Working Group further discussed the general utility of the results from the habitat modelling with respect to the identification of wide-spread coastal areas as potential habitat for chinstrap penguins during the breeding season. In particular, the Working Group noted that the distribution of the chinstrap penguin population will affect predation pressure within the potential foraging habitat. The Working Group agreed that a better understanding of interactions between predators, prey and the fishery in these coastal areas is desirable. The Working Group further noted that an experimental framework could be developed within coastal zones to help study how krill movement and predation interact in the absence of fishing. Such experimental approaches could help to resolve the relative roles of predation and flux on krill distributions and improve the assessment of potential fisheries impacts on krill predators (paragraph 3.36).

3.60 The Working Group noted that results of the habitat models could help parameterise a risk assessment for the krill fishery and may help prioritise areas for such research. The Working Group recalled that a risk assessment required appropriate data from predators and the fishery, and that not all predator data relevant to the risk assessment process are CEMP data. The Working Group noted that several non-CEMP datasets are available (e.g. tracking data, at-sea observations) and that improving visibility of such data would be helpful. The Working

Group agreed that a metadata database to assimilate attributes of data that may be useful for a risk assessment would improve accessibility and transparency of the risk assessment process (paragraph 3.38).

3.61 The Working Group recalled a study (Warren and Demer, 2010) that reported that high and stable krill densities may be accrued in shallow nearshore waters up to 500 m in depth. This krill biomass may be more important ecologically for penguin colonies than krill found offshore. The Working Group noted that fishing vessels cannot operate in very shallow water, which can reduce some of the spatial interactions of fishery and penguins, but the Working Group recalled that there is evidence of overlap in predator foraging distributions and fishing activity. The Working Group also recalled previous studies that show that the krill fishery does operate close to shore at times (WG-EMM-16/17; SC-CAMLR-XXXV/BG/14), including within 5 km of the coast.

3.62 The Working Group noted that it is necessary to establish appropriate temporal scales for investigating interactions between predators, prey and the fishery. For example, criteria are needed for understanding observed krill biomass variability and for separating potential impacts of the fishery, predator consumption and environmental changes. It further noted that the predator feeding behaviour in relation to prey switching, prey distribution and prey density is another important issue to understand predator demand, and encouraged research in this field.

3.63 Dr S. Kasatkina (Russia) expressed concern that it would be difficult to adequately parameterise a risk assessment framework for the krill fishery at small spatial and temporal scales without the development of new field programs. Furthermore, she highlighted that a risk assessment for the krill fishery might require the development of target points for predator population states and that these target points should form part of krill fishery management. She noted that without reference points it would be difficult to clarify the extent to which the fishery is having an impact on the status of krill resources and krill-dependent predators.

3.64 The Working Group briefly discussed the appropriate scale for a risk assessment. It recalled that the risk assessment is intended to be an iterative process, and the scale of the risk assessment should be sensitive to the availability of data.

3.65 The Working Group considered an approach to identifying important bird areas (IBA) provided in WG-EMM-17/35. This paper updated prior analyses presented to WG-EMM (WG-EMM-15/32, WG-EMM-16/20) on methods to identify IBAs for penguin conservation.

3.66 The Working Group noted that the methods used in this analysis had identified five IBAs in Subareas 48.1 and 48.2 that cover the most important at-sea areas of ca. 100 000 pairs of chinstrap penguins, 200 000 pairs of Adélie penguins and 6 000 pairs of gentoo penguins. The IBA approach was compared to models described in WG-EMM-17/33 and, in general, the Working Group noted the general overlap of spatial results generated by the two approaches.

CEMP data

3.67 The Secretariat presented WG-EMM-17/17 that provided an update on the CEMP data submitted to the Secretariat and analysis of existing data from Subarea 48.1. The Working Group welcomed the submission of data from, and the establishment of, the new Narebski Point CEMP site in Subarea 48.1 by the Republic of Korea. The update on the spatial analysis of

CEMP data in Subarea 48.1 using combined standardised indices (CSIs) for breeding season parameters and population size data demonstrated a considerable degree of concordance between parameters for sites on either side of the Bransfield Strait. The long-term change in the standardised Adélie and chinstrap penguin breeding population size from 2000 to 2017 showed an early period characterised by a concordant decline, followed by a recent period with no trend, but with a lower level of concordance. The concordance in the combined indices using breeding season parameters indicated that predators show a similar response to conditions at the scale of the subarea, whereas the lower level of concordance in breeding population indices likely reflects the much larger spatial and temporal scales that influence these indices.

3.68 The Working Group thanked the Secretariat for this update and noted that the changing pattern observed in population size indices in recent years reflected changes in the index of population size at different sites and the method of standardisation rather than in an absolute measure of penguin abundance. The Working Group noted that further work on CEMP data analyses was planned (WG-EMM-17/02) as part of the proposed five-year work plan for the Scientific Committee. The Working Group recognised that evaluating different methods for the presentation of CEMP data would be valuable as part of this work. The Working Group thanked all Members that contributed data to CEMP and encouraged the consideration of the submission of additional data, consistent with the objectives of CEMP, including information from the use of new technologies for the collection of CEMP data.

3.69 WG-EMM-17/03 provided an assessment of the use of UAVs to assess the population size of Adélie, gentoo and chinstrap penguins at King George Island. Analysis of images from the UAVs provided an estimate of approximately 30 000 nests in 12 breeding sites during 2016. The study indicated that the main obstacles for the use of UAVs for population assessments were harsh weather conditions resulting in infrequent suitable conditions for UAV flights. There were also difficulties distinguishing between Adélie and chinstrap penguin nests at the same site because they have similar inter-nest spacing. Dr Korczak-Abshire highlighted the importance of starting the UAV a suitable distance from the colony to reduce the impact from noise on penguins during take-off. Despite some difficulties, the technology allowed access to areas for population counts which had not been previously accessible. The Working Group congratulated the authors and noted that the initiatives summarised in WG-EMM-17/03 were of considerable interest for CEMP and broader ecosystem monitoring.

3.70 Understanding where krill predators forage to provide overlap indices between tracking data and the spatial distribution of krill catches is a priority for the Working Group. WG-EMM-17/07 provided a brief update on progress towards this from a tracking study funded and supported by the Secretariat. Data from the deployment of 130 instruments during the 2016/17 breeding season at sites including King George Island, Livingston Island, Cierva Cove and Galindez Island, indicated a high level of utilisation of coastal zones by gentoo penguins, while Adélie and chinstrap penguins exhibited larger-scale movements into pelagic areas. The spatial use by penguins showed that some individuals stay within the small-scale management units (SSMUs) containing the deployment site, whereas others go beyond the SSMU. The Working Group noted that results emerging from this work were of interest. These results demonstrated both spatial and temporal overlap between the distribution of juvenile Adélie penguins tracked from Subarea 48.1 in this study and the location of post-breeding adult Adélie penguins tracked from Signy, Powell and Laurie Islands in Subarea 48.2 (in studies carried out by UK and Argentinean scientists in recent years). The areas used by all these penguins were to the south of the South Orkney Islands.

3.71 In recent years, the Working Group has acknowledged and welcomed the opportunity for expanding monitoring for CEMP by the use of remotely operated cameras. One recommendation associated with the use of cameras was the need to have a consistent approach to analysing images derived from these cameras. WG-EMM-17/10 described progress to develop a software tool for assessing nest camera images to achieve this objective. The Working Group was informed that work is currently underway through the Australian Antarctic Division to develop this software. Specifications for the software followed a consultation process with the CCAMLR camera users group. The Working Group noted the importance of this project to allow consistent data interpretation and analysis of images from the expanding camera network, and thanked the authors for their efforts to progress this work.

3.72 WG-EMM-17/16 Rev. 1 provided a brief update in the progress of the CEMP Special Fund project to establish a camera network in Subarea 48.1. The project was initiated in 2014/15 and is now fully operational. In 2016/17, data were recovered from 50 cameras across the range of the camera network which were monitoring Adélie, gentoo and chinstrap penguins at their breeding sites. Data summaries indicated variation in phenological timing within species across sites with relatively high reproductive success for all species across sites. The data indicated generally good breeding conditions across the camera sites, with breeding chronology varying primarily in relation to latitude. The paper also noted that Chile intends to extend the camera network with three new installations along the Peninsula. The Working Group noted that development of remotely operating cameras for collection of breeding success and phenology data is important for CEMP because it has allowed the expansion of monitoring to new sites, as well as the continuation of monitoring at sites where data collection would otherwise no longer be possible.

3.73 WG-EMM-17/21 described progress on the installation of cameras at Galindez, Petermann and Yalour Islands as the beginning of annual monitoring of chronology and breeding success of chinstrap and Adélie penguins in Subarea 48.1. The paper reported the successful operation of cameras and downloading of photos in the 2016/17 season and deployment of 15 satellite trackers on adult gentoo penguins. The Working Group thanked Ukraine for its contribution to the camera network project in Subarea 48.1, funded by the CEMP Special Fund. Dr L. Pshenichnov (Ukraine) highlighted that detailed and expanded information will be submitted to the meeting of the Scientific Committee in October 2017.

3.74 The Working Group recalled that additional cameras were being used for penguin monitoring in the Antarctic Peninsula through Penguin Lifelines (https://penguinlifelines.wordpress.com) and that data from these cameras could be useful for expanding CEMP camera monitoring. Dr P. Trathan (UK) agreed to approach the organisers of this initiative to explore whether the data could be made available.

3.75 Dr Kasatkina noted that it is important to clarify how the design of CEMP data sampling matches with predator distributions and population structure. Analysis of the structure and trends of CEMP indices should provide adequate information to reveal the response time between fishing activity and predator response and to delineate changes in CEMP indices caused by fishing activity and concurrent changes in the relationship between predator species.

Other monitoring data

3.76 WG-EMM-17/01 Rev. 1 presented Adélie penguin breeding success data from Adélie Land in East Antarctica, showing that in two out of the last three years there had been total reproductive failure across the colony. The paper described changes in the environment over the last six years in the vicinity of the colony, including extensive sea-ice preventing penguins from adequately provisioning their offspring coupled with poor weather conditions resulting in further chick mortality. The Working Group noted that there is information about pelagic prey in this sector from Japanese, Australian and French surveys conducted in the region. It further noted that the opening of a polynya immediately offshore of the colony allowed access to inshore depressions where penguins consumed Antarctic silverfish (*Pleuragramma antarctica*) and krill (*E. superba*), and that these conditions were associated with high breeding success. The Working Group requested further analysis of penguin data in relation to sea-ice and the pelagic prey field in the region.

3.77 The Working Group welcomed the submission of WG-EMM-17/01 Rev. 1. It noted that other penguin breeding sites had years with occasional reproductive failure (e.g. WG-EMM-17/P02). The Working Group considered that it was important to continue to monitor this site, particularly given the unusual environmental conditions in the area that have not been observed during the last six decades of monitoring. The Working Group encouraged submission of data from this site to CEMP and noted that data from this site is consistent with the objectives of CEMP and that the site could be used as a reference area to compare with other sites to distinguish changes due to fisheries compared with environmental change.

3.78 WG-EMM-17/49 outlined approaches for estimating abundance of Type A killer whales in the coastal waters around the Antarctic Peninsula. The study used satellite telemetry and photographic identification of individual whales over a decade to describe movement patterns of the whales and to estimate their abundance trends. Tracking data indicate wide-ranging movements, while the photographic record suggests an affinity of this population to the coastal areas along the Antarctic Peninsula and an increase in their annual abundance. The increase in abundance may be a result of changes in the sea-ice conditions and the positive influence that may have had on the whale’s key prey species.

3.79 The Working Group welcomed such information regarding top predators and was interested in the increase in Type A killer whale abundance and recommended that this topic be included for consideration in preparation for the Joint SC-CAMLR–IWC Workshop (paragraphs 5.20 to 5.23).

Fishery dynamics

3.80 WG-EMM-17/27 described an analysis of metrics of interannual, monthly and inter-vessel variability from the krill fishery in Subarea 48.1 between 2010 and 2016. The analysis used standardised catch per unit effort (CPUE) as an index of krill biomass to propose that, as the krill biomass during the fishing season did not decrease, this provided evidence of krill biomass replacement due to flux and did not support the hypothesis of the fishery having an impact on krill-dependent predators.

3.81 The Working Group questioned the utility of using an overall CPUE from the krill fishery as an index of krill biomass as there was unlikely to be a consistent relationship between krill density and catch rates, as vessels target different quality of krill for particular products and were unlikely to simply optimise catch rates. There are probably also trends in the data due to development of technology and experience in the fleet.

3.82 Dr Kasatkina noted that CPUE values were standardised using GLM. She emphasised that the additional evidence on krill biomass replacement in the fishing grounds during the fishing season is that the dynamic change in the krill biomass was reflected by increasing CPUE of all vessels operating there. Moreover, observed changes in CPUE values correspond with acoustic observations on krill density provided on board Chinese commercial vessels operating in the fishing grounds (WG-EMM-17/40).

3.83 The Working Group noted the comments from WG-SAM on an analogous analysis (WG-SAM-17/23 and Annex 5, paragraphs 4.56 to 4.59), in particular the benefit of using GLM and/or GLMMs to use fishing method as an explanatory variable in the analysis, rather than to analyse fishing methods separately. Such an analysis should also include information of the product type being produced by a vessel as well as some index of technology development and experience of a vessel in the fishery.

3.84 The Working Group also noted that such an analysis would be required in order to substantiate the hypothesis presented in WG-EMM-17/27 on the role of krill flux and the absence of an effect of the fishery on krill-dependent predators.

3.85 Dr Kasatkina highlighted that investigation in WG-EMM-15/21, WG-EMM-16/40 and WG-EMM-17/27 had shown that the product type being produced, daily processing capacity and other indices of technology development can have a significant impact on the strategy of a fishing vessel that can influence the resulting CPUE values. She recalled that while information on vessel capacity and product type was included in the notifications it was not possible to use this information for daily or monthly analyses of CPUE.

3.86 The Working Group recalled the discussion on the issues with the reporting of krill catches in two-hour periods in the continuous fishing system (SC-CAMLR-XXXV, Annex 6, paragraphs 2.18 to 2.22) and that these discrepancies probably meant that an accurate estimation of CPUE from the continuous fishing system may not be possible with the data provided to CCAMLR at present.

3.87 WG-EMM-17/45 presented an examination of the fishing behaviour of the Chinese krill fishing fleet using the frequency distribution of distances between consecutive krill fishing locations and to investigate which random walk model best describes the pattern in the fishery. The results indicated that the behaviour of the Chinese fishery is consistent with a Levy walk model consistent with previous analyses of the Japanese krill fishery (WG-EMM-09/18).

3.88 The Working Group welcomed the analysis presented in WG-EMM-17/45 and noted that:

(i) it provides a baseline from the early years of the Chinese krill fishery against which to compare future changes in the behaviour of the fishery

(ii) changes in the slope parameter μ of the power function that might reflect spatial differences in the operation of the krill fishery, noting that both the analyses in WG-EMM-17/45 and WG-EMM-09/18 indicated differences between subareas in the form of the power law parameters

(iii) it suggested that the behaviour of the krill fishery was analogous to the foraging of natural predators and, hence, that the fishery was operating in the same way as other krill predators, which would also include analysis of the spatial concentration effects of the fleet, a factor that often is considered important for the spatial distribution of fishing effort.

3.89 The Working Group suggested that linking the analysis with acoustics data on the distribution of krill swarms collected from the krill fishing vessels would provide a means to expand the analyses to examine the relationship between fishery behaviour, krill abundance and catch rates.

3.90 Dr X. Zhao (China) introduced the elements of the report of SG-ASAM-17 (Annex 4) that were of particular relevance to WG-EMM. The major outcome of the SG-ASAM meeting had been the agreement on a swarm-based approach to acoustic data analysis, rather than the traditional along-transect echo-integration approach. SG-ASAM had also tested, and agreed to, the use of an EchoView template for automated data processing of acoustic data collected on fishing vessels to be used during the method development.

3.91 Dr Zhao also noted that SG-ASAM had reiterated that 70 kHz was likely to be the optimal frequency for krill, with an increasing number of krill fishing and research vessels being equipped with 70 kHz transducers, and encouraged further research on the properties of this frequency for krill biomass estimation.

3.92 The Working Group supported the agreement from SG-ASAM on the value of the collection of acoustic data by each vessel in the fishery from at least one nominated transect each month. In response to the suggestion from SG-ASAM on the need to examine incentives for vessels to undertake these transects, the Working Group encouraged all Members, particularly those engaged in the krill fishery, to propose implementable incentives and/or regulations to promote the undertaking of those krill acoustic transects (Annex 4, paragraphs 4.1 and 4.2).

3.93 The Working Group noted that in 2014 SG-ASAM had indicated that it planned to provide a method for processing krill acoustic data from krill fishing vessels by 2017 and congratulated all participants of the Subgroup for achieving this important objective.

3.94 Dr Godø thanked Dr Zhao and his colleagues for the very successful SG-ASAM meeting in Qingdao, China, that had made a major step forward in the ability of CCAMLR to use acoustic data from krill fishing vessels. Importantly, he noted that the agreement to use a swarm-based approach provided a method that was simple enough to allow an automated approach to data processing.

3.95 The Working Group noted that the use of the swarm-based approach provided a method to deliver very useful data on the distribution and abundance of krill at biologically meaningful scales that was not dependent on the use of calibrated two-frequency echosounders.

3.96 Dr Y.-P. Ying, the recipient of a CCAMLR scientific scholarship for 2017 and 2018, presented WG-EMM-17/41 on the standardisation of krill CPUE and comparison of krill CPUE and acoustic data collected from Chinese fishing vessels in Subarea 48.1. The analysis used general additive models to standardise CPUE data collected from Chinese fishing vessels from 2010 to 2014 and compared the CPUE data and acoustic data collected by the Chinese fishing vessel *Fu Rong Hai* from 2016. The result compared CPUE (catch per hour) and catch per vessel per day (CPVD) with the nautical area scattering coefficient (NASC) from concurrent acoustics over time and also investigated the potential effect of vertical distribution and movement of krill on the relationship between CPUE and acoustic data.

3.97 The Working Group congratulated Dr Ying on his analysis that provided a novel insight into the operation of the krill fishery and was another good example of the success of the CCAMLR scholarship scheme. The Working Group provided advice on the future development of the CPUE standardisation model, including the need to examine potential autocorrelation effects, examining the impact of daylight and diel changes in depth and the use of model selection approaches to determine the most suitable model configuration.

3.98 WG-EMM-17/41 included an analysis that showed the increase in the depth of the maximum values of NASC and the depth of fishing from March to May. However, the Working Group noted that although the fishing depths increased, the vessels appeared to be targeting shallower depths than the depth of the maximum NASC. This might indicate that as krill move deeper, the same amount of krill could be available in the water column but the portion of this krill that is in the upper 100 m, and most accessible to both the fishery and krill predators, might decrease and this could hence potentially increase the level of competition between fishery and predators.

3.99 The Working Group also suggested examining the potential to detect a threshold krill density for the operation of the Chinese krill fishery and comparison with historical analysis of Soviet fishing fleet dynamics.

3.100 In considering the analysis presented in WG-EMM-17/41, the Working Group noted that at a daily resolution CPVD appeared to show a closer relationship with the NASC values. The CPUE, the catch per hour when the vessel was actually fishing, could provide an index of krill density within individual swarms whereas the CPVD provided an index of the abundance of krill swarms as this index implicitly included searching time. The Working Group noted that the index of CPVD could be considered analogous to the foraging behaviour of a natural krill predator in which foraging success (krill consumption per day) would be expected to vary with the number and quality of krill swarms in an area.

3.101 WG-EMM-17/44 examined approaches to linking acoustics scattering to catch to study relationship between measures of CPUE and acoustics. The analysis of CPUE (catch per hour) and catch per unit area (CPUA) found that day time catches are higher than night-time catches. There was also a high correlation between catch/CPUA and NASC, but the authors underlined that more data is needed to properly study these relationships. They suggested that catch information might become an important source of informative on krill abundance and dynamics when used with caution.

3.102 The Working Group agreed that CPUE is a fundamental metric used in fisheries but its interpretation and use reflects specific attributes of different fisheries. Whereas, in some demersal finfish fisheries CPUE can provide a suitable index of biomass, this is not the case for small pelagic fisheries such as the krill fishery. Nevertheless, measures of catch and the effort/investment in obtaining those catches provides important information about the operation and performance of an individual vessel and/or an entire fishery. Therefore, when using CPUE data for preliminary (indicative) krill stock estimation, in case when no acoustic data are available, the methods should be specifically designed to ensure an adequacy of the used approach.

3.103 The Working Group agreed that the analyses presented in WG-EMM-17/40, 17/41 and 17/44 indicated that the combination of CPUE data and concurrent acoustic data provides a potentially powerful approach to the analysis of indices of CPUE.

3.104 The Working Group agreed that making progress on the use of indices of CPUE from the krill fishery would benefit from the extension of the analyses presented in WG-EMM-17/41 to different vessels fishing in different subareas and years. The Working Group encouraged the further analysis of CPUE and noted that such analyses should include a clearly articulated objective and use a measure of CPUE that was specifically designed to address this objective.

3.105 WG-EMM-17/08 described the surveys by the Republic of Korea carried out in Subarea 48.1 in the 2015/16 and 2016/17 fishing seasons, following the transects of the US AMLR Program to estimate the density and biomass of krill around the South Shetland Islands using the krill fishing vessels *Kwang Ja Ho* with 38 and 120 kHz echosounders in April 2016 and *Sejong Ho* with 38 and 200 kHz in March 2017. The paper included an update from the analysis presented in SG-ASAM-17/04 to include the use of the swarm-based approach to estimating krill abundance. The results from these surveys indicated that krill density and biomass were significantly higher in 2016 than in 2017.

3.106 It was noted that the 2017 survey used 200 kHz for biomass assessment and this may make results sensitive to krill behavioural impacts and reduces depth range available for assessment. The Working Group noted the discussion and recommendations at the SG-ASAM meeting (Annex 4) in relation to the use of this frequency. The Convener of SG-ASAM clarified that the use of the dB difference method is recommended as part of the CAMLR standard method for scientific acoustic surveys. However, an alternative more robust method (the swarm approach) is recommended to support collection of acoustic data, including automatic processing on board fishing vessels.

3.107 The Working Group welcomed the details of these two surveys conducted by acoustic scientists on board Korean fishing vessels and this was a very positive development for CAMLR.

3.108 The Working Group emphasised the progress made in collecting and using acoustic data from krill fishing vessels and thanked all those engaged in the planning, collection and analysis of this data.

Operational management regimes for FBM in the krill fishery

3.109 The Working Group noted WG-EMM-17/20, which described the first steps towards the development of a risk assessment of the krill fishery in Divisions 58.4.1 and 58.4.2, in response to the re-initiation of commercial krill fishing in this region. It noted that data layers on the historical distribution of krill catch, acoustic krill densities from the BROKE-West survey, and krill predators, including crabeater seals (*Lobodon carcinophagus*), penguins, flying seabirds and baleen whales, had been assembled for input into the risk assessment. It noted that the risk assessment was intended to evaluate whether the current conservation measures that apply in this region sufficiently mitigate the risk of the krill fishery disproportionately concentrating catches in areas that are also important to krill predators, using the same framework used for Area 48 (WG-EMM-16/69).

3.110 The Working Group welcomed the development of a risk assessment for the krill fishery in East Antarctica. It noted that the risk assessment method was becoming one of the approaches in the development of management procedures for the krill fishery. It encouraged the further development of the risk assessment for Areas 48 and 58, and recommended that the methodological components of the risk assessment and development of data layers be considered at WG-SAM-18. It further noted that as some datasets are relatively old or sparse, and, as the Southern Ocean is undergoing change, it recommended that explanatory habitat models be developed for incorporation into the risk assessment. It also recommended that data layers be developed that incorporate the changes in the historical krill fishery in relation to sea-ice retreat and position relative to the shelf break. It further recommended that scenarios be developed to evaluate the appropriate scale at which the krill catch might be distributed off East Antarctica.

Spatial management in Planning Domain 1

Data layers for Planning Domain 1

4.1 Dr Santos, Lic. A. Capurro and Dr Cárdenas presented WG-EMM-17/23, 17/24 and 17/25 Rev. 1, which were introduced in a single presentation which described the design process for an MPA in Domain 1 led by Argentina and Chile. The process has followed a multinational approach since its inception in 2012, and has resulted in the compilation and analysis of a large amount of information, including eight conservation objectives and 143 spatial data layers.

4.2 An MPA model was constructed using Marxan and took into account climate change and krill fishery management. Priority Areas for Conservation were identified among the three ecoregions – South Western Antarctic Peninsula (SWAP), North WAP (NWAP) and South Orkney Island (SOI) – which differ not only in their ecology, but also in their current management and resilience to climate change. The preliminary proposal incorporated fishing management strategies that included a combination of General Protection Zones and Special Fishery Management Zones (Figure 1), to take into account aspects such as spatial variability and the balance between fisheries and priority areas for conservation. Given the complexity of the area and the large number of human activities in the region, an Expert Group (referred to in the document as Steering Committee) was proposed. The Proponents expressed their gratitude towards all Members and Observers that were involved in the different stages of the planning process.

4.3 WG-EMM-17/22 described the work of Lic. Andrea Capurro, a CCAMLR scholarship recipient mentored by Dr Grant and co-mentored by Dr Santos. The work aims to improve the understanding of spatial and temporal variability in krill fishing activity in Domain 1, by providing further detail on the location of areas of high concentration of krill catches – or 'hotspots' – across an 11-year period from 2005/06 to 2015/16 aggregated by month and by year. The work investigated whether these hotspots could be incorporated into a single cost layer that adequately accounts for the variability in fishing dynamics, to assist in the MPA planning process. The authors concluded that the development of a single cost layer that adequately represents fishery patterns for Domain 1 is not feasible. However, krill fishing catch and effort information is an integral part of the Domain 1 MPA planning process and should be incorporated into the consideration of required management provisions, once priority areas for conservation have been identified.

4.4 The Working Group congratulated Lic. Capurro for the work done in the context of the scholarship and encouraged Members to continue to support this young scientist and her work associated with the Domain 1 initiative. The work provides a clear picture of the development of interannual and seasonal variation in fishing distributions. The Working Group noted that work on Domain 1 had progressed considerably since the workshop held in the margins of WG-EMM-16, and thanked colleagues from Argentina and Chile for this important step towards an MPA for a complex ecosystem in which climate change is a major threat. The Working Group appreciated:

(i) the submission of the three documents on 'Domain 1 Marine Protected Area Preliminary Proposal' (WG-EMM-17/23, 17/24 and 17/25 Rev. 1) which give comprehensive information about the scientific elements of the spatial planning process that was used

(ii) the impressive number of geographic layers used in this work (143 layers) which allowed identification of ecoregions from their abiotic and biotic characteristics.

4.5 Proponents of the Weddell Sea MPA (WSMPA) emphasised that both the Domain 1 and Domain 3 planning processes, that were undertaken separately, identified similar priority areas for protection in the overlap (approx. 4° latitude overlap) between the two domains.

4.6 Some participants suggested that additional data could be included in the analysis, such as further information on krill distribution and movement, and that krill distribution might be a useful proxy for the potential distribution of fishing. It was noted that the CCAMLR synoptic survey information on krill distribution is 17 years old and that a new survey might help with FBM and MPA planning. The proponents clarified that krill distribution data from KRILLBASE was included in their analysis. Complementary analyses that identify current and future favourable nursery areas for krill will be added and results will be presented during the meeting of the Scientific Committee in October 2017.

4.7 All data used in the proposal, including metadata, is available through the Domain 1 planning e-group. It was noted this data could be useful for other strategies such as spatial management of krill (paragraph 3.41).

4.8 Some Members expressed concern that krill fishing was not included as a cost layer in the analysis, and noted that other human activities also occur in Domain 1, including some research projects on toothfish species to the east of the South Orkney Islands. The proponents presented evidence and stressed that the main reason for not including information on the krill fishery as part of a single cost layer was the temporal variability in fishing patterns (as demonstrated in WG-EMM-17/22), with the effect that there is no distribution that adequately reflects fishery distribution for more than a few years. The proponents concluded that, since the variability of the fishery cannot be directly reflected in a cost layer, further research will be conducted into the potential displacement of fishing effort in order to evaluate management scenarios. The Working Group agreed that methods such as this could be an appropriate way to include information on fisheries in the MPA planning process, and looked forward to further results.

4.9 Dr Godø expressed concern that the Working Group was not provided with sufficient evidence that a cost layer based on krill fishing information could not be used, as concluded by the proponents. He asked the proponents to provide further information on the cost layers which had been considered, including associated Marxan results.

4.10 The Working Group discussed the proposed coastal buffers in NWAP-foraging grounds and SOI-benthic (Figure 1) and whether they should exist all year round or just during the predator breeding season. The proponents explained that these buffers should apply year-round in order to protect, inter alia:

(i) foraging areas of predators during summer

(ii) early stages of fish (larvae/young juveniles) that may be taken as by-catch by krill trawlers and

(iii) whale feeding grounds.

4.11 Some participants suggested that the coastal buffers were important for minimising by-catch of larval fish by the krill fishery and were coherent with the ecological (important bird and mammal areas, fish essential habitats) and environmental values (large-scale pelagic system) of the area as described in WG-EMM-17/24. Other participants suggested that the fishery attempts to avoid by-catch to minimise catch contamination due to the nature of the products from this fishery.

4.12 The Working Group agreed that analysis of observer data on fish by-catch as well as updates on the status of stocks of adult demersal fish would be useful to establish the risks associated with fish by-catch. The research project described in WG-SAM-17/18, if conducted, should provide new information on the status of stocks. Reviewing previous advice from WG-FSA (SC-CAMLR-XXXI, Annex 7, Appendix E, paragraphs 26 and 27) on the status of depleted stocks and the impact of fish by-catch in the krill fishery, would also be worthwhile.

4.13 The Working Group noted that while the MPA design approach described in WG-EMM-17/23 may be adequate for the protection of benthic habitats, alternative approaches may be required to supplement the planning process for pelagic ecosystems.

4.14 Some participants noted that the MPA proposal over-represented some of the conservation objectives and under-represented others. The proponents stressed that some of the under-represented objectives are already protected by CM 24-04, or represented by other conservation objectives. It was also noted that Marxan analyses can lead to over-representation due to spatial complexity, including overlap between layers.

4.15 The Working Group agreed that there might be a need to evaluate how proposed MPAs could contribute to ecological resilience to climate change, particularly in Domain 1 and especially in pelagic parts of the ecosystem which are spatially dynamic relative to fixed MPA boundaries. MPAs which include ecological gradients might be useful in this regard. Also MPAs might be useful reference areas to assess the effects of climate change. The mechanism for responding to climate change might include rapid adjustment to MPA research and management plans.

4.16 The Working Group noted that the uses of MPAs include both fisheries management and ecosystem conservation. In this context, the Working Group noted a need for coordination between the various existing and proposed fishery management approaches in Domain 1. These include existing (CM 91-03) and potential MPAs, krill catch limits at the regional (Subareas 48.1 to 48.4) and subarea scale (CM 51-01 and CM 51-07), protection for areas exposed by ice-shelf retreat (CM 24-04), the prohibition of fishing for most finfish (CM 32-02), and the proposed FBM approach (CM 51-07). The Working Group requested that the Scientific Committee consider a strategy for integrating across the various existing and proposed management approaches for Domain 1.

4.17 The Working Group noted Members are investing substantial research effort to support the management approaches listed above, especially FBM. Where MPAs or other spatial measures displace fishing activity, it is important to evaluate the associated risks. The Working Group noted that ecosystem models can be used to help evaluate the effects of multiple conservation measures on the fishery and the ecosystem.

4.18 Dr Kasatkina noted that the MPA proposal did not provide any evidence of impact of the fishery or other human activities on the ecosystem and biodiversity. Moreover, potential threats from human activities regulated by effective conservation measures are very low, and protection against climate change cannot be achieved by MPAs. She recommended further clarification of the MPA objectives to protect ecosystems and conserve biodiversity, as well as criteria for assessing whether the MPA's specific objectives may be achieved. She emphasised concerns that MPA Planning Domain 1 includes the existing South Orkney Islands southern shelf MPA (SOISS MPA) and Special Areas for Scientific Study of ice-shelf retreat or collapse in Subarea 48.1.

4.19 The Working Group noted the importance of documenting the process by which decisions on proposed MPA boundaries and management regimes are made.

4.20 Some participants stressed that evidence of the need for an MPA in the proposed area should be an important element of the MPA proposal. Such evidence should identify endangered species that are protected by the proposed MPA, provide evidence of negative trends in these species and explain why existing conservation measures are inadequate to achieve this protection. It would be very useful to include in the proposal a forecast of the effects of the proposed MPA on the fishery in Subareas 48.1 and 48.2.

4.21 The proponents proposed that the creation of an Expert Group on Domain 1 MPA development would be an appropriate mechanism for addressing some of the issues that were raised. The proponents further suggested that the Expert Group should include two representatives from each interested Member, and observers from the fishing industry and non-governmental organisations (NGOs). The existing Domain 1 planning e-group should be used to draft the terms of reference for the Expert Group to be considered by the Scientific Committee meeting in October. The priority of the Expert Group would be to identify a work plan with clear goals and deadlines, for work to progress during the intersessional period. The Working Group agreed with this proposal and requested advice from the Scientific Committee on how to include observers from the fishing industry and NGOs in the Expert Group.

4.22 The Working Group noted the need to coordinate with the work plan of the Scientific Committee (paragraphs 6.24 to 6.29), and that some issues, such as how MPAs contribute to ecological resilience, are relevant to other planning domains. The Working Group also noted the opportunity for these issues to be discussed further during the proposed spatial planning workshop to be held during the 2018 intersessional meetings (WG-EMM-17/02).

4.23 WG-EMM-17/37 described analyses of biodiversity data from the 2016 benthic survey of the South Orkney Islands region (SO-AntEco), undertaken by the British Antarctic Survey in collaboration with an international team of scientists from the SCAR State of the Antarctic Ecosystem research program. The aim of the cruise was to investigate biodiversity within selected benthic habitats around the South Orkney Islands in relation to geomorphic zones both inside and outside the SOISS MPA, to detect differences in diversity between habitats, and to map species that are indicative of specific habitat types. This addresses one of the key objectives set out by the draft South Orkney Islands southern shelf MPA Research and Monitoring Plan. The results from this cruise will contribute towards the understanding of benthic habitats and vulnerable marine ecosystems (VMEs) in this region of Domain 1, and will be useful in the review and ongoing management of the South Orkney Islands southern shelf MPA, as well as in the wider context of marine spatial planning for Domain 1.

4.24 The Working Group thanked the authors and looked forward to further results from this survey. The paper provides a useful comparison between methods for assessing benthic assemblages. Previous work has shown identification of VMEs from camera images is as effective as identification by fishery observers (Welsford et al., 2014).

Other business

Weddell Sea MPA

5.1 WG-SAM-17/30 addressed questions raised by WG-EMM-16 (SC-CAMLR-XXXV, Annex 6, paragraphs 3.1 to 3.14) and SC-CAMLR-XXXV (SC-CAMLR-XXXV, paragraphs 5.14 to 5.28), including:

(i) development of additional data layers on flying seabirds and seals
(ii) Antarctic toothfish (*D. mawsoni*) habitat modelling
(iii) new Marxan analyses performed with revised data and cost layers
(iv) outline of how the results of the scientific analyses were translated into the draft WSMPA boundaries and management zones as set out in CCAMLR-XXXV/18.

5.2 The Working Group welcomed the significant work and new updates from the WSMPA project team, and congratulated them on their efforts to address these points.

5.3 The Working Group noted that penguin tracking data are now being collected by South Africa and can be made available for use in future analyses.

5.4 Dr Kasatkina asked for further information on how the MPA boundaries consider ice conditions for research fishing. She noted that the proposal for the establishment of an MPA in the Weddell Sea described the species composition of fish fauna and krill and Russia repeatedly indicated that information on commercial potential of dominant fish species and krill for future rational use should be included into the MPA proposal (SC-CAMLR-XXXIV, paragraphs 3.19 and 3.20). Dr Kasatkina asked what new information on commercial potential for dominant species in the MPA was obtained and what activities in relation to these issues are planned.

5.5 The Working Group noted that an ice analysis model is under development to identify potential ice-free areas suitable for research fishing, and to ensure that regular sampling in these areas is feasible.

5.6 The Working Group recalled the discussions by WG-SAM on this paper, which noted the following points (Annex 5, paragraph 6.8):

(i) the desire for increased clarity on the interaction between the CCAMLR decision rules and the 60% protection targets for toothfish in the Weddell Sea proposal

(ii) importance of determining toothfish life-history and stock dynamics of the region, including the offer from Germany to host a workshop in early 2018 to examine toothfish dynamics and movement in the region in order to inform a working stock structure hypothesis.

5.7 The Working Group supported the suggestion of holding a workshop to discuss the development of a toothfish population structure and movement hypothesis. It noted that WG-SAM had concluded that a stock hypothesis (as developed for the Ross Sea region) was needed to further develop its work in Subarea 48.6 and the wider region. Once a hypothesis has been developed, data can be collected to parameterise a model and used to inform stock assessment. This would be key to the work of WG-SAM as well as helping to inform spatial management in the region.

5.8 The Working Group welcomed Germany's offer to host the workshop, and recommended that representatives from the fishing industry could be invited to attend.

5.9 The Working Group considered WG-EMM-17/42 which outlined technical and procedural recommendations on the use of Marxan analyses to inform the delineation of MPA boundaries and fisheries considerations. Replication of the recursive Marxan approach developed by Germany produced very similar results. Additional comparisons were undertaken to investigate the suitability of data layers, and it was discussed how data layers using weighting schemes in particular might benefit from sensitivity analyses to ensure that appropriate weighting factors had been applied. The paper advised caution when using very sparse datasets, and particularly those where spatial sampling bias is evident. It also suggested that the complex recursive approach developed for the WSMPA planning process may not be necessary, as a simpler non-recursive approach produced very similar results. The use of a simpler approach may help to increase the understandability and clarity of the Marxan analysis, particularly for those Members who are less familiar with Marxan. The paper raised the question of the population structure of *D. mawsoni* in Domain 4, concluding that understanding the distribution of toothfish across the entire Domain 4 will be critical for designing an MPA in this region.

5.10 Prof. T. Brey (Germany) expressed his appreciation for this helpful analysis, which makes a valuable contribution to inform future work. He noted that the data used in the WSMPA analysis were available upon request to any Member who wished to undertake their own analyses. He highlighted that the core priority area for conservation identified by Marxan remained consistent within the range of conditions and settings of parameters explored by both approaches. However, he noted that WG-EMM-17/42 had identified a number of concerns and questions regarding data and analysis that required further consideration. Some of these have already been addressed in the analyses presented in WG-SAM-17/30, but further work will take into account issues including the spatial projection of data, the use of the recursive Marxan procedure, the reliability of the sparse datasets such as the larval krill layer, and the development of separate cost layers for krill and toothfish. He indicated that the WSMPA project team is ready to work with all Members to discuss these issues further, and that they welcome further inputs.

5.11 Dr Godø thanked the WSMPA project team for their cooperation, particularly for their patience in allowing time for Norway to provide this further input. He looked forward to further work to progress the development of this MPA.

5.12 The Working Group encouraged Members to continue working together to look at similarities and differences in their analyses, specifically:

(i) further use of sensitivity analyses to provide robust conclusions

(ii) further consideration and explanation of technical aspects of the use of Marxan, including the most effective use of cost layers, and the inclusion of high selection frequency areas to inform MPA proposals

(iii) consideration of how common ground from analyses presented in WG-SAM-17/30 and WG-EMM-17/42 might be taken forward

(iv) investigation of the ecological consequences of both approaches for the achievement of conservation objectives in the Weddell Sea region.

5.13 The Working Group noted the importance of consistent approaches, particularly when using the same software, for example the use of fishing data to develop a cost layer in Marxan. It noted that it is important to consider best-practice approaches and to find common solutions to technical analyses where possible. The proposed spatial management workshop in 2018 (WG-EMM-17/02) would be a valuable opportunity to consider such issues. However, it is also important to recognise that the unique characteristics, data availability and objectives of different regions should allow for the development of a range of different approaches and methodologies for MPA planning, that may be unique to each region.

5.14 The Working Group acknowledged that different analyses can be helpful in supporting and improving MPA planning processes, particularly where different groups undertake separate comparative investigations that can identify new issues and confirm consistent findings. It welcomed the positive progress on MPA planning for the Weddell Sea region, and encouraged Members to continue collaborating to further develop this work.

Vulnerable marine ecosystem (VME)

5.15 The Working Group considered WG-SAM-17/09 which introduced a new data acquisition protocol for by-catch of benthos in the French fisheries of the Southern Ocean, including Subarea 58.6 and Divisions 58.4.2, 58.4.3a, 58.4.4b and 58.5.1 for use in both longline fisheries and bottom trawl survey activities. Development of the protocol began in 2015 at the Muséum national d'histoire naturelle (MNHN) in Paris and aims to assist in producing presence and abundance data for benthic macro-invertebrates caught during fishing. This will provide additional information on the distribution of VMEs and assist in the development of MPAs by improving habitat mapping. The protocol is based on the collection, weighing and photographing of samples of benthic macroinvertebrates with subsequent identification by taxonomic experts.

5.16 The Working Group welcomed the development of the protocol undertaken by France and noted that it could save time for scientific observers and didn't require observers to possess specialist taxonomic skills as samples and images were sent to the MNHN for identification. The Working Group also noted that the protocol would be trialled alongside benthic camera deployments in the near future to help establish how representative invertebrates caught as by-catch are of the benthic communities from which they were sampled. The Working Group noted that a range of commercially available image analysis software and image database packages exist that may assist in VME studies.

Ross Sea region MPA Research and Monitoring Plan Workshop (WS-RMP)

5.17 The Ross Sea region MPA Research and Monitoring Plan Workshop (WS-RMP) was held at the Palazzo Farnesina (Ministry of Foreign Affairs and International Cooperation, MAECI) in Rome, Italy, from 26 to 28 April 2017 (WG-EMM-17/43). The draft research and monitoring plan (RMP) was considered by the Working Group. The RMP will be introduced to CCAMLR at the annual meetings of the Scientific Committee and Commission later this year, prior to the Ross Sea Region MPA's implementation in December 2017.

5.18 The Working Group noted that following the Workshop, the Co-conveners submitted the draft RMP to the Ross Sea MPA implementation e-group for further comment. The Working Group encouraged the submission of further comments on the RMP through the dedicated e-group and noted that it would be submitted to WG-FSA and the Scientific Committee for further consideration.

5.19 The Working Group recommended that time be made available during the proposed spatial management workshop (WG-EMM-17/02) to allow further consideration of the development, implementation and coordination of Members' research efforts supporting the objectives of the RMP. The Working Group noted that it was intended that the RMP would be a 'living document' that would require regular updating to reflect developments in regional research and monitoring activities.

International Whaling Commission (IWC)

5.20 WG-EMM-17/15 reported on progress towards a second Joint SC-CAMLR–IWC Workshop on the development of multi-species ecosystem models of interest to both organisations. The Working Group noted the revised terms of reference discussed at the IWC SC and the desire by the IWC workshop steering committee to hold two meetings, the first a two-day plenary meeting held in conjunction with the annual IWC SC meetings and the second a full workshop.

5.21 The Working Group agreed that whales were key krill predators in the Southern Ocean and would form a major component of regional ecosystem models. Whale distribution was also a key, but undeveloped, element of the risk assessment approach for Area 48.

5.22 The Working Group agreed that the terms of reference for the workshop were still relevant to the work of WG-EMM and the CCAMLR Scientific Committee but questioned the need to hold a plenary meeting in advance of the workshop rather than developing an agenda and identifying data requirements through an e-group. It was noted that some whale abundance and distribution data might already be available from the IWC.

5.23 The Working Group agreed that a single workshop would be desirable but, given its heavy work schedule, that it should be considered alongside the other priority issues and financial implications for WG-EMM and SC-CAMLR.

Southern Ocean Observing System (SOOS)

5.24 WG-EMM-17/38 Rev. 1 submitted to the Working Group on behalf of SOOS provided a general summary of the outcomes of the first meeting of the West Antarctic Peninsula (WAP) Working Group (WG) held at the British Antarctic Survey, Cambridge, UK, on 15 and 16 May 2017. At the well-attended and productive meeting, the structure of the WAP workplan was discussed. Participants also considered a range of issues relevant to the work of WG-EMM, including drivers of environmental change in the WAP and spatial heterogeneity in regional change. The Working Group noted that CCAMLR was likely to benefit from the work of SOOS, in particular in the development of data layers for the krill risk assessment. The Working Group noted the forthcoming Indian Ocean sector SOOS working group meeting in Japan scheduled for August 2017 and that this would be of interest to the work of CCAMLR.

5.25 The Working Group also noted that a scientist who is also engaged in the work of CCAMLR had attended the recent SCAR Assessment of Antarctic Biodiversity meeting held in Monaco in early July 2017. Engagement with a broad range of scientists from different programs and initiatives would help develop links between CCAMLR and the wider scientific community.

Sentiment analysis of online content

5.26 The results of a sentiment analysis of online content relating to Antarctic krill fishing and related search terms were reported in WG-EMM-17/18. Public perception of the fishery was analysed through sentiment and relevant keyword searches from three online platforms. The analysis revealed an overall neutral to positive sentiment of Antarctic krill fishing related content across all search platforms. This study formed a baseline result for future monitoring of sentiment regarding Antarctic krill fishing as it continues to operate in a changing environment as well as a providing a method for using online content sentiment analysis to gauge the public's perception of other fisheries.

5.27 The Working Group welcomed the study and agreed that undertaking similar work in the future would enable changes in public perception of Southern Ocean fisheries to be evaluated. The Working Group noted that while such a study may not truly reflect public perception, it highlighted which news items and online content were most accessed and most frequently read in relation to krill fisheries in the CCAMLR area. The Working Group suggested a similar exercise on other CCAMLR key issues, such as toothfish fishery, MPA development or ecosystem-based management.

5.28 The Working Group noted that analysis methods of scientific contents such as systematic reviews are available and these maybe of use to the work of the Scientific Committee. Prof. Koubbi proposed to table an overview of the use of these methods for consideration by the Scientific Committee.

5.29 The Working Group recommended that the Scientific Committee consider the development of a CCAMLR communications strategy, that integrates across different types of communications media and allows CCAMLR to promote its various activities, successes and actions over time.

Global Environment Facility proposal

5.30 WG-EMM-17/46 updated on the development by the Secretariat of a proposal for funding support from the Global Environment Facility (GEF) to build capacity among GEF-eligible CCAMLR Member countries to strengthen their participation in CCAMLR. The Working Group noted the approval of the project by the GEF Council at its meeting in May 2017 and the subsequent work that will be associated with developing the full Project Document over the next 12 months.

5.31 Representatives from GEF eligible CCAMLR Member countries Dr A. Makhado (South Africa), Dr H. Manjebrayakath (India), Dr Cárdenas and Dr K. Demianenko (Ukraine) welcomed the report by the Secretariat and thanked the Secretariat for the successful coordination. GEF-eligible CCAMLR Member countries all showed the commitment and recognise its importance in building capacity and progress the work of CCAMLR within their region.

5.32 The Working Group welcomed the report and agreed that, if successful, it would contribute significantly to building capacity within CCAMLR among GEF-eligible Members. The Working Group noted the outlined timetable for the process and looked forward to receiving updates on future progress.

5.33 The Working Group thanked the Secretariat for leading the development of the proposal with GEF-eligible CCAMLR Members and, in particular, noted the major contribution to the project made by Mr A. Wright, CCAMLR Executive Secretary.

Iceberg calving from Larsen C ice shelf

5.34 The Working Group noted that a large (5 800 km^2) iceberg calved from the Larsen C ice shelf in Subarea 48.5 on 12 July 2017. UK scientists, in accordance with CM 24-04, intend to examine the available data on the areal extent of this newly exposed area and, if appropriate, to submit information to the Secretariat on a proposed Stage 1 Special Area for Scientific Study.

CEMP Special Fund

5.35 The Working Group recalled SC CIRC 17/41 that described the change to the membership of the CEMP Special Fund management group and the revised timescale for the submission of proposals to 1 October 2017. The Working Group looked forward to the announcement of opportunity, including the priorities arising from WG-EMM, and encouraged Members to apply to the Fund to address priority areas of work to support CEMP monitoring.

Discards in CCAMLR fisheries

5.36 WS-SISO-17/02 highlighted how the lack of consistent terminology and definition of discards hampers the quantification of this globally important issue and the lack of consistent definition of 'offal', 'discards' and 'by-catch' in use in CCAMLR is an important precursor to the application of targets for non-target catch and discards in CCAMLR fisheries.

5.37 The Working Group agreed that a common set of definitions should be implemented in CCAMLR and noted that this issue had been discussed at WS-SISO and would be progressed in the Scheme of International Scientific Observation e-group. The Working Group noted that while internal consistency of terminology would be essential, it would also be beneficial to harmonise terminology used in other fisheries to help to achieve a broader understanding of the issue.

5.38 The Working Group discussed the potential difficulties in undertaking a full evaluation of total biomass removals in CCAMLR fisheries and requested that the Secretariat work with interested Members to provide a review of the fate of non-target catch in CCAMLR fisheries.

Future work

6.1 In this agenda item the Working Group considered a series of papers that described proposals for research projects and surveys that will contribute to the work of CCAMLR.

Norwegian SWARM project

6.2 WG-EMM-17/26 presented an update on plans from Norway to extend its monitoring efforts in the area around the South Orkney Islands by deploying acoustic moorings in an area of operation of the krill fishery. Data gathered from the moorings will be used to parametrise models, in order to gain better understanding of the interaction between ocean physics and behaviour in driving krill biomass variation in the area. The mooring will use a combination of acoustics and acoustic Doppler current profiler (ADCP) to monitor the movement of water and krill to examine real-time dynamics. The project will coordinate with multi-beam sonar data from commercial fishing vessels to collect 3-d data on krill swarms in the vicinity of the mooring.

6.3 The Working Group welcomed this research initiative and noted that the combination of upward looking moored acoustics and multi-beam sonar would allow a better description of the abundance of krill in the surface layer that is not sampled using conventional hull-mounted acoustics.

Modelling movement of Antarctic krill (MMAK)

6.4 WG-EMM-17/31 provided details of a project that will use numerical ocean sea-ice models at differing resolutions to improve current understanding of the regional and local/small-scale processes that influence the distribution of krill in Area 48. Modelling will focus on the South Orkney Islands region, and will help inform WG-EMM activities on the development of FBM procedures and provide the present-day context for considering the potential impacts of climate change on this region.

6.5 The Working Group noted that this modelling project will be closely linked to the SWARMS project (paragraphs 6.2 and 6.3) and will utilise high-resolution oceanographic models developed for Subareas 48.2 and 48.3 (WG-EMM-17/30).

6.6 In discussion of WG-EMM-17/26 and 17/31, the Working Group identified the need to determine the appropriate spatial and temporal scales to allow the integration of different processes as mismatches in the scales used may influence the interpretation of the results when used in management.

Plan for pelagic ecological research within the US AMLR Program

6.7 WG-EMM-17/04 presented an update on the proposal to revise at-sea research within the US AMLR Program to better address questions necessary for understanding the consequences of overlap among krill, predators and the krill fishery. This includes the movement away from ship-based research to an instrument-based (moorings and gliders) program of oceanographic and ecological observations and research to support the US commitment to CCAMLR and ecosystem science in the Southern Ocean.

6.8 The Working Group welcomed the decision of the US AMLR Program to implement a flexible program to collect data at finer time and space scales but that remain comparable to the historical data collected by the program. The Working Group acknowledged that the requirement for the presence of scientists to collect data was a challenge when working in the Antarctic and that, while there would be challenges in implementing this new program, it agreed that this presented an opportunity to demonstrate a new approach to collecting data that would be crucial to the effective management of the krill fishery.

6.9 The Working Group noted the desire for regular estimates of krill biomass from Subarea 48.1 in order to further understand the linkage with the reproductive performance of krill predators in the region.

German acoustic krill biomass survey in Subarea 48.1

6.10 WG-EMM-17/39 described a proposal from Germany for an acoustic krill biomass survey in Subarea 48.1 during April 2018 in relation to the hydrological environment and in conjunction with carbon cycling and temperature adaptation experiments of krill and salps. The survey will be part of a larger research program investigating the role of krill and salps in Southern Ocean carbon cycling and the temperature adaptation capacities of both species in the context of climate change.

6.11 An acoustic survey with associated physiological experiments will be conducted in conjunction with a detailed description of the biological and physical environment of the krill habitat. The overall objective of the research is to provide an assessment of the effect of climate change on krill and associated ecosystem processes.

6.12 The Working Group noted the importance of such surveys to its understanding of the processes affecting the dynamics of the pelagic ecosystem in Area 48, particularly in response to monitoring the effects of climate change. The Working Group emphasised the importance of using standardised survey procedures that are consistent with CCAMLR protocols such that the results can be used across a range of its research in the subareas to be surveyed.

Proposal for a dedicated krill survey for CCAMLR Division 58.4.1

6.13 WG-EMM-17/05 described a proposal for a dedicated krill survey to be conducted by the Japanese survey vessel *Kaiyo-maru* in Division 58.4.1 in 2018/19. The plan proposed to repeat the BROKE survey in order to provide an updated estimation of krill biomass and to collect oceanographic observations to evaluate long-term changes in this region. The survey will follow the same design as the BROKE survey conducted by Australia in this region in 1996.

6.14 Dr H. Murase (Japan) informed the Working Group that the final acoustics protocol for the survey would be submitted to SG-ASAM in 2018, including details of broadband data recoding methods, and the final plan for the entire survey would be submitted to WG-EMM in 2018.

6.15 The Working Group thanked Japan for this proposal and noted that WG-EMM-17/05 was based on a proposal for a dedicated krill survey that was originally presented in WG-EMM-15/43 and that had been considered by SG-ASAM (SG-ASAM-17/01; Annex 4, paragraphs 5.1 to 5.3). The Working Group welcomed the opportunities for collaboration with others who had more recent scientific surveys in the East Antarctic (Collaborative East Antarctic Marine Census, French National Programs, Kerguelen Axis program) to combine scientific efforts on the ecology of krill species and micronekton, including the use of stable isotopes for studying trophic webs. Dr Murase encouraged all scientists wishing to collaborate to contact him.

6.16 The Working Group noted the possibility of extending the range of the survey to include the Krill Research Zone and address priority research items identified in the Ross Sea region MPA RMP. However, such an expansion of the survey scope would be difficult to accommodate in the time available.

6.17 The Working Group noted that the spatial distribution of krill in the East Antarctic, where juvenile krill are typically found offshore, was distinctly different to the Atlantic sector, where juvenile krill are more typically found inshore and that this research survey would help to elucidate why these two regions were so different.

Integrating Climate and Ecosystem Dynamics in the Southern Ocean (ICED)

6.18 WG-EMM-17/36 provided an update from the Integrating Climate and Ecosystem Dynamics in the Southern Ocean (ICED) program which is undertaking integrated circumpolar analyses with a major focus to more comprehensively assess (and where possible quantify) key impacts of change on Southern Ocean ecosystems. In response to the questions posed by WG-EMM in 2016 (SC-CAMLR-XXXV, Annex 6, paragraph 6.25), ICED will hold a

Projections Workshop in April 2018, in association with the Marine Ecosystem Assessment for the Southern Ocean (MEASO) conference, with the following objectives:

1. Assess the potential drivers of change (within three decades and over the 21st century) in the ecosystems in the Scotia Sea and Antarctic Peninsula region of the Southern Ocean (Area 48).

2. Assess potential future sea-ice change in Area 48 and the potential impacts on availability of krill to predators and the fishery.

3. Examine alternative approaches to modelling and projecting changes in distribution, abundance and biomass of Antarctic krill in Area 48.

6.19 The Working Group welcomed this proposal by ICED that directly addressed the questions and spatial focus presented by the Working Group in 2016. In response to the invitation from ICED for nominations for involvement in the workshop steering committee from WG-EMM, the Working Group agreed that having someone with a broad experience of CCAMLR would be an advantage in further developing the workshop objectives and preparatory activities, and ensuring the optimum outcomes for CCAMLR from the workshop.

6.20 The Working Group noted that future collaborations with ICED could have a focus on other regions by creating regional working groups as has been done by SOOS.

Climate change response work program

6.21 WG-EMM-17/19 presented a draft climate change response work program addressing the remaining terms of reference of the climate change intersessional correspondence group (ICG) to develop approaches for integrating considerations of the impacts of climate change into the work of CCAMLR. Acknowledging the important role of WG-EMM in CCAMLR, the climate change ICG sought feedback on the draft work program, specifically advice on issues, information gaps identified, proposed actions and relevant activities already underway, as well as advice on appropriate timeframes for responding to research activities.

6.22 The Working Group thanked Australia and Norway for preparing WG-EMM-17/19 and noted that the workplan set out in the paper would need to be considered in the context of the other priorities identified by the Scientific Committee. The Working Group recognised that there were important elements of climate change related work in almost all of its work and was, therefore, keen to support the climate change response work program and noted that there was a need to ensure that the program was kept up to date and relevant.

6.23 Dr Welsford drew the Working Group’s attention to the MEASO conference to be held from 9 to 13 April 2018 in Hobart, Australia. He noted that the conference intended to progress many of the issues raised in the climate change response work program, including assessing and managing the impacts on climate change on Southern Ocean ecosystems and Antarctic marine living resources.

Development of a five-year work plan for the CCAMLR Scientific Committee

6.24 The Working Group considered the proposed five-year work plan for the Scientific Committee presented by the Chair of the Scientific Committee (WG-EMM-17/02). The paper provides an expansion of the recommendations of the Scientific Committee (SC-CAMLR-XXXV, Table 1) which were discussed and put forward by the Scientific Committee Symposium in October 2016. The paper outlined the work in themes and it also indicated a timeline by which each topic should be addressed.

6.25 The Working Group welcomed the plan outlined in WG-EMM-17/02 and thanked the Chair and also the conveners of the working groups for working with the Chair to advance this important topic for the Scientific Committee.

6.26 The Working Group noted that the timescales included in WG-EMM-17/02 should be consistent with the requirements to review particular conservation measures (e.g. CM 51-07).

6.27 The Working Group noted the proposal for a joint meeting of WG-EMM, WG-SAM and SG-ASAM in 2019 to consider acoustic survey methods and design to facilitate FBM and considered that it was helpful to focus on the theme of the meeting rather than emphasising that it was a joint meeting of existing working groups. In response to a question of how the planning for this meeting would be progressed, the Chair of the Scientific Committee clarified that, pending agreement of the Scientific Committee, a steering committee could be established to develop the terms of reference and agenda for the meeting, see also paragraph 3.14.

6.28 The Chair of the Scientific Committee also described how he had regular teleconferences with the Vice-chairs and the working group conveners to coordinate the work of the Scientific Committee and he hoped that this process would continue the enhance the delivery of the priorities of the Scientific Committee.

6.29 The Working Group encouraged the Scientific Committee Representatives to focus on priority topics when submitting their scientific work to be considered by WG-EMM meetings in order to assist the Working Group Convener to allocate meeting time to the discussions of priority topics.

Advice to the Scientific Committee

7.1 The Working Group's advice to the Scientific Committee is summarised below; the body of the report leading to these paragraphs should also be considered.

7.2 The Working Group advised, and sought advice from, the Scientific Committee on the following topics:

(i) review whether the catch and effort data submitted from the continuous fishing system is consistent with CMs 21-03 and 23-06 (paragraph 2.5)

(ii) changes to the instructions to observers for collecting data on by-catch in the krill fishery (paragraph 2.17)

(iii) collection of data on air-breathing predators as part of SISO (paragraph 2.26)

(iv) continuation of trials of a net monitoring cable in the krill fishery (paragraph 3.4)

(v) a strategy for integrating across the various existing and proposed management approaches for Domain 1 (paragraph 4.16)

(vi) the development of a CCAMLR communications strategy (paragraph 5.29).

Close of the meeting

8.1 In closing the meeting, Dr Korczak-Abshire thanked all participants for their enthusiasm and the rapporteurs for their hard work in preparing the report that she looked forward to presenting to the Scientific Committee.

8.2 Dr Korczak-Abshire thanked the hosts, in particular Ms Bárbara Casas, who had provided such a wonderful venue and provided the meeting participants with opportunities to experience a little of the history and culture of Buenos Aires. Dr Korczak-Abshire also thanked the Secretariat for their support and organisation.

8.3 Dr Korczak-Abshire highlighted the excellent contribution made to the meeting by the two scholarship recipients and encouraged all Members to find ways to engage early career scientists in the work of CCAMLR.

8.4 Dr Belchier, Chair of the Scientific Committee, congratulated Dr Korczak-Abshire for conducting her first meeting as Convener with humour and patience. He noted that she has confessed some nervousness prior to the meeting but appeared to have shown no sign at all of this in conducting the meeting.

8.5 Mr Gowland hoped that all participants had enjoyed their time in Buenos Aires and wished everyone a safe journey home.

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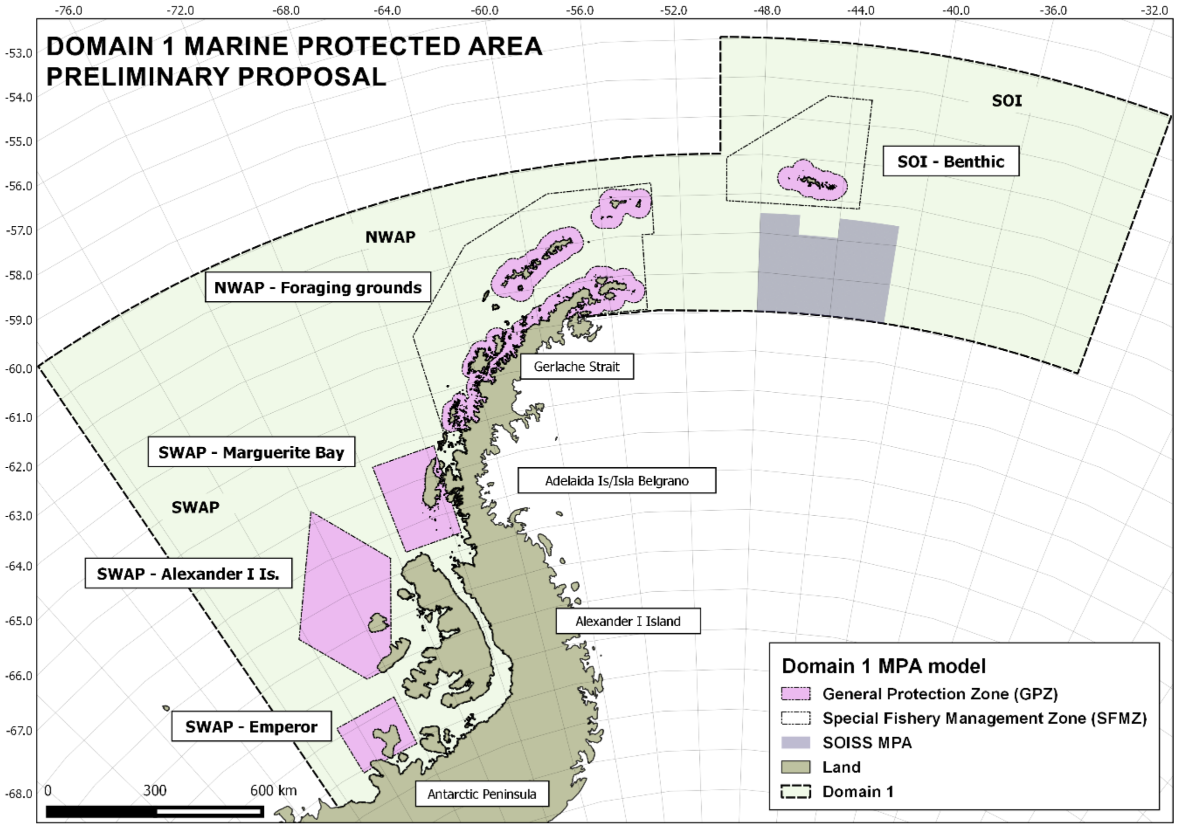

Figure 1: The Domain 1 MPA model presented in WG-EMM-17/23, including potential management components.

Appendix A

List of Participants

Working Group on Ecosystem Monitoring and Management
(Buenos Aires, Argentina, 10 to 14 July 2017)

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Appendix B

Agenda

Working Group on Ecosystem Monitoring and Management
(Buenos Aires, Argentina, 10 to 14 July 2017)

1. Introduction

    1.1 Opening of the meeting
    1.2 Adoption of the agenda

2. The krill-centric ecosystem and issues related to management of the krill fishery

    2.1 Fishing activities (updates and data)
    2.2 Scientific observation

3. Operationalising feedback management in the krill fishery in Subarea 48.1

    3.1 Krill biology, ecology and population dynamics
        3.1.1 Krill life-history parameters
        3.1.2 Krill assessment models

    3.2 Ecological interactions: predators
        3.2.1 CEMP data
        3.2.2 Other monitoring data

    3.3 Fishery dynamics
        3.3.1 CPUE and spatial dynamics
        3.3.2 Fishing vessel surveys

    3.4 Operational management regimes for feedback management in the krill fishery

4. Spatial management in Planning Domain 1

    4.1 Data layers for Planning Domain 1
    4.2 CEMP and MPA research and monitoring data

5. Other business

6. Future work

7. Advice to the Scientific Committee and its working groups

8. Adoption of the report and close of the meeting.

Appendix C

List of Documents

Working Group on Ecosystem Monitoring and Management
(Buenos Aires, Argentina, 10 to 14 July 2017)

WG-EMM-17/01 Rev. 1	Adélie penguins as indicators of the state of the sea-ice in Adélie Land Y. Ropert-Coudert, A. Kato and C. Barbraud
WG-EMM-17/02	Development of a five-year work plan for the CCAMLR Scientific Committee M. Belchier (Chair of SC-CAMLR)
WG-EMM-17/03	New possibilities of krill-dependent indicator species monitoring – UAV survey in Subarea 48.1 M. Korczak-Abshire, A. Zmarz, M. Rodzewicz, R. Storvold, M. Kycko, I. Karsznia, A. Kidawa and K.J. Chwedorzewska
WG-EMM-17/04	A new plan for pelagic ecological research within the US AMLR Program C. Reiss and G. Watters
WG-EMM-17/05	Proposal for a dedicated krill survey for CCAMLR Division 58.4.1 during 2018/19 season by the Japanese survey vessel, *Kaiyo-maru* H. Murase, K. Abe, T. Ichii and A. Kawabata
WG-EMM-17/06	A preliminary survey on breeding population of Adélie penguins at Cape Hallett in the Ross Sea region, Antarctica J.-H. Kim, H. Chung, W.Y. Lee, J.-W. Jung, M.C. Park, H.C. Shin and J.H. Kim
WG-EMM-17/07	Progress report of the CEMP Special Fund overwinter penguin tracking project J. Hinke, G. Watters, M. Santos, M. Korczak-Abshire, G. Milinevsky and V. Lytvynov
WG-EMM-17/08	Estimating density and biomass of Antarctic krill around South Sheltland Islands using the 2-dB difference method S.-G. Choi, K. Lee and D. An
WG-EMM-17/09	New data acquisition protocol for benthos by-catch in the French fisheries of the Southern Ocean, presentation of the protocol and first preliminary results A. Martin, M. Eléaume, N. Améziane, P. Pruvost and G. Duhamel

WG-EMM-17/10	Progress report of the CEMP Special Fund project to develop an image processing software tool for analysis of camera network monitoring data C. Southwell, L. Emmerson, K. Newbery, J. Hinke, G. Watters, M. Santos, G. Milinevsky, M. Korczak-Abshire, N. Ratcliffe and P. Trathan
WG-EMM-17/11	Update on work to estimate krill consumption by flying seabirds in CCAMLR Divisions 58.4.1 and 58.4.2 C. Southwell and L. Emmerson
WG-EMM-17/12	Estimating prey consumption of the non-breeder component of an Adélie penguin population L. Emmerson and C. Southwell
WG-EMM-17/13	Dietary studies of Adélie penguins through faecal DNA analysis L. Emmerson, B. Deagle, C. Waluda, M. Dunn, P. Trathan and C. Southwell
WG-EMM-17/14	Feeding habits and prey consumption of Antarctic minke whale *Balaenoptera bonaerensis* in the Indo–Pacific region of the Southern Ocean T. Tamura
WG-EMM-17/15	Outcomes from the IWC SC relating to progress towards SC-CAMLR–IWC workshops in 2018 and 2019 M. Belchier (Chair of SC-CAMLR)
WG-EMM-17/16 Rev. 1	Progress report of the CEMP Special Fund camera network in Subarea 48.1 J. Hinke, G. Watters, M. Santos, M. Korczak-Abshire, G. Milinevsky, V. Lytvynov, A. Barbosa, C. Southwell and L. Emmerson
WG-EMM-17/17	CEMP data summary and updated analysis of CEMP data from Subarea 48. Secretariat
WG-EMM-17/18	A sentiment analysis of online content containing Antarctic krill fishing search terms J. Barrett, K. Reid and J. Jabour
WG-EMM-17/19	Proposal for a Climate Change Response Work Program for CCAMLR Delegations of Australia and Norway on behalf of the Climate Change Intersessional Correspondence Group

WG-EMM-17/20	Towards an ecological risk assessment of krill fishing in East Antarctica (CCAMLR Divisions 58.4.1 and 58.4.2) N. Kelly, M. Cox, L. Emmerson, S. Kawaguchi, B. Raymond, C. Southwell and D. Welsford
WG-EMM-17/21	CEMP cameras and satellite transmitters installation by Ukraine at the Galindez, Petermann, and Yalour Islands penguin colonies as a part of CEMP Fund projects G. Milinevsky, I. Dykyy, D. Lutsenko, O. Savitsky, A. Simon, M. Telipska, V. Lytvynov and L. Pshenichnov
WG-EMM-17/22	Incorporating information on the distribution of the krill fishery into Domain 1 MPA planning – report of the CCAMLR scholarship recipient A. Capurro, M. Santos and S. Grant
WG-EMM-17/23	Domain 1 Marine Protected Area Preliminary Proposal – PART A: MPA Model Delegations of Argentina and Chile
WG-EMM-17/24	Domain 1 Marine Protected Area Preliminary Proposal – PART B: Conservation objectives Delegations of Argentina and Chile
WG-EMM-17/25 Rev. 1	Domain 1 Marine Protected Area Preliminary Proposal – PART C: Biodiversity Analysis by MPA zones Delegations of Argentina and Chile
WG-EMM-17/26	The Norwegian SWARM project: from swarming behaviour to trophic interactions: modelling dynamics of Antarctic krill in ecosystem hotspots using behaviour-based models T.A. Klevjer, G. Rieucau, A.H.H. Renner, G. Skaret and O.R. Godø
WG-EMM-17/27	Analysis of the krill fishery in Subarea 48.1 considering trawl fishing method used (2010–2016) S. Kasatkina S. and L. Boronina
WG-EMM-17/28	Analysis of inter-vessel variability of krill length distribution in the catches obtained in the fishery in the Bransfield Strait (Subarea 48.1) S. Kasatkina
WG-EMM-17/29	Density and geographical distribution of krill larvae in the Atlantic Sector of the Antarctic region during summer 2011, 2012 and 2014 E. Rombolá, C. Franzosi, G. Tossonotto, V. Alder and E. Marschoff

WG-EMM-17/30	Oceanography of the South Georgia and South Orkney Islands regions using high-resolution models E. Young, E. Murphy and P. Trathan
WG-EMM-17/31	Modelling Movement of Antarctic Krill (MMAK): the importance of retention, dispersal and behaviour for krill distribution S. Thorpe, E. Young and E. Murphy
WG-EMM-17/32	A bioenergetics model assessment of the prey consumption of Adélie penguins in Subarea 48.1 and 48.2 C. M. Waluda, L. Emmerson, C. Southwell and P.N. Trathan
WG-EMM-17/33	Using preferred habitat models for chinstrap penguins (*Pygoscelis antarctica*) to help improve krill fisheries management during the penguin breeding season V. Warwick-Evans, N. Ratcliffe, H.L. Clewlow, L. Ireland, A. Lowther, F. Manco and P.N. Trathan
WG-EMM-17/34	Characterising the preferred at-sea habitats used by chinstrap penguins and the fishery for Antarctic krill: slow-flowing, nearshore waters over shallow bathymetry P.N. Trathan, V. Warwick-Evans, J. Hinke, E.F. Young, A.P.B. Carneiro, M.P. Dias, K. Kovacs, O.R. Godø and M. Santos
WG-EMM-17/35	Identification of marine Important Bird and Biodiversity Areas for penguins in South Shetland and South Orkney Islands: a comparison of two different approaches M.P. Dias, A.P.B. Carneiro, V. Warwick-Evans, C. Harris, K. Lorenz, P. Trathan
WG-EMM-17/36	Integrating Climate and Ecosystem Dynamics in the Southern Ocean (ICED) program: developing ICED and CCAMLR joint activities E. Murphy on behalf of ICED SSC
WG-EMM-17/37	SO-AntEco: Contributing information and scientific advice on benthic biodiversity in the South Orkney Islands (Domain 1) region M.J. Brasier, S.M. Grant, P.N. Trathan, L. Allcock, O.S. Ashford, H. Blagbrough, A. Brandt, B. Danis, R. Downey, M. Eléaume, P. Enderlein, C. Ghiglione, O. Hogg, K. Linse, M. Mackenzie, C. Moreau, L. Robinson, E. Rodríguez, V. Spiridonov, A. Tate, M. Taylor, C. Waller, H. Wiklund and H.J. Griffiths
WG-EMM-17/38	Southern Ocean Observing System West Antarctic Peninsula (WAP) Working Group Meeting P. Trathan on behalf of the SOOS West Antarctic Peninsula (WAP) Working Group

WG-EMM-17/39	Proposal for an acoustic krill biomass survey in CCAMLR Subarea 48.1 in relation to the hydrological environment and in conjunction with carbon cycling and temperature adaptation experiments of krill and salps B. Meyer, L. Suberg, S. Fielding, O.R. Godø and C. Reiss
WG-EMM-17/40	Dynamics of Antarctic krill in the Bransfield Strait during austral summer and autumn investigated using acoustic data from a fishing vessel X. Wang, G. Skaret, O.R. Godø and X. Zhao
WG-EMM-17/41	Krill CPUE standardisation and comparison with acoustic data based on data collected from Chinese fishing vessels in Subarea 48.1 Y. Ying, X. Wang, J. Zhu and X. Zhao
WG-EMM-17/42	The Weddell Sea MPA revisited: questions, comments and suggestions M. Bristow and O.R. Godø
WG-EMM-17/43	The Ross Sea region Marine Protected Area Research and Monitoring Plan (WG-EMM 2017) A. Dunn, M. Vacchi and G. Watters
WG-EMM-17/44	Linking acoustic scattering coefficient to krill fishery data: feasibility of estimating krill abundance using fishing survey T. Wang, G.P. Zhu, J.F. Tong and L.X. Xu
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WG-EMM-17/46	Progress report 4: Proposal for GEF (Global Environment Facility) funding to support capacity building in the GEF-eligible CCAMLR Members CCAMLR Secretariat
WG-EMM-17/47	The use of net monitoring cable in trawl fishery for krill O.R. Godø
WG-EMM-17/48	Reporting procedures for the continuous fishing method O.R. Godø and T. Knutsen
WG-EMM-17/49	Increasing abundance of Type A killer whales (*Orcinus orca*) in the coastal waters around the Antarctic Peninsula H. Fearnbach, J.W. Durban, D.K. Ellifrit and R.L. Pitman

WG-EMM-17/50 Rev. 1	From CEMP to krill fishing: data collection, availability and spatial distribution in Subarea 48.1 M. Söffker

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WG-EMM-17/P01	Diving location and depth of breeding chinstrap penguins during incubation and chick-rearing period in King George Island, Antarctica W.Y. Lee, S. Park, N. Choi, K.W. Kim, H. Chung and J.-H. Kim *Kor. J. Orni.*, 23 (1) (2016): 41–48
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WS-SISO-17/02	Discards in Antarctic fisheries E. Marschoff and J.A. Serra
WS-SISO-17/05	Using fishing vessels as opportunistic seabird and marine mammal observation platforms M. Söffker, V. Laptikhovsky and J. Clark
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