Report of the Working Group on Ecosystem Monitoring and Management
(Virtual meeting, 4 to 11 July 2022)

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Report of the Working Group on Ecosystem Monitoring and Management
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Opening of the meeting

1.1 The meeting of the Working Group on Ecosystem Monitoring and Management (WG-EMM) was held online from 4 to 11 July 2022 starting at 21:00 UTC. The meeting was convened by Dr C. Cárdenas (Chile), who welcomed the participants (Appendix A).

Adoption of the agenda and organisation of the meeting

1.2 The meeting's provisional agenda was discussed, and the Working Group adopted the proposed agenda (Appendix B).

1.3 Documents submitted to the meeting are listed in Appendix C. The Working Group thanked the authors of papers and presentations for their valuable contributions to the work of the meeting.

1.4 This report was prepared by the Secretariat and the Convener. Sections of the report dealing with advice to the Scientific Committee and other working groups are highlighted and collated in 'Advice to the Scientific Committee'.

1.5 The Working Group noted that due to the short duration of the meeting and the extensive discussions required to progress the krill management approach, there was not enough time to consider and comment on all papers. The Working Group agreed to consider all published papers ('P-papers') as read and only consider recommendations arising from those papers. The Working Group recognised that while many agenda items would have benefitted from longer discussions, progress has been made in good spirit and in good cooperation.

Krill management

2.1 WG-EMM-2022/07 presented the report of the 2022 Scientific Committee on Antarctic Research (SCAR) Krill Action Group (SKAG) meeting, held online from 7 to 11 March 2022. The discussions focused on recruitment estimation and modelling, with an emphasis on gear selectivity, standardisation of data collection, computation of proportional recruitment and opportunities for collaboration between researchers and the fishing industry.

2.2 The Working Group thanked all those involved in the SKAG meeting and noted the valuable role that SKAG plays in allowing for further consideration and more detailed discussion of krill biology, sampling methodology and krill research projects than is possible by CCAMLR working groups due to the time constraints of these meetings.

2.3 WG-EMM-2022/11 presented results of scientific research on krill conducted on board the *Antarctic Endurance*, a commercial fishing vessel. The study demonstrated the potential for using commercial krill trawlers to address questions identified by CCAMLR to support krill fisheries management (e.g. seasonal size and sex composition, vertical movements, identification of spawning hotspots and the role of the northwestern Weddell Sea as a source of recruits to the area of the South Orkney Islands (SOI)).

2.4 The Working Group welcomed the successful at-sea collaboration between the fishing industry and scientists, noting that the increase in fishing depth during autumn and early winter in comparison to summer, and the variation in maturity and sex of krill caught throughout the study period are important aspects to the interpretation of catch data.

2.5 WG-EMM-2022/41 presented a comparison of data collection protocols and outputs between CCAMLR Scheme of International Scientific Observation (SISO) observers and scientists taking part in an Alfred Wegener Institute (AWI) research project on a trawl vessel using a continuous fishing system. The study focused on the effects of methodological differences in data collection by comparing concurrently collected length-frequency distributions from SISO observers with dedicated researchers. Results indicated that length frequencies collected by SISO observers tended to underestimate small individuals when compared to those collected by AWI researchers in some cases.

2.6 The Working Group noted that this study represented an effective collaboration between scientists, observers and the fishing industry and that reasons for the observed differences in length frequencies, in addition to methodological aspects, may include individual observer effects as length measurements were taken by multiple SISO observers. It also noted that SISO data were collected far less frequently and usually whilst vessels were actively fishing krill swarms. The Working Group further noted that the tendency of SISO observers to sample whilst vessels were fishing krill swarms may affect the composition of by-catch records and potentially results in by-catch underestimates.

2.7 Noting that the aim of the SISO krill length data collection is documenting the size composition of the catch, and that the workload of observers is already substantial, the Working Group discussed the possibility of involving dedicated scientists on board fishing vessels to augment data collection capabilities in the future. It also recalled WG-SAM-16/39 which discussed changes to SISO length sampling requirements and sampling instructions to allow better estimates of catch at length. The Working Group suggested that more robust statistical tests were required to determine if the length distributions were significantly different, and that in the study area, samples may have come from different swarms with different geographic origins. The Working Group further noted that many of the issues discussed could potentially be addressed at the future krill observer workshop (paragraph 5.18).

2.8 The Working Group noted that the vessel had also collected acoustic data and that once analytical issues associated with processing data that were not collected during transects and calibration issues are addressed with the help of WG-ASAM, the data may potentially provide biomass estimates.

2.9 WG-EMM-2022/39 presented a proposed workplan for developing and implementing data collection needs for CCAMLR krill fisheries, and re-scoping of the krill observer workshop that has been delayed by COVID-19 to align it with the timeline of the proposed workplan. The document outlines several pressing issues that have been identified for consideration by the Scientific Committee and its working groups, processes to address these, a timeline for changes to data entry forms and instructions, and implementation of these outcomes through appropriate liaison with industry and training (see WG-EMM-2022/39, Table 1).

2.10 The Working Group supported the proposed changes to the terms of reference for the krill observer workshop planned to be hosted by China (Appendix D).

2.11 The Working Group noted that issues such as sampling protocols, by-catch in krill fisheries and incidental mortality may result in changes to SISO observer sampling requirements and encouraged Members to submit papers addressing these issues to WG-IMAF and WG-FSA (paragraph 5.18). It further noted the importance of training observers in new or revised sampling protocols and with respect to the potential future increases in krill catch limits and highlighted the possible future use of electronic monitoring on board krill fishing vessels to assist in data collection.

2.12 WG-EMM-2022/06 presented the report of an online workshop held in August and November 2021 to investigate a potential krill ageing method for their absolute age based on the count of growth bands in eyestalks. Given its low accuracy and the low level of agreement among age readers, the workshop concluded that this method requires further development before it can be applied.

2.13 The Working Group thanked Members who participated in the online workshop and encouraged further work to develop a method to determine the absolute age of krill.

2.14 WG-EMM-2022/P08 presented findings from a genetics study examining the spatial structuring of krill bacterial epibiont communities in the East Antarctic. Distance, rather than environmental factors, was found to be the leading driver, and bacterial communities associated with Antarctic krill (*Euphausia superba*) were found to be geographically segregated, in contrast with the current assumption of a panmictic krill population.

2.15 The Working Grouped noted that this study raised questions regarding the relationship between oceanographic processes and population dynamics and encouraged further research on this topic, including on possible seasonal variations of bacterial epibionts. It further noted that the hypothesised panmixia of krill could be a result of the very large and diverse genome of Antarctic krill, which may render the detection of sub-populations difficult, particularly in combination with the enormous population size of Antarctic krill. The Working Group noted the great potential of this method to help develop krill stock structure hypotheses, given the more rapidly changing microbiome compositions.

2.16 WG-EMM-2022/18 presented an overview of CCAMLR-related ecosystem monitoring and scientific activities undertaken by the British Antarctic Survey during the period April 2021 to March 2022, including sea-ice extent and sea-surface temperature observations, results from acoustic mooring and plankton research trawls, and data collected from several higher predator CCAMLR Ecosystem Monitoring Program (CEMP) sites. Observations of low krill abundance in the 2021 winter in Subarea 48.3, followed by an influx of small krill in October 2021, with impacts on seals and penguin colonies, were reported.

2.17 The Working Group noted the observations of low krill abundance in the winter of 2021 in Subarea 48.3, recalled that a similar anomaly was reported in 2009 (WG-EMM-09/23) and encouraged the authors to investigate possible causes of these events, as understanding such events is crucial to the management of the krill fishery. The Working Group noted that observed natural events of low krill abundance may be important for understanding the existence of food chains in which krill is not the dominant species. The Working Group further noted that this study exemplified how CEMP monitoring could contribute to management, and that some of the observed patterns were also seen in CEMP sites in the western region of the Antarctic

Peninsula. The Working Group encouraged the authors to consider the use of automated camera systems to ensure the continuity of data collection during years of reduced accessibility to certain CEMP sites.

2.18 While noting that investigating these anomalies represented a significant body of work, the Working Group recommended that it would be beneficial to consider cycling through topics (e.g. every three years) in its terms of reference, as the krill fishery management topic had taken a lot of resources in recent years and more discussion on ecosystem status was needed. It also noted, based on many regional and potentially conflicting CEMP indices, that WG-EMM would benefit from developing integrated ecosystem reporting to ensure a more comprehensive view of the monitored ecosystems (see also paragraph 5.5).

Krill fishery status

2.19 WG-EMM-2022/P09 presented an analysis of the implications of the spatial and temporal concentration of Antarctic krill fishing effort. Analysis of 38 years of data revealed the highest spatial and temporal fishing concentration across the west Antarctic Peninsula and South Orkney Islands, a general declining trend in catch-per-unit-effort (CPUE), and the need to expand the coverage of krill surveys to new, highly fished, and non-monitored areas such as the Gerlache Strait.

2.20 The Working Group noted that this analysis represented an effective use of krill fishery data, confirming the concentration of fishing operations in recent years (see also WG-FSA-2021/56). It discussed concerns regarding the interpretation of CPUE trend declines, which could be indicative of localised depletion, but noted that CPUE data needed careful consideration since it could be affected by krill demographics, flux, fishing tactics (skippers may leave a given fishing spot to search for higher-quality krill rather than high-density krill aggregations) and changes in fishing technology. The Working Group noted that this study reported important trends in the fishery, highlighting the need for regular acoustic surveys to enhance the responsiveness of the management of the krill fishery.

2.21 WG-EMM-2022/29 presented a review of trawl gear information provided by vessels operating in the krill fishery during the notification process. The paper proposed a framework to standardise trawl gear reporting requirements based on SC-CAMLR-XXVIII, Annex 9 and in accordance with Conservation Measure (CM) 21-03.

2.22 The Working Group welcomed this paper and noted that CM 21-03 requires that Members, during the fishery notification process, submit net configuration measurements and refer to a relevant net diagram in the CCAMLR gear library or, if no relevant diagram is available, submit a detailed diagram and description to the forthcoming meeting of WG-EMM. The Working Group further noted that there are no krill trawl diagrams available from the CCAMLR gear library and that information is currently only available in the fishery notifications.

2.23 The Working Group recommended that the Secretariat be tasked with collating the available net diagrams and net configuration measurements submitted during the fishery notification process in the CCAMLR gear library and Members be requested to submit papers with additional net diagrams, configurations and descriptions of operations to subsequent meetings of WG-EMM for inclusion in the gear library.

2.24 The Working Group noted WG-EMM-2022/09, which presented a summary description and analysis of the activities the fishing vessel *Antarctic Endeavour* carried out in the Antarctic krill fishery between December 2020 and November 2021, but did not discuss this paper due to time constraints.

WG-ASAM advice and considerations on the krill management strategy

2.25 The Co-convener of WG-ASAM, Dr S. Fielding (UK) presented an overview of relevant advice pertaining to the management of the krill fishery (WG-ASAM-2022). She noted that WG-ASAM discussed standardised procedures for survey design, data analysis and quality control of acoustically derived estimates of krill biomass. Dr Fielding also noted the new R code available to aid in the creation of CCAMLR strata and the computation of their areas (WG-ASAM-2022/02 and updated output posted on the 'Krill biomass estimates from acoustic surveys' e-group), indicating the potential utility of this method for WG-EMM. She further reported that WG-ASAM considered biomass estimates for Subarea 48.1 at scales relevant to the area of operation of the fishery, noting discussions to calculate such estimates over different time periods. Lastly, Dr Fielding reported on discussions about fishing vessels conducting surveys on the CCAMLR-nominated transects and welcomed papers describing methods for acoustic surveys targeting icefish, to be submitted for discussions at WG-ASAM-2023.

2.26 The Working Group recognised the success of the WG-ASAM meeting and the relevance to WG-EMM discussions on krill assessments, and reinforced the need for standardisation of data collection and processing methodologies when combining survey results.

2.27 WG-EMM-2022/25 Rev. 1 presented krill biomass estimates for the combined Subarea 48.1 strata defined by WG-ASAM-2022. A range of options were presented based on the duration of biomass time series used and different approaches to pooling strata. Based on a preliminary wavelet analysis indicating that similar periods with high power seemed to occur within five years, the authors considered the 'y5' scenario to be appropriate for computing subarea-level mean biomass and its coefficient of variation (CV).

2.28 The Working Group noted the utility of the wavelet analysis to document the periodicity observed in the data and the consistency of this periodicity with that observed in proportional recruitment time series. It discussed the impact of the choice of time period over which to average acoustic estimates on the estimation of the variability in biomass estimates (see also WG-EMM-2021, paragraph 2.27). Given the observed period, the Working Group agreed that the 'y3' option could be excluded from the table of biomass estimates provided by WG-ASAM-2022 (Table 1).

2.29 The Working Group recommended that future analyses would benefit from including data from the long time series of surveys conducted by Peru in the Antarctic Peninsula area.

2.30 The Working Group noted that the biomass estimate for the Gerlache Strait stratum was based on the result of a single acoustic survey, which would not account for interannual variability and the episodic recruitment that is evident in other areas within Subarea 48.1. It also noted reports of juvenile aggregations in the area, which warranted caution if it were a potential source region, and indicated the need for development of a juvenile krill distribution layer in this area within the risk assessment. The Working Group further noted that the transect coverage of the single survey was mainly offshore, and thus had limited spatial overlap with fishery operations in this area. Some participants indicated that this issue would result in an underestimate of biomass since high abundances targeted by the fishery were mainly closer to the shore. The Working Group also noted that the large biomass estimates in the outer strata were driving up the resulting subarea-scale biomass estimate.

2.31 The Working Group considered the time series of acoustic biomass estimates provided by WG-ASAM-2022. The Working Group noted that when only a single survey was available for a given stratum, using the lower bound of the one-sided 95% confidence interval (assuming a lognormal distribution) of estimates would provide a precautionary estimate of biomass. It discussed whether consistency across strata could be increased by using the same approach for all estimates, in line with current management strategies applied to mackerel icefish (*Champsocephalus gunnari*) fisheries. The Working Group agreed that this approach could be applied to the Gerlache Strait, Drake Passage and Powell Basin strata.

2.32 The Working Group discussed the time period over which to average acoustic biomass estimates. Some participants noted that using all the available data would ensure representativeness and that the best contemporary estimate, when surveys are not conducted in every stratum and every year, would be obtained by computing the long-term average. Other participants noted that contemporary estimates would be better depicted using recent data that covered a single cycle of a periodic signal to reflect the latest trend of the stock.

2.33 The Working Group noted that the wavelet analysis presented in WG-EMM-2022/25 Rev. 1 was undertaken on data spanning 1997–2011, where there was at least one survey every year. They noted that the ‘y5’ time period could be appropriate if surveys had occurred in every year. The Working Group recognised that data collection gaps in recent years and areas meant there was insufficient data to use the ‘y5’ time period at present.

2.34 The Working Group identified that the best contemporary estimate would, for the purpose of an initial revision to catch limits in Subarea 48.1, be obtained by computing the long-term average, and therefore recommended using the ‘yall’ time period for those areas. It further recommended to use the lower bound of the one-sided 95% confidence interval (assuming a lognormal distribution) for strata with a single survey. Should strata surveys occur annually, the Working Group considered that a five-year window to average acoustic biomass estimates may become appropriate.

2.35 The Working Group recommended that given the periodic and dynamic nature of krill population dynamics, future catch limits should be revised frequently to ensure a precautionary management of the krill fishery.

2.36 The Working Group noted that enabling responsive management would require regular acoustic surveys and discussed the possibility of making such surveys mandatory for krill fishing vessels, in line with the tagging requirements for participation in toothfish longline fisheries. In such context, the participants favouring the use of all acoustic data at hand indicated that if surveys were to be conducted frequently, the time period over which biomass estimates were averaged could be shortened.

2.37 The Working Group noted that the overarching management strategy of different fisheries needed to account for the specific dynamics and ecosystems in the areas where those fisheries operate.

WG-SAM advice and considerations on the krill management strategy

2.38 Dr S. Parker (Secretariat), on behalf of the WG-SAM Co-conveners, summarised the discussions regarding the krill stock assessment using the generalised R yield model (Grym) provided by WG-SAM-2022. WG-SAM noted that a range of opinions regarding parameter values and the implementation of the decision rules as applied to krill persisted and made a request to WG-EMM to help constrain the range of potential scenarios by providing expected bounds to output values from the models (WG-SAM-2022, paragraph 3.22). Dr Parker noted that WG-SAM recommended Members develop stock hypotheses to guide the interpretation and use of data for parameter estimates (WG-SAM-2022, paragraph 3.13). The Working Group noted that WG-SAM-2022 agreed that the Grym and krill assessment model implementations are fit for purpose as a numerical projection tool.

2.39 WG-EMM-2022/05 presented a proposed practical revision to CM 51-07 that would distribute catch and increase catch limits in Subarea 48.1. Using selected Grym parameter values, an alternative decision rule, selected biomass estimates and a risk-assessment scenario that specifies management units consistent with the likely conduct of future surveys, the analysis proposed summer and winter catch limits for each management stratum. The authors further indicated that if consensus could not be reached on the revision of the krill management approach, a subdivision of the current trigger level in Subarea 48.1 would be possible.

2.40 The Working Group thanked the authors for providing a proposed revision to CM 51-07, noting the utility of seeing the three components of the krill management strategy integrated into the proposal. It suggested that accounting for the redefinition of strata boundaries by WG-ASAM (paragraph 2.25) would be welcome, and that catch limits could be presented in tonnes, rather than percentages, to simplify the revised conservation measure. The Working Group noted that the proposed revision to CM 51-07 involved a change to the CCAMLR decision rules and recalled that WG-SAM-2022 recommended that comprehensive management strategy evaluations be undertaken to assess the impacts of any changes to the decision rules (WG-SAM-2022, paragraph 3.21; paragraph 2.54).

2.41 The Working Group noted that using this reformulated decision rule resulted in a gamma value of 0.03 rather than 0.0018, and that for a short-lived species this value was notably lower than for other fisheries in the Convention Area (e.g. 0.04 for data-limited toothfish fisheries). The Working Group noted, however, that low gamma values for krill could also be explained by the high variability in krill recruitment.

2.42 Many participants recalled studies that hypothesised ecosystem effects from fishing under the current management regime (Watters et al., 2020; Krüger et al., 2021) and noted that whilst the proposal represented an overall increase in the catch limit, the distribution of catch limits both in time and space reduced the risk of localised depletion from fishing. Some participants stated that there was not currently enough information to quantify fishery impacts and that future surveys and studies were needed to provide such assessments as well as to better understand the effects of climate change.

2.43 The Working Group supported the recommendation from WG-SAM-2022 that establishing a krill stock hypothesis would provide a framework for interpreting patterns observed in survey and fishery data, and provide a crucial tool to direct surveys and analytical efforts (e.g. surveys designed to investigate recruitment in hypothesised source areas).

2.44 The Working Group agreed on the use of the weight-at-length and maturity-at-length relationships presented in 'Scenario 18' of Table 5 in WG-FSA-2021/39 and used in WG-EMM-2022/05, for the purpose of the krill stock assessment using the Grym, until further data could be collected to update these parameter values.

2.45 WG-EMM-2022/01 presented a review of recruitment studies conducted over the last 30 years and previously discussed at WG-Krill and WG-EMM. The authors considered that the proportional recruitment parameter values should be derived using data from long-term monitoring programs in the areas in which the fishery occurs, using standard techniques, and including recently collected data where available. The authors demonstrated that three long-term studies (the US AMLR Program, Palmer LTER and German surveys) all show consistent periodicity and that much of the estimated recruitment variability is a result of this periodicity. They further highlighted issues with other data sources currently considered potentially useful to estimate recruitment parameters, in particular those excluding surveys with observations of zero or low recruitment. While presenting a draft stock hypothesis, the authors indicated that the Antarctic Peninsula was a well understood and well documented system.

2.46 The Working Group noted that the periodic recruitment patterns were consistent across long-term time series, from different areas along the Antarctic Peninsula and reflected a key characteristic of the krill population in the area. It noted that while the periodicity was evident, the magnitude of peaks might be affected by selectivity, availability and net avoidance. Further noting the correspondence between time series generated by these historical surveys, sometimes using different survey nets and recruitment indices, the Working Group considered that these issues have likely had a minimal impact on describing the dynamics of recruitment. However, for estimation of proportional recruitment values further investigation in the future may be useful.

2.47 The Working Group discussed the importance of spatial coverage for future surveys as some participants noted that juveniles were often found aggregated in coastal areas, which may present accessibility issues. It also noted that periods of low proportional recruitment were not followed by subsequent low fishery yield, and that studies quantifying the relative contribution of krill production from different areas to the harvested stock in Subarea 48.1 may be necessary.

2.48 The Working Group recalled that krill length-frequency, abundance and acoustic survey data have been collected by Peruvian scientists for more than 25 years in Bransfield Strait and noted that it would be valuable to account for these data in this context (paragraph 2.29). The Working Group recalled a previous request from the Scientific Committee to develop a database for biological data from the surveys as well as from the krill fishery (WG-FSA-2021, paragraph 5.12), which could include those data as well as the data presented by WG-EMM-2022/01.

2.49 WG-EMM-2022/02 presented an analysis of krill proportional recruitment indices in Subarea 48.1 based on seven different data sources and using different size thresholds below which individuals are considered as recruits. The choice of size threshold had a larger effect on proportional recruitment parameters than differences among datasets, and, given the importance of gear selectivity, in particular for fishery data, the authors argued that length-frequency distributions should be adjusted prior to the computation of proportional recruitment parameters.

2.50 The Working Group welcomed the paper and noted that the periodicity in recruitment indices (paragraph 2.46) was supported by predator diet data. It noted that the selectivity of the commercial gear was potentially reducing the capture of small individuals. Some participants noted that the location of fishing operations, away from coastal areas (where juveniles may aggregate) was a factor to consider as well. The Working Group noted that differences in magnitudes between time series from very different data sources were possibly due to a combination of differences in selectivity and availability (paragraph 2.46).

2.51 The Working Group noted that prior to the calculation of recruitment indices, the krill length-frequency data from the US-AMLR surveys and the LTER surveys were standardised by swept volume and the fishery data were standardised by catch (WG-SAM-2021/07). The Working Group noted that while the krill length-frequency data obtained from penguin diets showed periodicity, it could not be used at present for proportional recruitment indices in a stock assessment as it could not be standardised.

2.52 WG-SAM-2022/28 Rev. 2 presented an alternative method of computing precautionary yield in the krill stock assessment projections. Instead of using the current implementation of the decision rules which compares the spawning stock biomass (SSB) under different fishing mortalities to pre-exploitation SSB, SSB in each year of fishing is compared to the same projections without fishing. As a result, non-zero yield is possible under simulations of high recruitment variability, which may not be the case when using the current decision rules.

2.53 The Working Group noted the usefulness of studies focusing on decision rules but voiced concern that this approach was less precautionary than intended. The Working Group recognised that the relationship between proportional recruitment and the resulting mortality estimates was an area of potential future improvements, and that the current implementation (WG-SAM-2021/09) was already an improvement over the original proportional recruitment model (de la Mare, 1994).

2.54 The Working Group agreed that further work on this subject required a management strategy evaluation which could test different decision rules as well as different proportional recruitment models.

2.55 The Working Group noted that in other areas with long time series of data, methods such as time series weighting are used to enable recent data, which is likely more relevant, to have a greater weight than historic data whilst still allowing for the variability in the time series to be present. This method may be useful for exploring future proportional recruitment values which may have changed through time due to regime shifts.

2.56 WG-SAM-2022/26 presented a summary of the status of the krill assessment fitted using the Grym following work undertaken during 2021. While recalling that the Grym model for krill stock assessment is ready for use, the paper noted that agreement on some parameter values has not yet been reached. Regarding proportional recruitment, the authors identified two sets of parameter values that they deemed appropriate (recruitment scenarios (1) and (4) in Table 4 of WG-FSA-2021/39). The authors noted that the results of scenario (1) showed the most overlap with the expected natural mortality range, used a clear and biologically well-defined age class

(R2) as the recruitment, and estimated the recruitment with data collected by the recommended sampling net (RMT8), which can reduce net avoidance by krill. The results of scenario (4) overlapped the expected natural mortality range to an acceptable level, and used data collected based on a sampling net with a mouth opening (6 m^2), similar to an RMT8.

2.57 The Working Group noted the usefulness of the pros/cons table generated by the authors in their presentation. The Working Group noted that such a table may be useful to assist in the selection of scenarios and could help guide future analysis of the existing long-term data to provide recruitment series for the Grym model for stock assessment. Some participants also noted that using an R2 recruitment index alleviates concerns over the under-representation of small individuals in samples due to gear selectivity and krill availability.

2.58 WG-EMM-2022/32 presented the results of an experiment which estimated the length-weight relationship of krill on board a krill fishing vessel by grouping krill specimens by length classes and weighing them together to reduce the impact of vessel movement. Results indicated that an adequate krill length-weight relationship could be obtained using this method. The Working Group did not have time to discuss this paper, which had been considered by WG-SAM (WG-SAM-2022, paragraph 3.6).

2.59 WG-EMM-2022/28 presented an analysis comparing krill length composition between research and commercial samples in a local area in Subarea 48.2. Noting the difference in fishing tactics and gears between research and commercial vessels, the authors highlighted the significant differences of both the recruits and largest individuals in fishery catches of 12 fishing vessels in the Bransfield Strait compared to research trawl samples from the *Atlantida*. The authors expressed concern that typical sample size of length measurements per observed haul and sampling interval (200 individuals of krill should be sampled once every 3 or 5 days) would not be effective for accurate data to assess krill length compositions from fishery catches. They advocated for the standardisation of trawl sampling protocols for acoustic surveys (including gear construction and fishing tactics) and for the use of research trawls during acoustic surveys on board commercial vessels as well as increase in observer sampling frequency in the krill fishery, taking into account the number of hauls per day and the amount of catch per haul. They noted that the requirements for krill sampling during an acoustic survey on board fishing vessels should be determined by the objectives of the survey, going beyond the requirements of SISO.

2.60 The Working Group noted that due to the dynamic nature of krill populations, the possibility that different swarms had been sampled by the compared vessels could not be excluded. It noted that the difference in trawling methods between vessels was also to be considered. The Working Group noted that the study raised an important point about the representativeness of observer data, which warranted the need for an assessment of SISO sampling methodologies, while recognising that the aim of observer data collection was to document the harvested stock (see also paragraphs 2.18 and 5.8). It supported the suggestion of deploying research nets from fishing vessels during acoustic surveys, while enabling some flexibility on gear design to avoid the exclusion of data due to small differences between the survey nets used and the recommended RMT-8. The Working Group encouraged the authors to augment their analysis by including statistical tests to quantify the differences between size distributions as well as using their data to attempt and estimate gear selectivity (WG-SAM-2022/27).

2.61 Dr G. Watters (USA), reflecting on the discussion regarding the comparison between the gamma for krill fisheries and that for data-limited toothfish fisheries (paragraph 2.41), presented a proposal, developed ad-hoc, in an attempt to facilitate the provision of advice on the revision of the krill management strategy. Noting that while agreement had been reached on several points during discussions, Dr Watters indicated that several issues precluded agreement on a gamma for the krill fishery in Subarea 48.1. He noted that a range of options, with a range of desirability were at hand, including a rollover of CM 51-07 and a spatial subdivision of the trigger level. Aiming towards agreement, he argued that the suggested proportionality between gammas in different fisheries could prove useful and presented a relationship in which harvest rate (i.e. gamma) divided by the inverse of recruitment variability was hypothesised to be equal across fisheries. Solving the equation resulted in a gamma of 0.03, hence providing support for the estimate provided in WG-EMM-2022/05. After swapping the proposed catch limits between the Bransfield Strait and the Gerlache Strait to alleviate concerns over the catch limit for the latter stratum (paragraph 2.30), noting that a few issues could soon be resolved regarding the risk assessment, Dr Watters indicated that agreeable interim advice was now at hand for this year, and that further collaborative refinements of the krill fishery management approach could be developed in the future.

2.62 Dr C. Darby (UK) thanked Dr Watters and noted that agreement over acoustic biomass estimates and the risk assessment was close, but that agreement over the appropriate krill stock exploitation rate, derived using the Grym, remained more distant due to the uncertainty around recruitment. Given that the role of the Grym was to estimate a single number, gamma, he suggested that a possible approach would be to agree on a range of values to be applied to acoustic biomass estimates, while using the survey time series of biomass estimates to provide a retrospective analysis. The resulting range of proposed catch limits and the consequences of applying them could then be discussed via an e-group in preparation for WG-FSA-2022.

2.63 Dr X. Zhao (China) thanked both speakers and indicated that he was in general agreement with them. He noted that having a backup approach was very useful and agreed that agreement over the revision of the krill fishery management approach was very close. He shared their optimism and indicated that collaborative refinements were possible to reach interim advice, including concessions regarding elements for which complete agreement has not yet been reached (e.g. using all years of available acoustic data). He thanked Dr Watters and Dr Darby for their valuable contributions and indicated that e-groups were available to progress discussions prior to WG-FSA-2022.

2.64 Dr S. Kasatkina (Russia) thanked all speakers for their very interesting discussion and noted that a direct comparison of harvest rates between toothfish and krill fisheries was not appropriate. She argued that krill fluxes needed to be taken into account as oceanic transport had a larger impact on krill than on toothfish, and that fish stocks were comparatively more affected by harvesting. She noted that the revision of the krill fishery management approach will require regular standardised acoustic surveys.

2.65 The Working Group recalled that the use of a data-limited approach to the revision of the krill fishery management strategy (SC-CAMLR-40/BG/28) was a recognition of the difficulty of accounting for all ecological, biological, oceanographic and fishery elements underpinning the dynamics involved. Without ignoring these important elements, the Working Group agreed that sufficient information was available to provide interim advice, which will be regularly improved over years, through international collaboration and intensive scientific efforts.

Advice from the meeting on the details of the risk analysis
for Subarea 48.1, data layers, catch scenarios

2.66 WG-EMM-2022/17 presented the implementation of the krill risk assessment in Subarea 48.1, at a scale more closely aligned with the scale at which the krill fishery would potentially operate under different management scenarios. The lowest relative risk scenarios were those whereby management of the fishery was based on the US AMLR survey strata, but split further into additional management units. The next joint lowest relative risk scenarios were also based on the US AMLR survey strata, but with extra management units added. In many cases there was very little difference in relative risk or in the proportion of catch assigned to each management unit, whether the fishery desirability was scaled or unscaled.

2.67 The Working Group noted that both the baseline and the fishery desirability scenarios where management of the fishery were split into US AMLR survey strata with additional management units, resulted in lower overall relative risk than the current fishery management scenario.

2.68 The Working Group acknowledged that whilst in some cases there was very little difference in risk between including and omitting the fishery desirability layer, agreement could not be reached on using a single approach. Some participants considered that using the baseline scenario was more appropriate as the inclusion of the fishery desirability layer may introduce spatial concentration of catches in particular management areas, counter to the purpose of the risk assessment. Other participants considered that the inclusion of the fishery desirability layer was appropriate as it represented a proxy for the current krill distribution (paragraph 2.30; WG-FSA-2021/56).

2.69 Noting the lack of winter distribution data, some participants indicated that the risk assessment would benefit from accounting for fishery desirability as it may help reflect the recent krill distribution (WG-FSA-2021/56).

2.70 The Working Group noted that CEMP was designed to monitor impacts from the fishery on dependent predators. If spatial management of the fishery is modified as part of a revision of CM 51-07, this may result in catches being taken in areas where less information from CEMP is currently available. Under such a scenario, more survey information would be required to ensure adequate understanding of any impacts from the fishery in these new management areas. The Working Group further noted that data gaps during the winter period exist for both krill and predator distributions which may be biasing estimates of relative risk. The Working Group noted that increased monitoring of both krill and krill-dependent predators is required in each management unit to fill in current data gaps, in addition to monitoring potential impacts from the fishery (paragraphs 2.95 and 2.96).

2.71 The Working Group noted that the desirability layer used in the krill risk assessment was based on the current location of the fishery and overlapped with higher predator distributions. Thus, the Working Group considered the approach to be a data-limited spatial overlap analysis. The Working Group further noted that the current approach calculates ‘relative risk’, however, previous work (Plaganyi and Butterworth, 2012; Watters et al., 2013) has demonstrated that ‘absolute risk’ to the ecosystem is reduced when catch is spread in space and time.

2.72 The Working Group considered that the term krill risk assessment was potentially misleading to managers and Commissioners as it implied an unspecified level of threat, whereas the values produced from the analysis produce relative risk levels. The Working Group recommended renaming the process as the 'spatial overlap analysis' to more accurately reflect the procedures undertaken.

2.73 WG-EMM-2022/27 presented comments and proposals on the use of the risk assessment framework to allocate catch in Subarea 48.1 based on the results of two acoustic surveys, carried out in the Bransfield Strait with one month time shift (February–March 2020), and accompanied by regular observations of marine mammals and seabirds. The authors proposed that the presence of krill transport casts doubt on the impact of the krill fishery on krill stocks and populations of dependent predators, and that krill transport processes affecting krill biomass and distribution variability should be considered in the risk analysis for Subarea 48.1. Proposals in the paper include: (i) the development of scientifically based indicators accompanied by criteria and diagnostics to assess the potential ecosystem impact of the fishery, taking into account the mixed effects of fishing, environmental variability (or climatic changes), and the competitive relationship between predator species; (ii) a set of indicators for the risk assessment framework, accompanied by transparent descriptions, criteria and diagnostics that should be approved by the Scientific Committee; and (iii) investigating the possibility of using CEMP data to provide information on the effects of fishing on dependent species.

2.74 The Working Group noted that while the *Atlantida* survey conducted in the Bransfield Strait during March 2020 showed a lower krill density and a higher predator density than the survey conducted in the same area during February 2020, the spatial distribution of areas with high krill density in 2020 did not overlap with areas of high predator density in 2020. The Working Group noted that the krill spatial overlap analysis was not designed to be used to evaluate impacts from the fishery, rather it is a mechanism by which to split the krill catch limit between management units, to reduce any potential impact based on spatial overlap of krill and predators.

2.75 The Working Group considered that the establishment of marine protected areas (MPAs) contributes to holistic conservation objectives, builds ecosystem resilience and protects against uncertainties, and would be an important contribution of the future krill management approach. The Working Group recalled that the Domain 1 MPA proposal (D1MPA) to establish an MPA includes Subarea 48.1, and that it was developed using Marxan, an already agreed methodology. It also noted that a combination of different measures is needed to comply with Article II of the Convention.

2.76 WG-EMM-2022/31 presented a comparison of distribution and biological data between the CCAMLR 2000 Krill Synoptic Survey of Area 48 and the Russian *Atlantida* 2020 survey. Results indicate significant seasonal variability, and clearer links between size classes and water masses in 2020 than in 2000. In particular, larger krill were observed in the warmer waters of the Antarctic Circumpolar Current (ACC) compared to the colder waters of the Weddell Sea.

2.77 WG-EMM-2022/42 Rev. 1 highlighted recent changes to the conservation status of Antarctic fur seals (*Arctocephalus gazella*) summarised in WG-EMM-2022/P15 and presented an update on the population status and a metric of foraging habitat quality for South Shetland Islands (SSI) Antarctic fur seals, based on data from the 2021/22 field season at Cape Shirreff. The post-weaning dispersal and habitat use of SSI Antarctic fur seal pups over four austral winters between 2005 and 2019 were also summarised. Analysis of post-weaning distribution highlighted that Antarctic fur seal pups were dependent on continental slope areas around the Antarctic Peninsula during the austral autumn and winter, with the shelf and slope north of Livingston Island showing the highest concentration of animals in April and May.

2.78 The Working Group welcomed the paper and noted that the decrease in Antarctic fur seal pups in the Cape Shirreff area was dramatic (86% reduction in pup production between 2007 and 2020) and coincided with increasing foraging trip duration by adult females and an increase in leopard seal (*Hydrurga leptonyx*) predation during the breeding season.

2.79 The Working Group further noted that despite low breeding success, adult females forage during winter north of the Antarctic Convergence and were returning to breeding colonies exhibiting high rates of survival and good body condition. Collectively, these results indicate that the environmental stressors forcing the population decline are likely spatially restricted to the northern and western Antarctic Peninsula.

2.80 The Working Group recommended that data on the overwinter distribution of SSI fur seal juveniles be integrated into the data layers of the spatial overlap analysis and the D1MPA proposal. The Working Group also noted that this previously depleted population has fallen below a level which ensures greatest net annual increment. As such, it should be of concern to the Commission.

2.81 The Working Group noted that while myctophid fish represent a small portion of overall fur seal diet, in years before 2010 where foraging trips by breeding females were abnormally long, myctophids tended to increase in their diet. The Working Group considered that myctophid fish could be a candidate for incorporating in CEMP parameters and noted that this could be considered during the CEMP workshop (paragraph 2.96) to support further evaluation of the role of krill in fur seal diets. The Working Group also noted that fur seals continue to eat krill during the winter even as they move north of the Antarctic Convergence but that the proportion of myctophids, other pelagic fish and squid in their diet increases.

2.82 WG-EMM-2022/P10 presented a study on adaptability of the spiny icefish (*Chaenodraco wilsoni*) that is dependent on Antarctic krill to potential changes in food availability. Muscle samples were collected and analysed for fatty acid composition from three areas in the Bransfield Strait and the northern Antarctic Peninsula during February–April 2016 to evaluate their feeding variability. The results showed the diet of *C. wilsoni* varied in different marine environments. This flexibility in prey may assist their adaptation response if available prey species vary due to the effects of climate change.

2.83 The Working Group welcomed this paper and noted that New Zealand and Chinese scientists have applied for joint funding to use fatty acids to investigate trophic linkages in the Ross Sea region.

2.84 WG-EMM-2022/P11 presented a simulation on the influence of the tide on residual water mass transport in the Bransfield Strait. The model indicated that the residual current produced by the diurnal tide is dominant and primarily distributed along the shelf break and near the coast, and water stratification amplifies this residual current system. The model suggests that tidal dynamics in this region should be included when studying cross-shelf water transport.

2.85 WG-EMM-2022/P12 presented a study on the concentrations of four trace elements present in Antarctic krill in the northern Antarctic Peninsula, to explore the suitability of Antarctic krill as a bioindicator of trace elements to reflect the heterogeneity of marine environments in this area. The results suggested some trace elements found in Antarctic krill are suitable and effective bioindicators for reflecting regional heterogeneity in marine environments in the northern Antarctic Peninsula (paragraph 2.89).

2.86 The Working Group noted that regional and large-scale demographic and ecological studies need to consider the localised areas and hydrographic interactions between them, particularly in the northern Antarctic Peninsula region (paragraph 2.89). These studies can be useful to better understand krill stock structure in this region and are especially important for krill ecology and management.

2.87 The Working Group noted, but did not consider, WG-EMM-2022/16 which presented a dynamic krill distribution model for the waters surrounding the SOI Archipelago and the wider Subarea 48.2, using data from a spatially and temporally consistent krill-targeted acoustic survey (2011–2020) and year-specific environmental predictors within a two-part 'hurdle' model. Predictors found to be important in both hurdle components were distance from shelf break, distance from summer sea-ice extent, and salinity. Year-specific projections of krill distribution revealed that the shelf break surrounding the SOI, particularly the northern shelf break, was a consistently important area for krill. Model projections for 2021 also revealed low probability of krill presence and the combined hurdle model estimated krill densities to be an order of magnitude lower than previous years, aligning with reports of poor breeding success in krill predators at SOI.

Advice to the Scientific Committee on the review of CM 51-07
and implementation of the krill management for other subareas

2.88 WG-EMM-2022/21 presented options for the interim revision of CM 51-01 and CM 51-07 to progress the new krill management approach in 2022. Two options were proposed, one requiring revisions to CM 51-01 and CM 51-07, the other to revise CM 51-07 only, but with an interim exemption of the relevant provisions stipulated in CM 51-01. The authors argued that given the state of scientific knowledge, Subarea 48.1 should be separated from the other subareas (catch limits in these other subareas would be updated at a later stage), and that the advice initially given for Subarea 48.1 should be reviewed in two years. The review periodicity of krill catch limits in all subareas was highlighted as a subject to be discussed by the Working Group.

2.89 The Working Group welcomed the paper and noted that, as krill stocks have a known transport pathway from Subarea 48.1 to Subareas 48.2 and 48.3, a holistic approach to all subarea catch limits is required when considering any revision to CM 51-07. The Working Group recommended the need for a krill stock hypothesis workshop.

2.90 The Working Group recommended that if CM 51-07 is revised, data reporting and collection, including from the fishery, need to be reviewed and increased as necessary to assess the possible effects of the revised measure consistent with CM 23-06, paragraph 4.

2.91 The Working Group encouraged Members to continue ongoing data collection designed to elucidate the potential effects of fishing and climate change on Antarctic Marine Living Resources.

2.92 The Working Group noted that proposed text for a revision to CM 51-07 was also included in WG-EMM-2022/05 and invited Members to participate in further discussions on both papers in the 'CM 51-07 revision' e-group.

2.93 The Working Group noted but did not discuss WG-EMM-2022/P02, which presented a summary of the current krill management strategy, the evolution of the fishery's dynamics and a proposed way forward for the revision of the management of that fishery in Subarea 48.1. The authors suggested that CM 51-01 alone is not sufficient to limit concentrated fishing, and that a continuation of CM 51-07 remains an imperfect, but acceptable, fallback if agreement on a revision to CM 51-07 cannot be reached.

CEMP

2.94 WG-EMM-2022/38 Rev. 2 presented an updated summary of the CEMP data holdings. The CEMP database contains time series for 479 unique site–species–sex–colony parameter indices, with many spanning more than 10 years. The paper provided suggestions to assist in the improvement of annual monitoring reporting, in addition to recalling the recommendation from WG-EMM to enhance CEMP to better inform the krill management approach.

2.95 The Working Group welcomed the paper and recommended a workshop on CEMP be convened, noting the last workshop occurred in 2003 when the program had no direct links to fishery management. The Working Group noted that updating CEMP to support both fishery management and MPA objectives is an important consideration, as the krill fishery in Area 48 continues to evolve.

2.96 The Working Group recalled that the terms of reference for such a workshop have already been drafted (SC-CAMLR-XXXVII, Appendix 8, paragraph 4.36), however, may need to be revised given the recent developments in the krill management approach. It further noted that such revisions should include consideration that an expanded CEMP provides data required to inform spatial distribution layers for higher trophic level predators in key areas, and for winter periods where data gaps are largest.

2.97 The Working Group agreed that the terms of reference should be further developed in the 'CCAMLR Ecosystem Monitoring Program (CEMP)' e-group and refined during WG-IMAF and WG-FSA, as many CEMP participants will be attending these meetings. Following these discussions, it is intended a complete workshop proposal be developed, inclusive of conveners, timing and location, to be considered by the Scientific Committee.

2.98 The Working Group discussed a number of CCAMLR activities requiring ecosystem monitoring in addition to management of the krill fishery through CEMP, including MPAs (paragraphs 3.8 to 3.15), vulnerable marine ecosystems (VMEs) (paragraphs 3.61 to 3.66) and climate change (paragraphs 4.1 to 4.9). Noting the breadth of these monitoring needs and the large amount of work required, the terms of reference for the CEMP enhancement workshop will need to define the scope of the workshop in relation to which of these monitoring needs will be addressed.

2.99 The Working Group also recognised the need to develop sustainable funding mechanisms for the CEMP work required to deliver and maintain the krill fishery management approach. This could be developed using contributions to the CEMP Special Fund and the CCAMLR General Capacity Building Fund.

2.100 WG-EMM-2022/22 presented a preliminary review of data obtained from the Ukrainian monitoring program across three CEMP sites (Peterman Island, Galindez Island and Yalour Island). Results indicated a small number of nestlings were observed, possibly the result of an unusually large amount of snow and unfavourable ice conditions. Updated CEMP data for the 2021/22 breeding season will be submitted to the Secretariat when completed.

2.101 The Working Group welcomed the preliminary contributions and synthesis of the observations, and invited interested Members to contact the authors directly as there was not sufficient time to discuss the paper in plenary.

2.102 WG-EMM-2022/P01 described results from the long-term monitoring of the diets of breeding macaroni penguin (*Eudyptes chrysolophus*) and eastern rockhopper penguin (*E. filholi*) between 1994 and 2018. The study found substantial overlap in diets with annual variations in relative prey contribution, however, no significant long-term changes were detected when compared with previous literature. Changes in the relative proportions of prey were considered unlikely to account for the recent declines in these populations.

2.103 The Working Group thanked the authors for the analysis of this long-term dataset and acknowledged its value in contributing towards the krill management approach. Due to the time constraints imposed by the virtual meeting, there was not sufficient time to discuss further questions pertaining to this paper.

Spatial management

3.1 WG-EMM-2022/45 requested CCAMLR to review the management plan for the Antarctic Specially Protected Area (ASPA) that would result from the proposed merger of ASPA No. 152 (Western Bransfield Strait) and ASPA No. 153 (Eastern Dallmann Bay) for consideration by the Committee for Environmental Protection (CEP) following Antarctic Treaty Consultative Meeting (ATCM) Decision 9 (2005).

3.2 The Working Group recalled the significant amount of research already undertaken in this area and noted that this proposal provided an opportunity to communicate results with relevant CCAMLR stakeholders. The Working Group noted that the proposals sought to allow unimpeded transit of vessels and benthic protection of waters deeper than 20 m. The proposal included a minor increase in the size of the protected areas to simplify boundaries and better align them with relevant depth contours. The Working Group requested a justification for these changes and requested regular reporting of scientific studies conducted in ASPAs.

3.3 The Working Group supported the revised management plan for ASPA No. 152 and No. 153 and referred it for consideration to the Scientific Committee.

3.4 WG-EMM-2022/08 presented a management plan for ASPA No. 145 Port Foster, Deception Island and SSI. The revised management plan incorporates a new sub-site, considered to be a biodiversity hotspot for benthic fauna. This new sub-site of Deception Island is between 0 and 50 m depth and has been named sub-site C.

3.5 The Working Group considered this proposal, highlighting the importance of continuing scientific research of this nature which increases understanding of unique biological hotspots of ecological significance.

3.6 The Working Group supported the revised management plan proposal for ASPA No. 145 and referred it for consideration to the Scientific Committee.

3.7 The Working Group requested the Scientific Committee and Commission give further consideration to the process for engagement with the ATCM on the development of new or revised ASPAs with only a marine area.

3.8 WG-EMM-2022/44 presented a study which tracked Adélie penguins (*Pygoscelis adeliae*) from the Ardley Island CEMP site in the SSI. Preliminary results showed that habitat use during the breeding stage was concentrated in Subarea 48.1, while during the post-breeding and moulting stage, habitat use was in Subareas 48.1, 48.2 and 48.5 during winter. Results highlighted the importance of this data for protection and conservation proposals such as the D1MPA and the Weddell Sea MPA.

3.9 The Working Group welcomed the preliminary results from this paper, acknowledging the difficulties in linking local area management with large-scale processes. Further, the Working Group recognised the value of information concerning the movement of juvenile and non-breeding predators and welcomed further studies targeting the tracking of multiple colonies. The Working Group noted the importance of continuing this study to assist in filling gaps in winter distributions, in addition to revealing ecosystem interactions during other life stages of Adélie penguins.

3.10 WG-EMM-2022/33 presented a report from recent scientific expeditions from a small research vessel (i.e. 23 m) in the Western Antarctic Peninsula, Gerlache Strait and surroundings. The value of this research was emphasised through the provision of biodiversity data from places that large research vessels cannot easily reach, and obtained using a range of methods.

3.11 The Working Group welcomed the results of this study and acknowledged its importance in contributing to the development of new ways to observe ecosystems. The Working Group noted progress with similar efforts to develop autonomous vehicles and using ships of opportunity to help long-term monitoring of the CAMLR Convention Area.

3.12 WG-EMM-2022/03 presented a methodology employing baited remote underwater video systems to survey fish and identify benthic organisms at depths that are not well-studied due to technology restrictions. The survey was conducted in Silverfish Bay, which is located near the Italian and Korean research stations in the Ross Sea region MPA (RSRMPA) general protection zone (i). The surveys were analysed using video data collected during 2017 and 2018 and found 26 taxa belonging to four phyla identified from the video data and associated with habitat morphology.

3.13 The Working Group welcomed the preliminary results from this paper, noting the area is of high ecological value and the technique represents an efficient way to bring new information on the characterisation and locations of diverse benthic communities to the discussion on VME management in other areas as well. The Working Group noted that the local area of the research was near several notified VMEs in Silverfish Bay, some of which are in ASPA No. 161 and knowledge of the benthos described by the survey may better inform the distribution of fragile habitats in the area.

3.14 WG-EMM-2022/40 presented a multi-year NASA-funded project designed to produce data layers of polynyas at a circum-Antarctic scale. The project is developing novel methods to aid in the classification and quantification of polynyas as they can be important drivers of ecosystem processes.

3.15 The Working Group thanked the author for providing valuable inputs to discussions concerning the ecological value of polynyas in the broader Southern Ocean ecosystem and looked forward to the results, especially regarding how polynyas develop and may move along the coast seasonally. The Working Group noted the authors' intention to develop a data portal to make the data layers available to the CCAMLR community once completed.

3.16 The Working Group noted that both WG-EMM-2022/03 (Dr E. Carlig, Itlay) and WG-EMM-2022/40 (Ms Z. Sylvester, Belgium) were led by current CCAMLR scholarship recipients. The Working Group noted that despite challenges due to COVID restrictions, the projects have been successful and the CCAMLR scholarship scheme was an essential part of the Scientific Committee's capacity building strategy and drew attention to the continued success of this program to the Scientific Committee.

3.17 WG-EMM-2022/10 presented the report of a workshop on pelagic regionalisation held virtually in June 2022, which focused on determining pelagic ecoregions by combining abiotic and biotic variables to classify the ecological areas of the Indian Ocean sector between 20°W to 160°E and 30°S (includes waters between subtropical and sub-Antarctic areas).

3.18 The Working Group welcomed the paper and considered the results important to evaluate various assemblages across many regions, especially in relation to climate change and the linkages made by species that migrate long distances between the subtropical and the northern part of the Southern Ocean. The Working Group suggested that it would be important for future work to expand the analyses to a larger scale to include more southern areas.

3.19 The Working Group noted that multi-Member collaborations, which can be leveraged by CCAMLR, and funding sources from non-governmental organisations have been a productive model for progressing important topics that are too complex to progress at CCAMLR meetings. The Working Group encouraged more use of this model in progressing issues and encouraged collaboration among Members.

Data analysis supporting spatial management approaches in CCAMLR

3.20 WG-EMM-2022/26 Rev. 1 reported findings from a recent multi-vessel sightings survey carried out as part of the International 2019 Area 48 Survey for Krill. Results demonstrated that the fin whale (*Balaenoptera physalus*) abundance in the area is increasing since the CCAMLR-2000 Survey period, an important consideration for the development of the krill management approach.

3.21 The Working Group welcomed this paper and noted that the assumed fin whale foraging time in the area (120 days) is based on data from the early 1980s and may be an underestimate as fin whales are known to forage around South Georgia through winter. The Working Group considered that whale tagging data could be used to update the estimated seasonal foraging duration of baleen whales in Area 48 for use in estimating krill consumption.

3.22 The Working Group noted that humpback whale (*Megaptera novaeangliae*) and blue whale (*B. musculus*) populations in Area 48 have also been reported to be recovering. The Working Group further noted that the distribution of the fin whales overlaps with the krill fishery around Subarea 48.2 and that fin whales likely account for a substantial amount of krill removal, which should be considered in the krill management approach and during the proposed CEMP workshop (paragraph 2.95).

3.23 The Working Group noted that the International Whaling Commission (IWC) is developing a Southern Hemisphere fin whale assessment and looked forward to having that information submitted to future working group meetings.

3.24 WG-EMM-2022/35 presented the first biological description of Welchness Cape, Dundee Island. Preliminary results from seabird and marine mammal surveys were reported with the aim to generate baseline data at this site to support decision-making regarding conservation and environmental management, and future research and monitoring initiatives such as those planned for the currently proposed D1MPA.

3.25 The Working Group welcomed the paper and noted the large number of observations of Antarctic fur seals relative to those reported at Cape Shirreff in WG-EMM-2022/42 Rev. 1. The Working Group noted the report that mainly skinny juveniles were observed and that the number represents the number of observations and not necessarily the presence of 3 000 individuals.

3.26 WG-EMM-2022/P14 and 2022/15 presented detailed information regarding the discovery of a breeding colony of notothenioid icefish (*Neopagetopsis ionah*, Nybelin 1947) of globally unprecedented extent observed in the southern Weddell Sea during the Continental Shelf Multidisciplinary Flux Study expedition from February to March 2021 on board the *Polarstern*. The colony was estimated to cover at least 240 km^2 of the eastern flank of the Filchner Trough, and comprised fish nests at a density of 0.26 nests m^{-2}, representing an estimated total of ~60 million active nests and associated fish biomass of over 60 000 tonnes. This discovery provides support for the establishment of a regional MPA.

3.27 The Working Group congratulated the authors for the discovery of this significant ecological feature which attracted interest from the general marine biology community and the public at large. The Working Group noted that despite extensive work in the Weddell Sea, discovery of the icefish spawning site was accidental and it is likely that other spawning sites with similar significance are still to be discovered. The Working Group noted that small numbers of nests for *N. ionah* have been observed in very different habitats in other areas and that nesting areas for other icefish species are also likely to be discovered in the future. The Working Group further noted the importance of protecting clearly defined spawning areas in terms of conservation and stock management and encouraged that further research be conducted.

3.28 The Working Group recommended that the recently discovered icefish spawning area should be protected in a timely manner, and that a suitable mechanism is needed to enable this.

3.29 The Working Group noted that protecting the icefish spawning area in the more immediate term could potentially be provided, for example by expanding CM 22-06 on VMEs to include fish nesting areas, or through the creation of a conservation measure dedicated to the protection of essential fish habitats. The Working Group invited interested participants to continue discussion of protection for important areas such as this spawning site in the 'Vulnerable Marine Ecosystems Review' e-group.

3.30 WG-EMM-2022/43 presented the Eastern Weddell Sea Observation System (EWOS), a new multinational initiative to provide coordinated and systematic observations in the Eastern Weddell Sea. An EWOS pilot study was carried out on board the *Polarstern* in March–April of 2022 which will provide unique quantitative information for integrated ecosystem functions such as carbon export and secondary production.

3.31 The Working Group congratulated the authors of the paper on the success of the pilot study and noted that the project represented an excellent example of scientific collaboration between Members. The Working Group strongly supported the continuation of the project as it contained many novel scientific approaches such as vertically integrated sampling within a well-defined and diverse region in the Weddell Sea. Ecosystem components sampled included characterising flying seabirds, air breathing predators, fish and invertebrates within and under sea ice, under ice shelves, in the water column, on the seafloor and under the seafloor. These approaches had the potential to greatly increase the scientific knowledge of the Weddell Sea region and contribute to environmental monitoring and management by CCAMLR.

3.32 The Working Group noted that while using a larger rectangular midwater net might allow for better sampling of pelagic fish, the M-RMT net which was used, allows for comparison of the krill data with previous surveys. The Working Group noted that the highest krill density was encountered in the deepest sampling layer (200–500 m), which is deeper than most maximum sampling depths of krill surveys.

3.33 The Working Group noted that this multidisciplinary international research made use of innovative technology such as under-ice sampling techniques. The Working Group noted that this approach to research could be used as a model that could be aspired to in other areas.

3.34 The Working Group noted, but did not discuss, WG-EMM-2022/P03, which presented the latest krill biomass estimate for Area 48 from the international large-scale 2019 Area 48 Survey. Following the acoustic transects of the CCAMLR-2000 Survey, survey vessels were provided by Norway, the Association of Responsible Krill harvesting companies and Aker BioMarine AS, the UK, Ukraine, Republic of Korea and China. Biomass was estimated to be 62.6 million tonnes (mean density of 30 g m^{-2} over 2 million km^2) with a sampling CV of 13%. The highest mean krill densities were found in the SOI stratum (93.2 g m^{-2}) and the lowest in the South Georgia Island stratum (6.4 g m^{-2}).

Research and monitoring plans

3.35 WG-EMM-2022/36 presented the initial steps undertaken by Argentina and Chile to map the extensive research developed and underway by CCAMLR Members in the West Antarctic Peninsula and South Scotia Arc, which can contribute to the development of a research and monitoring plan (RMP) for the proposed D1MPA. The paper provided a preliminary survey that responds to the need of developing a comprehensive, multinational and open RMP while contributing to other initiatives such as the krill management strategy and the CCAMLR MPA Information Repository (CMIR). The survey will be shared through the

D1MPA Expert Group for general suggestions and subsequently distributed more widely. The proponents encourage broad participation by other Members and stakeholders to this initiative.

3.36 The Working Group thanked Argentina and Chile for undertaking a survey to catalogue the research that has the potential to contribute towards an RMP for the D1MPA proposal and encouraged participation by interested parties.

3.37 WG-EMM-2022/30 presented data on the spatial distribution, density and size composition of two species of salps (family Salpidae) in Subarea 48.1, from a Russian survey conducted in January–March 2020 by the vessel *Atlantida*.

3.38 The Working Group noted that some studies in the scientific literature have suggested that salps may replace krill as the dominant species in the Antarctic due to the effects of climate change. The results from this study suggested that salps were constrained to coastal areas, with very little presence of salps in research hauls conducted offshore. The Working Group encouraged further analysis to explore spatial relationship with environment conditions and studies on *Ihlea racovitzai* as little is known about the life history of this species.

3.39 WG-EMM-2022/04 presented a summary of research on euphausiid larvae and salps conducted by Argentina during the summer seasons of 2019 and 2020 in waters off the West Antarctic Peninsula (Mar de la Flota/Bransfield Strait) and Elephant Island surroundings. During 2019, *E. superba* and bigeye krill (*Thysanoessa macrura*) abundances were very high, while during 2020 all euphausiid larvae had very low densities. Salp densities showed an opposite pattern. The paper correlated the changes in abundance with environmental conditions (satellite chlorophyll-*a* and water masses properties).

3.40 The Working Group welcomed the study and noted that investigating the correlations between different species as well as links to environmental variables in the data could provide valuable ecosystem information.

3.41 WG-EMM-2022/37 provided the first summary of projects within the CMIR and offered potential revisions to the structure of the repository to better align it with its intended use. It noted the highly collaborative nature of the CMIR with 20 Members, two States and seven Cooperating Parties partnering with submitted projects and suggested that revisions to the CMIR structure could assist in communicating progress in MPA-related research and in developing routine reporting.

3.42 The Working Group welcomed this paper, recognising the usefulness of the summary to map research activities supporting the RSRMPA, while also noting that this project list may not be representative of all Member research effort occurring in the area as it was driven by reports of activities from four Members and other research effort may not have been reported.

3.43 The Working Group noted that WG-EMM-2022/37 included a compilation of Member-submitted activities, as well as the current CMIR database as supplemental files and that the activity reports would be made available on the CMIR website.

3.44 The Working Group considered recommendations to improve the CMIR design, suggesting the development of categorical variables to be included in project reporting to improve accessibility for key metrics such as collaboration, geographic areas and key species investigated, in addition to providing the CMIR as an open-access resource for the wider scientific community. The Working Group suggested continuing discussion on aligning CMIR structure and function via the 'RSRMPA Member activities 2022' e-group.

3.45 WG-EMM-2022/47 presented the research and monitoring contributions by the Republic of Korea in the Ross Sea region in support of CM 91-05. The paper reported progress by the 'Korea Ecosystem Structure and Function of Marine Protected Area in Antarctica' program, by presenting a list of 15 datasets submitted to the CMIR, reporting on CEMP data collected at Cape Hallett, and providing summaries of 17 peer-reviewed scientific papers.

3.46 The Working Group welcomed this paper, acknowledging the value of the research in contributing information to the limited genetic database available for zooplankton species in the Southern Ocean. The data are freely available with access provided through the Korean Polar Data Centre, for which the Working Group expressed its appreciation for such transparency.

3.47 Many participants also noted their willingness to collaborate with Korea to continue progressing this work, in particular to contribute to the development of methods to monitor zooplankton.

3.48 The Working Group recalled the RMP for the Ross Sea region, noting the importance of undertaking research on all five designated geographic areas to address key indicators established within the plan.

3.49 WG-EMM-2022/14 presented an overview of the research activities conducted in the RSRMPA since its establishment, which were supported by the Italian National Antarctic Research Programme. A significant amount of work focused on environmental pollution, which is not a current focus of the management framework for MPAs.

3.50 The Working Group welcomed this paper, noting the significant contributions to the development of best practices and standardised procedures for research in the RSRMPA, in addition to the significant opportunity for collaboration among Members.

3.51 The Working Group further noted that this research enables the generation of various research opportunities for Members to develop future research plans based on agreed objectives, in addition to addressing emerging stressors to MPAs and the broader marine ecosystem, such as marine pollution and climate change.

3.52 WG-EMM-2022/P04 presented a study which investigated spatio–temporal distributions of the epipelagic meso-zooplankton community in the western RSRMPA based on three surveys conducted in the late summers of 2018, 2019 and 2020. The study also documented the drivers of the succession in zooplankton community structure within the area.

3.53 The Working Group welcomed the paper, noting the importance of increasing the understanding of the ecological role of meso-zooplankton for management of both MPAs and fisheries in the RSRMPA.

3.54 The Working Group recalled the opportunity for collaboration as requested within the presentation, with many participants noting their support of the coordination of this research in the RSRMPA as well as in other areas such as the East Antarctic ecosystem.

3.55 WG-EMM-2022/P13 presented a statistical model that evaluates the sea-ice cover with two measures: accessibility (i.e. the probability that a given area is navigable by vessels at a given time) and repeated accessibility (i.e. the probability that a given area is navigable by vessels at a given time and again at least once within a defined timespan). Such a tool may facilitate the planning of research and monitoring activities in the Southern Ocean, as well as in Arctic seas.

3.56 The Working Group welcomed the technique and considered it a useful tool to provide an overview of sea-ice and invited interested Members planning research to contact the authors directly as there was not sufficient time to discuss the paper in full.

3.57 WG-EMM-2022/P05 presented a study of metabarcoding methods to analyse plankton samples obtained during February 2018 and January 2019 from the Ross Sea region. The results indicated that zooplankton assemblages were highly diverse within sample sites and the authors concluded that as metabarcoding data accumulate, better insights will be gained into zooplankton communities and their ecological implications in the Ross Sea region.

3.58 WG-EMM-2022/P06 and 2022/P07 presented a study which reconstructed chlorophyll-*a* concentration data using machine learning-based models. Based on comparison with in-situ observations, the results of the chlorophyll-*a* reconstructions by the models proved to be relatively more accurate than satellite observations. WG-EMM-2022/P07 suggested that the random forest model would allow for studying multiple characteristics of phytoplankton dynamics more quantitatively, such as bloom initiation/termination timings and productivity peaks, as well as the variability in time scales of phytoplankton growth.

3.59 In the time available for the meeting, the Working Group was unable to discuss the published papers and invited interested Members to contact the authors directly.

3.60 The Working Group also noted that no projects have been uploaded towards the South Orkney Islands southern shelf MPA. Dr Zhao expressed disappointment over the lack of effort towards updating projects on the CMIR for this MPA in particular.

Vulnerable marine ecosystem data

3.61 WG-EMM-2022/34 presented a proposal for a new site to be considered as a VME off Cape Well-Met in Subarea 48.1. Citizen science was successfully employed with the use of video imagery via a tourist-deployed submarine, which was used to identify a high abundance and diversity of sponges, with species such as hexactinellids archetypical of a VME.

3.62 WG-EMM-2022/46 presented observations of benthic ecosystems collected during 10 submarine dives in Subarea 48.1 in 2022. Seven sites are proposed as VMEs based on high abundances of VME indicator taxa, which in many cases, exceeded abundances of previously registered VMEs. Seven of the 10 dives had characteristics similar to three VMEs registered in 2018 (see WG-EMM-18/35).

3.63 The Working Group noted that these results could be indicative of the presence of additional VMEs in other areas of the Antarctic Peninsula, and that photographs and videos provide baseline information that would be valuable to monitor changes in these communities through time.

3.64 The Working Group noted the utility of citizen science as demonstrated by the study and considered the potential of employing a random sampling design to enable an unbiased study of VME extent and distributions. The Working Group also noted that future citizen science efforts using tourist submarines are in development and that citizen science could be a powerful tool to aid in this work and in the monitoring of VMEs for changes over time.

3.65 The Working Group considered the proposal, noting the abundance of VME indicator taxa discovered, and recommended that these proposed VME sites be included in the CCAMLR VME registry.

3.66 The Working Group further noted the importance of findings of this nature, that they are likely to increase in the future, and agreed that more extensive VME discussions, including to develop standard methodologies and quantitative parameters to monitoring the evolution of those benthic communities, could be progressed through the established 'Vulnerable Marine Ecosystems Review' e-group.

Climate change

4.1 WG-EMM-2022/12 and 2022/13 together presented recent analyses combining observations and model outputs to assess future trends in the southern Indian Ocean due to climate change. The study reported on the projected long-term ocean warming and increased frequency and intensity of marine heatwaves north of the ACC, noting faster projected climate velocities (i.e. drift velocity of isotherms) in mesopelagic than surface waters and increased primary productivity. The authors noted that the choice of mitigation strategies (scenario SSP1-2.6 vs SSP2-4.5) will have significant impacts in the long term.

4.2 The Working Group noted the relevance of this analysis to the work of CCAMLR and encouraged similar studies south of the ACC be conducted (e.g. Montie et al., 2020). It welcomed the compelling, global-scale visuals presented and highlighted the importance of the mesopelagic zone to Antarctic krill early life history, noting that in addition to temperature, climate-change induced ocean acidification was an issue of concern for Antarctic krill early life stages (e.g. Kawaguchi et al., 2013). The Working Group noted that it was timely to consider projected climate change impacts in the current context of the revision of the krill fishery management approach, and that CCAMLR should aim to develop management approaches that incorporate the effects of climate change.

4.3 WG-EMM-2022/20 reported on the update by SCAR to its Antarctic Climate Change and the Environment decadal report, to draw the Working Group's attention to the evidence for, and implications of, climate change impacts on the Antarctic environment. The report includes recommendations on the most urgent research required for the region, and elements of particular relevance to CCAMLR were highlighted.

4.4 The Working Group noted this important report and its relevance to CCAMLR's scientific work.

4.5 WG-EMM-2022/19 presented a proposal for WG-EMM and WG-FSA to consider contributing to the development of a workshop which would focus on the integration of research on climate change and ecosystem interactions within CCAMLR's scientific work. The authors requested feedback on the draft structure and on the proposed terms of reference of the workshop.

4.6 The Working Group welcomed the proposal and received an update of an upcoming proposal to the Scientific Committee for a joint SC-CAMLR–CEP climate change workshop based on the recommendations from the previous joint workshop held in 2016. In addition, the Working Group also noted a Southern Ocean Observing System workshop to be held in 2023 where these topics could also be discussed.

4.7 The Working Group supported these collaborative workshop ideas as a means to assist in defining necessary monitoring efforts, as well as clearly identifying topics to be addressed by working groups under their relevant agenda items. While welcoming the invitation of external experts and observers, the Working Group indicated that organisers would benefit from developing a workshop proposal that includes all the necessary information needed by the Scientific Committee before the 2022 meeting to ensure approval. The Working Group noted that such a workshop would enhance international collaboration and data sharing. Furthermore, if the workshops were to be held virtually and clearly defined series of sessions were organised, it would enhance opportunities for Member participation.

4.8 The Working Group agreed that CCAMLR scientists should collaborate on the development of indicators using available information and analyses (e.g. from scientific surveys, satellite observations, model outputs, fishery data and CEMP data) to monitor and document the status of the ecosystem in general and its marine living resources in particular. Such work, conducted by Members with support from the Secretariat, would be made publicly available.

4.9 The Working Group noted the existence of a 'Climate change impacts and CCAMLR' e-group to initiate discussion and collaborations to develop the workshop and related climate change work.

Other business (incl. review of the terms of reference and Scientific Committee draft work plan and WG-EMM priorities)

Chair's report of the Scientific Committee Symposium

5.1 On behalf of the Chair of the Scientific Committee, Dr Parker presented the report of the CCAMLR Scientific Committee Symposium, which was held virtually on 8 and 10 February 2022 (WG-ASAM-2022/01). The informal Scientific Committee meeting discussed the progress and outcomes from the first CCAMLR Scientific Committee's workplan (SC-CAMLR-XXXVI/BG/40) and provided an opportunity for participants to propose long-term priorities and strategies to inform the development of the next five-year strategic plan (2023–2027). Recommendations and plans will be refined during the intersessional period by all working groups and agreed at SC-CAMLR-41 according to the Scientific Committee's Rules of Procedure. Additionally, the terms of reference for WG-EMM were presented and discussed to identify if they were still fit for purpose.

5.2 The Working Group welcomed and endorsed such an approach that will enable the working groups and the Scientific Committee to identify and focus their efforts on priority work. The Working Group undertook to review the priority research topics presented in Table 2 of the document (WG-ASAM-2022/01) and preliminary discussions and recommendations for work sequencing took place. However, due to the time constraints of the meeting, the review of the priority research tasks was only partially completed.

5.3 The Working Group noted that the WG-EMM terms of reference pre-dated both WG-SAM and WG-ASAM, had been formulated when WG-EMM was created by combining WG-Krill and WG-CEMP, and were still relevant given the current workplan of the Working Group. It further noted that a holistic approach to reviewing the terms of reference for all CCAMLR working groups by the Scientific Committee was a desirable approach as the Scientific Committee is ultimately responsible for tasking the working groups to manage cross-cutting issues.

5.4 The Working Group recommended that the Scientific Committee allocate topics to specific working groups to aid Members in scheduling work and making sure scientists with appropriate expertise are available at the appropriate working groups.

5.5 The Working Group undertook to continue progressing the review of tasks related to WG-EMM, develop a sequence of tasks for WG-EMM over the next five years, and suggest revisions to the WG-EMM terms of reference (including recommendations from paragraph 2.18) through the 'Scientific Committee Symposium 2022' e-group, with results to be integrated from WG-ASAM, WG-SAM and WG-EMM by the Chair of the Scientific Committee along with direct advice from WG-IMAF and WG-FSA and presented at SC-CAMLR-41.

5.6 The Working Group also noted the advantages of detailed articulation of complicated arguments in the report text, especially when different views existed, in aiding of mutual understanding and expediting report adoption.

Data access rules (Data Services Advisory Group)

5.7 The Working Group noted WG-ASAM-2022/15 which describes the implementation of the Rules for Access and Use of CCAMLR Data (hereafter referred to as 'the Rules') in CCAMLR data request procedures, and the procedure for publication of derived materials in the public domain.

5.8 The Working Group welcomed the paper and recalled that the paper had previously been discussed during the SC Symposium, WG-ASAM and WG-SAM (WG-ASAM-2022/01, paragraphs 5.1 to 5.7; WG-SAM-2022, paragraphs 8.1 to 8.3) and is open for consideration in the 'Data Services Advisory Group' e-group.

5.9 The Working Group discussed assigning digital object identifiers (DOIs) to data extracts and noted that this would be a practical approach to create a stable citable reference to the specific subset of data that was used to conduct analyses whether presented in a working group paper or a peer-reviewed paper. The Working Group further noted that assigning a DOI to a dataset or data extract requires the creation of a public metadata record but does not require the data themselves to be publicly available.

5.10 The Working Group discussed data use and noted that upon release the data are only authorised for use for the purposes cited in the data request that was presented to the data owners for approval.

5.11 The Working Group considered whether the Rules should include guidelines towards handling of personal private information, and noted that discussion on this topic should not be guided by specific regulations that apply to one specific region.

5.12 The Working Group agreed that for compliance data (including Catch Documentation Scheme for *Dissostichus* spp. and transhipment data) endorsement for the request and approval for release are to be sought from the Commissioner or an alternate appointed by the Commissioner.

5.13 The Working Group recommended that:

(i) Members identify alternate representatives for approving data requests to account for periods when the Scientific Committee Representative might not be available

(ii) the Secretariat reduces the length of the data request procedure to two weeks after the abovementioned alternate representatives have been identified

(iii) the Rules be modified to explicitly clarify the restrictions for using the data and the responsibilities of the data requester.

Other business

5.14 WG-EMM-2022/23 Rev. 1 presented results from a fishery-dependent study of zooplankton to document species composition and abundance in Subareas 48.1, 88.1 and 88.2. Results agreed with those typical of Antarctic waters, indicating copepods (and copepod eggs) to be the most diverse group, followed by Euphausiacea.

5.15 The Working Group welcomed the presentation of research on zooplankton, a key component of energy transfer in the ecosystem, noting that species identification is a very time-consuming and specialist task, and that sampling zooplankton requires significant sampling effort given their patchy distribution. The Working Group noted that the high abundances of copepod early life stages and eggs were potentially informative of linkages between the Weddell Sea and the Bransfield Strait. While noting the ongoing development of genetic identification methods by Korea and New Zealand, the Working Group encouraged the collaborative development and updating of species identification keys for the Southern Ocean by CCAMLR scientists. The Working Group further noted SCAR's compilation of identification keys (https://www.biodiversity.aq/find-data/identification-keys-resources/) as well as the existence of other sources (e.g. NIWA, ANARE and the Boltovskoy key for the South Atlantic). The Working Group also highlighted the important role that the CCAMLR General Science Capacity Fund has played in supporting such studies.

5.16 WG-EMM-2022/24 presented results from oceanographic research undertaken in the Weddell Sea from 2018 to 2021. The utility of surveys using fishing vessels was emphasised given the ease of gathering data without specialised equipment. A decrease in average water temperature in Subareas 48.1 and 48.2 was noted, however, further investigation was deemed necessary.

5.17 The Working Group thanked the authors for presenting the study and noted the excellent collaboration between the fishing industry and scientists in using fishing vessels as research platforms as evidenced in both WG-EMM-2022/23 Rev. 1 and 2022/24.

5.18 The Working Group discussed the proposed workplan to develop data collection needs for CCAMLR krill fisheries (WG-EMM-2022/39, paragraphs 2.9 and 2.10), noting that the timing and content for the proposed workshops were uncertain due to COVID restrictions in the krill observer workshop host country (China), and that both WG-IMAF-2022 and WG-FSA-2022 may request additional data collection requirements. The Working Group agreed to progress with the workplan and identify the number and venues for the necessary workshops in a dedicated e-group.

5.19 Dr N. Kelly (Australia) provided an update on recent IWC–CCAMLR collaboration, noting the attendance of Dr D. Welsford (Chair of the Scientific Committee), Mr N. Walker (New Zealand) and Dr Parker at the IWC SC68D meeting, and that discussions regarding whale by-catch in the krill fishery were undertaken in the IWC Human Induced Mortality (HIM) subgroup. Dr Kelly further noted that the aim of the collaboration would be to facilitate information exchange, to help facilitate both desk-based and fieldwork opportunities for collaboration between CCAMLR and IWC scientists, and that these could be further developed in an e-group. Dr Kelly also encouraged delegations to involve cetacean scientists from their own countries in CCAMLR activities as appropriate.

5.20 The Working Group noted that the IWC HIM subgroup has undertaken to submit a report to WG-IMAF regarding the whale by-catch events, and that following the discussions at SC-CAMLR-40, cetacean experts could attend WG-IMAF as part of CCAMLR Member delegations.

Advice to the Scientific Committee and future work

Future work

6.1 The Working Group requested that the Scientific Committee consider incorporating the following topics into the strategic workplan for WG-EMM:

Krill management –

(i) update the CCAMLR gear library for krill (paragraph 2.23)

(ii) acquire and incorporate data from surveys conducted by Peru (paragraphs 2.29 and 2.48)

(iii) progress the development of biomass estimates for strata and subareas (paragraphs 2.34 and 2.35)

(iv) progress data collection protocols to support the krill management approach (paragraphs 2.10 and 2.61)

(v) convene a workshop to develop a krill stock hypothesis (paragraphs 2.43 and 2.89) which would provide:

(a) a framework for interpreting patterns observed in survey and fishery data
(b) a tool to direct surveys and analytical efforts

(vi) coordinate with the CEP on a climate change workshop (paragraphs 4.6 to 4.8)

(vii) collaborate with the IWC to better include cetacean expertise in future working group meetings (paragraph 3.23).

Ecosystem monitoring –

(viii) convene a workshop to update CEMP to support fishery management and MPA objectives (paragraph 2.95)

(ix) develop integrated ecosystem reporting mechanisms (paragraphs 2.18 and 4.8).

Advice to the Scientific Committee

6.3 The Working Group's advice to the Scientific Committee is summarised below; these advice paragraphs should be considered along with the body of the report leading to the advice:

(i) krill workplan and workshop (paragraphs 2.10, 2.43 and 2.44)

(ii) focus topic cycling and reporting (paragraphs 2.18 and 5.4)

(iii) gear library update (paragraph 2.23)

(iv) revise catch limits for krill (paragraphs 2.29, 2.34 and 2.35)

(v) include SSI fur seals in risk analysis and D1MPA proposal (paragraph 2.80)

(vi) revision of CM 51-07 and krill stock hypothesis workshop (paragraphs 2.43, 2.89 and 2.90)

(vii) CEMP workshop and funding mechanisms (paragraphs 2.95 and 2.99)

(viii) ATCM and marine ASPAs (paragraphs 3.3 and 3.6)

(ix) scholarship scheme (paragraph 3.16)

(x) IWC collaboration (paragraph 3.23)

(xi) protection of fish nesting areas (paragraph 3.28)

(xii) consider VME designation (paragraph 3.65)

(xiii) consider developing a workshop on climate change (paragraphs 4.6 and 4.7)

(xiv) data access rules (paragraphs 5.12 and 5.13).

Adoption of the report

7.1 The report of the meeting was adopted.

7.2 At the close of the meeting, Dr Cárdenas thanked all participants for their hard work and collaboration that had contributed greatly to the successful outcomes from WG-EMM this year, and the Secretariat, the stenographers and the Interprefy support team for their assistance. Dr Cárdenas further noted that although the length of the meeting had been shorter than an in-person event, a large body of work had been accomplished through the e-groups and a considerable future workplan developed for WG-EMM.

7.3 On behalf of the Working Group, Dr Watters thanked Dr Cárdenas for his guidance during this foreshortened meeting, the Secretariat for its work compiling the report, and the stenographer and the Interprefy team for the technical support provided. The Working Group acknowledged the successful use of the Interprefy platform for hosting the meeting, and the provision of advice to the Scientific Committee.

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Table 1: Updated strata krill biomass estimates based on Table 2.6 in WG-EMM-2021/05 Rev. 1 and SC-CAMLR-40/11 using the strata area calculation method provided in WG-ASAM-2022/02. The revised values are shown in **bold**. Where multiple surveys, the overall coefficients of variation (CVs) were calculated as in WG-EMM-21/05 Rev. 1. Time periods: yall: all available years 1996–2020, y5107 = since implementation of CM 51-07 (2009–2020) and y5 = 5 years (2015–2020). Modified from WG-ASAM-2022, Table 9, after removal of option 'y3'.

Strata	Density gm^{-2}	Variance of weighted density	CV of weighted density (%)	**Revised strata area based on WG-ASAM-2022/02**	**Biomass (tonnes) based on revised strata area**	CV biomass %	Years included for averaging biomass	Number of years with surveys	Number of surveys
Joinville (JI)[1]	83.01	723.28	32.40	**23 001**	**1 909 313**	32.40	y5	1	1
Joinville (JI)	51.85	750.75	47.60	**23 001**	**1 192 602**	47.60	y5107	4	4
Joinville (JI)	37.42	410.24	46.86	**23 001**	**860 697**	49.51	yall	8	11
Elephant (EI)	85.48	253.13	22.31	**51 648**	**4 414 871**	22.31	y5	2	2
Elephant (EI)	78.45	250.21	18.64	**51 648**	**4 051 786**	18.65	y5107	5	5
Elephant (EI)	65.49	487.64	26.69	**51 648**	**3 382 428**	26.92	yall	18	27
Bransfield (BS)	54.36	204.27	30.30	**34 732**	**1 888 032**	30.30	y5	5	6
Bransfield (BS)	39.85	154.41	32.35	**34 732**	**1 384 070**	33.81	y5107	9	11
Bransfield (BS)	34.19	343.83	41.28	**34 732**	**1 187 487**	42.83	yall	21	30
South Shetland Islands West (SSIW)	47.08	166.29	26.93	**47 066**	**2 215 867**	29.85	y5	5	6
South Shetland Islands West (SSIW)	41.05	109.99	23.68	**47 066**	**1 932 059**	25.30	y5107	9	10
South Shetland Islands West (SSIW)	53.45	326.48	32.86	**47 066**	**2 515 678**	36.27	yall	21	29
Gerlache Strait (GS)[2]	58.53	**1364.31**	63.11	**44 198**	**2 586 908**	63.11	yall	1	1
Powell Basin (PB)[1]	**32.73**	**155.74**	**38.13**	**144 680**	**4 735 100**	**38.13**	yall	1	1
Drake Passage (DP)[1]	**41.53**	**40.56**	**15.33**	**294 531**	**12 233 000**	**15.33**	yall	1	1

1 Single survey: 2019 Area 48 large-scale survey (WG-ASAM-2019).
2 Single survey: 2020 *Atlantida* survey (WG-ASAM-2021/04 Rev. 1).

Appendix A

List of Registered Participants

Working Group on Ecosystem Monitoring and Management
(Virtual Meeting, 4 to 11 July 2022)

Convener	Dr César Cárdenas Instituto Antártico Chileno (INACH)
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Appendix B

Agenda

Working Group on Ecosystem Monitoring and Management
(Virtual meeting, 4 to 11 July 2022)

1. Opening of the meeting

2. Krill management

   2.1 Krill fishery status
   2.2 WG-ASAM advice and considerations on the krill management strategy (Biomass estimations and confidence intervals)
   2.3 WG-SAM advice and considerations on the krill management strategy (Advice on the Grym to subareas derived from exploitation rates)
   2.4 Advice from the meeting on the details of the risk analysis for Subarea 48.1, data layers, catch scenarios
   2.5 Advice to the Scientific Committee on the review of CM 51-07 and implementation of the krill management for other subareas
   2.6 CEMP

3. Spatial management

   3.1 Data analysis supporting spatial management approaches in CCAMLR
   3.2 Research and Monitoring Plans
   3.3 VME data

4. Climate change

5. Other business (incl. review of the terms of reference and Scientific Committee draft work plan and WG-EMM priorities)

6. Advice to the Scientific Committee and future work

7. Adoption of the report.

Appendix C

List of Documents

Working Group on Ecosystem Monitoring and Management
(Virtual Meeting, 4 to 11 July 2022)

WG-EMM-2022/01	Recruitment variability along the Antarctic Peninsula: What's the best way forward C.S. Reiss and G.M. Watters
WG-EMM-2022/02	Recruitment variability in Antarctic krill in Subarea 48.1 expressed as 'proportional recruitment' D. Kinzey, J.T. Hinke, C.S. Reiss and G.M. Watters
WG-EMM-2022/03	Remote visual techniques for research and monitoring of marine communities in fast ice-covered coastal areas of the Ross Sea Region MPA E. Carlig, L. Ghigliotti, S. Canese, D. Di Blasi, M. Vacchi and S. Grant
WG-EMM-2022/04	Density and distribution of krill larvae and salps in the Mar de la Flota/Bransfield Strait and Elephant Island surroundings during the summer seasons of 2019 and 2020 E. Rombolá, M. Sierra, J. Seco, F. Capitanio, B. Meyer, C. Reiss and E. Marschoff.
WG-EMM-2022/05	A practical revision to CM 51-07 that distributes catches and increases catch limits in Subarea 48.1 G.M. Watters and J.T. Hinke
WG-EMM-2022/06	Report of On-line Krill Ageing Workshop (August and November 2021) S. Kawaguchi, C. Reiss, B. Krafft, T. Ichii, G. Zhu, P. Hollyman and R. Kilada
WG-EMM-2022/07	SCAR Krill Action Group Meeting 2022 Report B. Meyer, S. Kawaguchi, S. Hill, A. Atkinson, J. Arata, R. Driscoll, J. Conroy, Z. Sylvester and K. Bernard
WG-EMM-2022/08	Management Plan for Antarctic Specially Protected Area No. 145 Port Foster, Deception Island, South Shetland Islands Delegations of Chile and Spain
WG-EMM-2022/09	Chilean operation in the Antarctic krill fishery, years 2020–2021 P.M. Arana and R. Rolleri

WG-EMM-2022/10	Online sub-Antarctic workshop on pelagic regionalisation – 1 June 2022 A.B. Makhado, J.A. Huggett, K.M. Swadling, P. Koubbi, C. Cotté, M.A. Lea and workshop participants
WG-EMM-2022/11	The potential of using fishing vessels as a research platform to address knowledge gaps in krill biology for supporting krill management B. Meyer, J. Arata, A. Atkinson, D. Bahlburg, K. Bernard, R. Driscoll, S. Hill, L. Hüppe, T. Ichii, S. Kawaguchi, B. Krafft, E. Murphy, C. Reiss, E. Rombola, Z. Silvester, S. Thorpe and X. Zhao
WG-EMM-2022/12	Climate change patterns in the southern Indian Ocean: warming and marine heatwaves C. Azarian, L. Bopp and F. d'Ovidio
WG-EMM-2022/13	Climate change patterns in the Southern Indian Ocean: primary production changes A. Nalivaev, C. Azarian, L. Bopp and F. d'Ovidio
WG-EMM-2022/14	Overview of the new scientific information from PNRA supported research since the establishment of the RSRMPA L. Ghigliotti, M. Azzaro and M. Vacchi
WG-EMM-2022/15	Icefish spawning aggregation in the southern Weddell Sea K. Teschke, R. Konijnenberg, S. Hain, P. Brtnik and T. Brey
WG-EMM-2022/16	Predicting the presence and abundance of Antarctic krill (*Euphausia superba*) in the waters of the South Orkney Island Archipelago J.J. Freer, V. Warwick-Evans, G. Skaret, B.A. Krafft, A. Lowther, S. Fielding and P.N. Trathan
WG-EMM-2022/17	Implementing the risk assessment in Subarea 48.1 at a scale relevant to fishery operations V. Warwick-Evans, M. Collins and P. Trathan
WG-EMM-2022/18	British Antarctic Survey: Ecosystem Monitoring in Area 48 (2021/22) C. Waluda, A. Bennison, R. Cavanagh, M. Dunn, T. Dornan, S. Fielding, J. Forcada, S. Grant, J. Jackson, N. Johnston, S. Hill, P. Hollyman, E.J. Murphy, R.A. Phillips, N. Ratcliffe, G.A. Tarling, S.E. Thorpe, P.N. Trathan, V. Warwick-Evans, A. Wood and M.A. Collins

WG-EMM-2022/19	Proposed workshop on integrating climate change and ecosystem interactions into CCAMLR science R. Cavanagh, M. Collins, C. Darby, T. Dahlgren, M. Eléaume, S. Hill, P. Hollyman, S. Kawaguchi, B. Krafft, E. Pardo, M. Pinkerton, P. Trathan, A. van de Putte, N. Walker, G. Watters and P. Ziegler
WG-EMM-2022/20	Informing climate change discussions: Antarctic Climate Change and the Environment Decadal Synopsis R. Cavanagh, C. Darby, S. Grant, N. Walker and G. Watters
WG-EMM-2022/21	Options for the interim revision of CM 51-01 and CM 51-07 to progress the new krill management approach in 2022 X. Zhao and Y. Ying
WG-EMM-2022/22	Preliminary information on the results of observations at CEMP sites PTI, YAL and Gai in the season 2021/22 Delegation of Ukraine
WG-EMM-2022/23 Rev. 1	Composition and abundance of zooplankton collected from Ukrainian longline fishery vessels in CCAMLR Statistical Subareas 88.1, 88.2 and 48.1 during the 2020/21 summer season L. Samchyshyna, E. Pakhomov, P. Zabroda, I. Slypko and T. Pestovskyi
WG-EMM-2022/24	Some results of the oceanological research in the Weddell Sea (Statistical Subareas 48.1 and 48.2) by Ukraine in 2018–2021 V. Paramonov and P. Zabroda
WG-EMM-2022/25 Rev. 1	Updates on krill biomass estimates for the combined strata in Subarea 48.1 X. Wang, X. Zhao, Y. Zhao and Y. Ying
WG-EMM-2022/26 Rev. 1	Return of the giants: Summer abundance of fin whales in the Scotia Sea M. Biuw, U. Lindstrøm, J.A. Jackson, M. Baines, N. Kelly, G. McCallum, G. Skaret and B.A. Krafft
WG-EMM-2022/27	Comments and proposals on the development of management strategy for krill fishery: Risk assessment framework to allocate catch in Subarea 48.1 Delegation of the Russian Federation
WG-EMM-2022/28	Comparison analysis of krill length compositions from catches obtained by research and commercial gears S. Kasatkina and S. Sergeev

WG-EMM-2022/29	Review of the trawl systems used in the Antarctic krill fishery S. Sergeev and S. Kasatkina
WG-EMM-2022/30	Distribution and size composition of salpa according to research data on the RV *Atlántida* in 2020 A.M. Sytov, D.A. Kozlov and S.V. Popov
WG-EMM-2022/31	Comparative analysis of the distribution and biology of Antarctic krill according to the data of the synoptic survey CCAMLR-2000 and Russian studies on the RV *Atlántida* (2020) A. M. Sytov and D.A. Kozlov
WG-EMM-2022/32	Preliminary results on the length-weight relationship of fresh Antarctic krill with weight-at-length based on multiple individuals Y. Ying, G. Fan, J. Zhu and X. Zhao
WG-EMM-2022/33	Nimble marine biodiversity expeditions to the Southern Ocean: the Belgica 121 expedition concept B. Danis, B. Wallis, C. Moreau, C. Guillaumot, F. Pasotti, H. Robert, H. Christiansen, Q. Jossart and T. Saucède
WG-EMM-2022/34	Evidence of a vulnerable marine ecosystem documented via tourist submarine off Cape Well-Met, Vega Island, Eastern Antarctic Peninsula (Subarea 48.1) S.J. Lockhart and R.C. Izendooren
WG-EMM-2022/35	First biological description of Welchness Cape, Dundee Island M. Abas, M.L. Abbeduto, M. Juáres, M. Libertelli, J. Negrete and M. Díaz
WG-EMM-2022/36	Mapping research capabilities of CCAMLR Members in Domain 1 with focus on the D1MPA Research and Monitoring Plan Delegations of Argentina and Chile
WG-EMM-2022/37	Summary of the CCAMLR MPA Information Repository (CMIR) Secretariat
WG-EMM-2022/38 Rev. 2	Summary of CCAMLR Ecosystem Monitoring Program (CEMP) data holdings through the 2021/22 monitoring season Secretariat
WG-EMM-2022/39	Proposed workplan for developing and implementing data collection needs for CCAMLR krill fisheries, and re-scoping of the Krill Observer Workshop S. Kawaguchi, G. Zhu and CCAMLR Secretariat

WG-EMM-2022/40	Hot spots in the ice: revealing the importance of polynyas for sustaining present and future Antarctic marine ecosystems Z. Sylvester, C. Brooks, A. DuVivier, K. Krumhardt, L. Landrum, M. Holland, M. Long, S. Jenouvrier, L. Bourreau and S. Labrousse
WG-EMM-2022/41	Connecting observer data to fishery management needs: A comparison of two concurrent datasets from the Norwegian krill fishing vessel *Antarctic Endurance* R. Driscoll, B. Meyer, L. Hüppe, D. Bahlburg, S. Kawaguchi and B. Kraft
WG-EMM-2022/42 Rev. 1	South Shetland Island fur seals: conservation status and distribution updates D.J. Krause and G.W. Watters
WG-EMM-2022/43	The Eastern Weddell Sea Observation System (EWOS): A multinational initiative that provides coordinated and systematic observations of the Antarctic marine ecosystem C.D. Jones, M. Bach, D.K.A. Barnes, K. Beyer, L. Chakrabarti, G.E. Cassola, B. Feij, H. Flores, C. Gebhardt, C. Held, M.E. Kaufmann, S. Kempf, N. Koschnick, S. Kühn, K. Leuenberger, H. Link, F.C. Mark, A. Meijboom, M. Pallentin, C. Papetti, D. Piepenburg, M. Powilleit, A. Purser, F. Schaafsma, H. Schröder, A. V de Putte, M. v Dorssen and M. Vortkamp
WG-EMM-2022/44	Adélie penguins of King George Island depend on resources in CCAMLR Subarea 48.1 in summer, but Subareas 48.5 and 48.2 in winter A. Soutullo, A.L. Machado-Gaye, Z. Zajkova, A. Kato and Y. Ropert-Coudert
WG-EMM-2022/45	ASPA No. XXX Western Bransfield Strait and Eastern Dallmann Bay for Review by CCAMLR P. Penhale
WG-EMM-2022/46 Rev. 1	Vulnerable marine ecosystems documented via submarine in the Bransfield Strait and the Eastern Antarctic Peninsula (Subarea 48.1) S.J. Lockhart, R. Downey, R. García-Roa, J. Hocevar and L. Meller
WG-EMM-2022/47	Korean Antarctic research and monitoring in the Ross Sea region in support of Conservation Measure 91-05 J.-H. Kim, H.S. La, K. Lee, H.-C. Kim, J.-U. Kim, J. Park, H. C. Shin, D.N. Kim and S. Chung

Other Documents

WG-EMM-2022/P01	Long-term variation in the breeding diets of macaroni and eastern rockhopper penguins at Marion Island (1994–2018) F.E. Dakwa, P.G. Ryan, B.M. Dyer, R.J.M. Crawford, P.A. Pistorius and A.B. Makhado *Afr. J. Mar. Sci.*, 43 (2) (2021): 187–199, doi: 10.2989/1
WG-EMM-2022/P02	Conservation in the Scotia Sea in light of expiring regulations and disrupted negotiations G.M. Watters and J.T. Hinke *Conserv. Biol.* (2022): e13925, doi: https://doi.org/10.1111/cobi.13925
WG-EMM-2022/P03	Standing stock of Antarctic krill (*Euphausia superba* Dana, 1850) (Euphausiacea) in the Southwest Atlantic sector of the Southern Ocean, 2018–19 B.A. Krafft, G.J. Macaulay, G. Skaret, T. Knutsen, O.A. Bergstad, A. Lowther, G. Huse, S. Fielding, P. Trathan, E. Murphy, S.-G. Choi, S. Chung, I. Han, K. Lee, X. Zhao, X. Wang, Y. Ying, X. Yu, K. Demianenko, V. Podhornyi, K. Vishnyakova, L. Pshenichnov, A. Chuklin, H. Shyshman, M.J. Cox, K. Reid, G.M. Watters, C.S. Reiss, J.T. Hinke, J. Arata, O.R. Godø and N. Home J. Crust. Biol., 41 (3) (2021): 1–17. https://doi.org/10.1093/jcbiol/ruab046
WG-EMM-2022/P04	Distribution of the Mesozooplankton Community in the Western Ross Sea Region Marine Protected Area During Late Summer Bloom S. H. Kim, B. K. Kim, B. Lee, W. Son, N. Jo, J. Lee, S. H. Lee, S.-Y. Ha, J.-H. Kim and H. S. La *Front. Mar. Sci.*, 2022. 9: 860025. doi: 10.3389/fmars.2022.860025
WG-EMM-2022/P05	Application of Dual Metabarcoding Platforms for the Meso- and Macrozooplankton Taxa in the Ross Sea J.-H. Lee, H. S. La, J.-H. Kim, W. Son, H. Park, Y.-M. Kim and H.-W. Kim *Genes*, 2022, 13 (5): 922. doi: https://doi.org/10.3390/genes13050922
WG-EMM-2022/P06	Reconstruction of Ocean Color Data Using Machine Learning Techniques in Polar Regions: Focusing on Off Cape Hallett, Ross Sea J. Park, J.-H Kim, H.-C Kim, B.-K. Kim, D. Bae, Y.-H. Jo, N. Jo and S. H. Lee *Remote Sens.*, 2019, 11 (11): 1366, doi: https://doi.org/10.3390/rs11111366

WG-EMM-2022/P07	Data Reconstruction for Remotely Sensed Chlorophyll-a Concentration in the Ross Sea Using Ensemble-Based Machine Learning J. Park, H.-C. Kim, D. Bae and Y.-H. Jo *Remote Sens.*, 2020, 12 (11): 1898; doi: https://doi.org/10.3390/rs12111898
WG-EMM-2022/P08	Bacterial epibiont communities of panmictic Antarctic krill are spatially structured L. Clarke, L. Suter, R. King, A. Bissett, S. Bestley and D. Deagle *Mol. Ecol.*, 2021. 30: 1042-1052, doi: https://doi.org/10.1111/mec.15771
WG-EMM-2022/P09	Spatial and temporal catch concentrations for Antarctic krill: Implications for fishing performance and precautionary management in the Southern Ocean F. Santa Cruz, L. Krüger and C.A. Cárdenas *Ocean and Coastal Management*, 223 (2022): 106146
WG-EMM-2022/P10	Biological-physical processes regulate autumn prey availability of spiny icefish *Chaenodraco wilsoni* in the Bransfield Strait, Antarctic G.P. Zhu, Q.Y. Yang and K. Reid *J. Fish Biol*., 1–13 (2022), doi: 10.1111/jfb.15120
WG-EMM-2022/P11	Influence of tides on mass transport in the northern Antarctic Peninsula G.P. Zhu, X.Q. Zhou and S. Hu *Polar Science*, 23 (2020): 100506
WG-EMM-2022/P12	Using Antarctic krill (*Euphausia superba*) to reflect regional heterogeneity in marine environments in the northern Antarctic Peninsula, Antarctic G.P. Zhu and D.R. Wang *Ecological Indicators*, 136 (2022): 108596
WG-EMM-2022/P13	A tool to evaluate accessibility due to sea-ice cover: a case study of the Weddell Sea, Antarctica H. Pehlke, T. Brey, R. Konijnenberg and K. Teschke *Ant. Sci*., 34 (1) (2022): 97–104, https://doi.org/10.1017/S0954102021000523

WG-EMM-2022/P14	A vast icefish breeding colony discovered in the Antarctic A. Purser, L. Hehemann, L. Boehringer, S. Tippenhauer, M. Wege, H. Bornemann, S.E.A. Pineda-Metz, C.M. Flintrop, F. Koch, H.H. Hellmer, P. Burkhardt-Holm, M. Janout, E. Werner, B. Glemser, J. Balaguer, A. Rogge, M. Holtappels and F. Wenzhoefer *Current Biology*, 32 (4) (2022): 842–850, https://doi.org/10.1016/j.cub.2021.12.022
WG-EMM-2022/P15	The rapid population collapse of a key marine predator in the northern Antarctic Peninsula endangers genetic diversity and resilience to climate change D.J. Krause, C.A. Bonin, M.E. Goebel, C.S. Reiss and G.M. Watters *Front. Mar. Sci.*, 8 (2022): 796488, doi:10.3389/fmars.2021.796488
WG-EMM-2022/P16	Krill finder: Spatial distribution of sympatric fin (*Balaenoptera physalus*) and humpback (*Megaptera novaeangliae*) whales in the Southern Ocean F. Alvarez and J.L. Orgeira *Polar Biol*. (accepted)

Appendix D

Terms of Reference for the Proposed Krill Observer Workshop

1. Reassess time allocations and instructions for krill observer data collection requirements for krill length frequency to adequately address the needs of the Scientific Committee. Training corresponding to data collection changes for observers to be provided if necessary.

2. Provide a forum for Members to share experience on the additional tasking of observers to develop common methods and approaches.

3. Provide opportunities for information exchange between observers and CCAMLR scientists, including discussion on the importance and potential of observer data for advancing krill science and management.